Public Engagement

Medical Physics

SET for BRITAIN

National Measurement System

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The Journal of the Parliamentary and Scientific Committee

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Very serious earth shaking events in Japan have created a global situation that is still running its course and which has the potential to cause the rest of the world to pause and reconsider the suitability of the nuclear option as a safe and reliable way of delivering low carbon base-load electric power to industrialised countries.

This issue is currently high on the UK agenda as the existing fleet of nuclear power stations are nearing the end of their life. Nevertheless it demonstrates clearly the need for much better evaluation and management of risk and the importance of taking all relevant factors into account when governments are planning major infrastructure projects and especially nuclear power stations. Indeed, in view of the potential for global risk arising from the impact of nuclear disasters should not such projects be reviewed in future by experts from a wide range of relevant disciplines on an international rather than a national basis?

On the other hand, when the EU was presented with a topic clearly requiring EU-wide legislation, such as better regulation of pesticides used in agricultural production, the opportunity was taken under REACH to extend the remit way beyond its original purpose on the "precautionary principle". The resultant effect will be to drive small scale users of essential imported chemical substances out of business.

The risk of long term damage from measures of this type that fail to take account of the priorities of EU Member States that rely on industrial manufacturing would appear to be unacceptable. The potential benefits, if any, of such legislation to the EU economy and environment are difficult to assess. Is this just the result of a misunderstanding, misapplication and misuse of the assessment and management of risk?

This issue also reports on two discussion meetings that are important to the UK both economically, such as the National Measurement System, and also from the human health standpoint where physics and engineering have created a new paradigm of medical physics, applying the fruits of basic physics research to clinical problems in a way that combines applied science, translational research and highly developed problem-solving skills.

SET for Britain, the poster competition initiated by Dr Eric Wharton, once again brought early-stage researchers to Parliament to celebrate and demonstrate the vital importance now placed on recognising, encouraging and rewarding the next generation of outstanding scientists, technologists, engineers, mathematicians and medics from universities and research organisations based in the UK.

On a more personal note I am particularly pleased to see the article by Steve Nicholson, Project Director, Mersey Gateway, and to learn that this badly needed and vital new communication link will come to pass in the not too distant future – and it is a really exciting bit of British engineering that will be a landmark for years to come.

Andrew Miller MP
Chairman, Parliamentary and Scientific Committee

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

The Parliamentary and Scientific Committee

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

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HOW THE EU CHEMICAL DIRECTIVE CREATED A DARK AGE IN EUROPE

Anthony Lipmann
Former Chairman, Minor Metals Trade Association (2003-06)
Managing Director,
Lipmann Walton & Co Ltd

At Rolls-Royce Plc in Derby, they are precision-casting the turbine blades for the Trent 1000, the lead engine for the Boeing Dreamliner. Developed by materials scientists at Rolls, the UK has maintained a lead in the technology to make high-pressure single crystal turbine blades for the past twenty-five years. Here a blade is grown through a ceramic core from complex molten alloy that comprises titanium, cobalt, tantalum, chrome, hafnium, molybdenum, tungsten, aluminium and rhenium on a base of Nickel. In a single disc-stage of a typical gas turbine, there are perhaps one hundred blades meant to withstand turbine inlet temperatures of up to 1600° centigrade. It is said that the force driven by each blade into the disc is approximately 18 tonnes or, put another way, the centrifugal pressure on the tip of each blade is equivalent to the weight of a double-decker bus.

Who would have thought then, that the rather simpler task of supplying elements needed to make these blades would now be a greater problem than the material science? But as governments around the globe wring their hands on the subject of strategic metals, and cast about for solutions, there is a danger that if this problem is not analysed correctly the matter could be made even worse.

As a dissident to the view that strategic metal price rises are only to be blamed on Chinese export quota restrictions, or fears that they are about to run out, I would offer the suggestion that a far greater threat to UK and EU manufacturing lies in the unintended consequences of the EU Chemical Directive.

With its origins in a UK Royal Commission enquiry into pesticides, the EU Chemical Directive later emerged from Brussels as something altogether rather more far reaching. Taking as its starting point Section 5/Environment/Article III-233 of the, as yet un-ratified, European Constitution *"Union policy on the environment shall…be based on the precautionary principle"* the law that emerged did not limit itself to warding off the threat posed to EU citizens by pesticides but, with mission creep, came to encompass almost all substances – chemicals, alloys, compounds, and pure elements.

With so wide a stroke of the EU biro, this clause had thrown away 2000 years of western civilisation by curbing the natural invention of man to experiment with elements and substances. With this law, we have to ask, would the single crystal turbine blade or a host of other modern applications of minor metals ever have emerged at all?

Before going further, though, I should like to make clear that the following article is not an anti-environment luddite diatribe. In fact I see no conflict between the demands of business for the free flow of raw materials and the need to ensure that the by-products of manufacturing do not pollute. My case is that the EU Chemical Directive does not achieve this. By regulating elements, which were not in the original frame of reference, it duplicates and exceeds the perfectly workable Dangerous Substances Act and the practical guidelines established by the International Maritime Organisation for transport of dangerous goods. Further, by pushing the metallic by-products of manufacturing, such as turnings, off-cuts and residues, to be classified as 'waste' rather than 'metal for re-melting', or 'material for recycling', the excessive zeal of the law has caused the disposal of some toxic substances to landfill that would once have been safely recovered.

Mooted as a law to protect (un-provably) the lives of 30,000 EU Citizens from direct contact with chemical substances, the EU Chemical directive possibly now threatens

the livelihoods of many more than that number through its unintended consequences.

In order to make the EU Chemical Directive a bit more real to anyone not directly affected by it, it is worth just running through the main points. Dubbed REACH, which stands for 'registration', 'evaluation' and 'authorisation' of 'chemicals', the law requires a dossier to be created on every substance that passes across the borders of the EU. In practice, some chemicals contain formulations so complex that they have had to be removed entirely from the European market. In the case of elements, alloys and compounds, it has meant that once fierce rivals in the marketplace have been ordered to come together for registration in consortia, where knowledge, but not market information, must be shared. Tests required by REACH on each substance include those for carcinogenicity, mutagenicity, and reprotoxicity (CMRs), aquatic dispersal and many more. The law also dictates that old science submitted for dossiers is not valid, which in practice means new tests (many on animals) conducted according to current EU best lab practice.

Even simple elements such as Iron require a dossier. Three years in, and very few consortia have completed their dossiers, and some elements or substances have been orphaned with not enough critical mass to invest in compiling the data. On items with complex compounds these dossiers may take up to eight years to complete. The costs are astronomic. The International Molybdenum Association has so far spent US$5.5 million over 5 years and 11 substances, while the Cobalt Development Institute has spent €7 million for the testing of the 30 or so Cobalt bearing substances – and both are still counting.

In practice the importer has two choices – either share the cost of testing as a member of a consortia or pay later for a 'letter of access' to the information that a consortia has compiled. In the case of our small private company, we have decided to be part of a consortia for one of our critical elements, Rhenium, for which we have budgeted about £100,000, whereas for an element such as Titanium we will opt for a letter of access which will cost €40,000 if the projected annual quantity imported is less than 1000 mt (It would be €60,000 if more than 1000 mt). For a private UK merchanting company, founded by my father in 1953, it all adds up to quite a bill when translated across the 20 or so different substances we supply to customers during the year. With a company net worth of about £2 million, we could easily spend all of that just on registration.

As a board member of *The Minor Metals Trade Association* (MMTA), the organisation that has been occupied since 1973 with the smooth running of the trade in minor metals, I often visit manufacturers round the UK who are REACH-affected. Last week, I visited two companies in the north-west bravely trying to make unique world-leading products in the face of the twin towers of Chinese rare earth quota restrictions and REACH; two ground-breaking UK manufacturers making products which, ironically enough, use minor metals in products which promote environmentally favourable outcomes.

At *Magnesium Elektron*, in Swinton, Manchester, their unique patented magnesium alloys are present in the Airbus A380, where weight reduction is paramount, increasing fuel efficiency. Due to new formulations originated here, which have increased the corrosion resistance in magnesium-base alloys, the prospect for wider use in aerospace is very exciting. But now, with so much time spent both securing rare earth metals from China, and then compliance with REACH, who in their right mind would set up a manufacturing operation in the UK today, if you were not already here?

Another UK manufacturer similarly affected is *Less Common Metals* in Birkenhead. Here, the UK possesses the only European manufacturer of Neodymium-Boron-Iron permanent magnets (as required by wind turbines) who also, at present, depend upon China for their rare earths. To free themselves of this dependency, LCM recently reversed into a Canadian entity called *Great Western Minerals Group* who in the future will be a primary supplier of rare earth metal oxides. But where will the conversion into metal take place? Ideally this would be in the UK next to the plant in Birkenhead, but REACH dictates that a full dossier will need to be produced for each element and compound within the rare earth complex. With only a handful of companies to share the dossier, costs of relatively data-poor elements such as these could stretch to many millions of pounds. Meanwhile, China, which believes rare earths to be national treasure, bears none of these costs, and in a further blow to European competitivity, is able to deliver freely articles which may have been made with such elements but with none of the REACH safeguards.

What applies to the two examples above also applies to Rolls Royce, but on an even greater scale. Here, by their own account, the world's second largest manufacturer of gas turbine engines does not actually know precisely how many substances go into a typical engine – it could be as many as 5000, and one way or another the EU wants to regulate all of them.

Using the example of single crystal turbine blades, where Britain is a world leader, we may take the example of Rhenium, one of the rarest elements (77th least abundant in the earth's crust) and the last naturally occurring element to be separated in 1925, which also happens to be un-substitutable in this application.

Here we have an element that starts its life at 0.4 parts per billion in the earth's crust, is never mined for itself, and only recovered from certain types of copper ores, where the flue dusts of by-product molybdenum are roasted. Its life is precarious to begin with, but it is not toxic and it is the key element which gives the turbine blade its resistance to deformation, which in turn leads to all the other outcomes desired by airlines and law makers – higher operating temperatures, fuel efficiency, longevity, lower emissions of nitrous oxides to the upper atmosphere.

However, despite its tiny production – the entire annual world output of 45 mt would easily fit into a Parliamentary Select Committee Room – the EU Chemical directive dictates that it could harm EU Citizens and must therefore be controlled.

The same procedure that applies to copper, whose annual world production is 15 million

metric tons, is applied to Rhenium with 45 mt. Three years into the process and we still do not know how much the exercise will eventually cost. The lawyers who run the consortia, according to EU rules, tell us that once registered we shall recoup our cost from other importers who will have to purchase a 'letter of access' to acquire the information we have created, the price of which will be determined by the amount that the consortia have already spent divided by the numbers of those requiring access. In practice, though, the machinery of registration, evaluation and authorisation is a steam-roller with no reverse gear and we do not expect funding to be returned to us; which is more likely to be gobbled up in the maintenance and reparation of the steam-roller.

Over the last two years, we have moved towards implementation, and industry has been swept into the process, dedicating vast amounts of time and money to compliance. We have seen decisions about investment abandoned and plant, equipment and processes hurried overseas to locations where neither the laws nor the controls are as great.

The great irony is that elements are not good or bad, they are substances with sometimes conflicting properties and uses. One of the best examples is Thallium. Used as rat poison by the Victorians, a few milligrams is enough to kill the human organism. And yet Thallium has a unique co-efficient of diffraction and, today, when doped in glass, is essential in fibre-optic repeaters to boost light signals. It is also used entirely safely in digital camera lenses and photocopier glass. But Thallium comes from lead and zinc ores and is refined out as a by-product on the route to making pure 99.9% Lead and Zinc. The problem for Thallium is that no consortia exists to register it under REACH. The cost would simply be too great. The puritanical zeal of the law, which effectively classifies elements not for their scientific and chemical properties but because of their moral worth to the environment, is shutting out the production of Thallium in Europe for ever, as well as any prospect of its further use. What will happen to the Thallium atoms you may ask? They will most likely go to landfill.

The problem for any business advocate of the removal of a piece of environmental legislation is that current orthodoxy means it is doomed to failure. However, as the EU Chemical Directive rolls out, and the EU slowly becomes a clean room, Europe is also becoming cleaned of manufacturing and innovation. The hypocrisy is that we remain content to import articles from other parts of the world made under circumstances and conditions which are far inferior to those being implemented under REACH. The net effect is the export of both jobs and morals. It is truly a dark age we are entering.

SCIENCE AND CITIZENSHIP

The Rt Hon the Lord Jenkin of Roding

Opening speech at Science and Citizenship conference held by the British Council at the Wellcome Collection Conference centre on 14th and 15th December 2010 to mark the Tenth Anniversary of the "Science and Society" Report of the House of Lords Select Committee on Science and Technology.

When the British Council invited me to open this important international conference – an event intended to mark the tenth anniversary of the House of Lords Select Committee on Science and Technology's Report "Science and Society" – I did not at first realise the full implications of what I would be taking on. The presence here today of so many delegates from countries outside the United Kingdom brings it home to everyone just how important across the world it has become to find ways to engage the public with science. Indeed, though I and my colleagues hoped that our Report might be useful, I certainly did not begin to realise that its influence would reach across the world. I believe the British Council is to be warmly congratulated on mounting this event and I am delighted to see so many visitors here in the hall.

My task has been described as "setting the scene". Perhaps I might start by briefly describing how the House of Lords Select Committee on Science and Technology works, how the subject of our Report came to be chosen, and how I – someone who never did any science at all at school or university – came to be invited to chair it.

Over recent years both Houses of Parliament in the UK have found that one of the most effective ways to hold Ministers to account, and to explore policy issues more deeply than can be done in debates on the Floor of the House, was to establish specialist Select Committees; the House of Lords set up the Science and Technology Committee nearly 30 years ago, and since then it has established itself as an authoritative and respected body whose Reports are widely studied and in many cases acted upon.

The House of Lords is fortunate in having among its Members scientists and engineers of great distinction, as well as Peers who are expert in other branches of learning and of course people who have held high office in previous governments. When selecting Members to sit on the Science and Technology Committee, the House has a rich store of experience and expertise on which to draw. The Select Committee is free to choose its

own programme of inquiries and this takes full account of current issues and developments in science and technology both in the UK and abroad.

Having chosen a subject, the inquiry then issues a call for evidence and this is then responded to by written evidence from the professions, academia, public bodies, industry, and interested non-government organisations. The Committee then identifies some of these who will be asked to give oral evidence to the Committee where they may be questioned by Members. The Committee may invite evidence from overseas and, in appropriate inquiries, will travel overseas to find out if we can learn from the experience of other countries.

After a Report is published, there are two more stages. First, the Government has to reply to the Report in not less than two months. Then there is a debate on the floor of the House in which any Peer is free to take part – and it is not unusual to listen to views which may either contradict the recommendations in the Report, or, more often, which roundly criticise the inadequacy of the Government's response!

I have no doubt that legislatures in other democratic countries could point to similar procedures.

Mr Chairman, that is how we work and that is exactly how the inquiry "Science and Society" worked ten years ago.

So how did we come to choose this subject? In the UK there had been for several decades an activity which was called "the public understanding of science". Despite the best efforts of many able and committed people in science and engineering, there was a growing perception that this was not succeeding in bridging the gulf between the world of science and technology on the one hand and the mass of the people on the other. So when at one of the Committee meetings I attended we were asked to suggest possible topics for future inquiries, tentatively – because I was a relatively new Member of the Committee – I suggested that we might look at the whole question of the gulf between science and the public.

We had recently had some quite serious scientific crises including a highly damaging outbreak of foot and mouth disease; there had been the alarm surrounding the new version of Kreutzfeld/Jacob disease, there was growing controversy over genetically modified foods; and a great deal of misunderstanding about the drivers of climate change.

You may be surprised to learn that I was rebuffed! Several of the very distinguished scientists who had been involved in the "public understanding of science" loftily told me that this was already in hand and did not need another inquiry. So I subsided!

However, the subject did not go away. The issues became ever more significant, and so late one evening I was approached by the then Chairman, Lord Winston, who invited me to chair an inquiry on "Science and the Public". Of course I accepted. We then had a meeting of the Committee where this was proposed, but one of the young advisors to the Committee suggested that, instead of "Science and the Public" perhaps "Science and Society" would have a better ring about it – and it was so decided. We then got to work.

Why was I invited to chair it? For that you must ask others; as I have said I was no scientist but I had held Office in the Cabinets of two successive Conservative Governments and had a good deal of experience as to how government worked.

Our first task was to appoint Special Advisors. In an earlier inquiry, about the handling of nuclear waste in which I had taken part, I had been hugely impressed by an academic from Lancaster University, Professor Brian Wynne, who had offered us much wisdom about how to approach the public on such matters. So he was my first choice and I might add that it is sad that he is unable through illness to take part with us today. Our second Advisor was your next speaker, Professor John Durant, then a professor of the Public Understanding of Science and a distinguished academic at Imperial College London.

After taking advice from these Advisors and from the Committee staff, we issued our call for evidence in April 1999. This set out the questions that we wished to examine, the first of which was "What is known about the attitudes in UK society towards developments in science? What is known about the levels of trust in scientists? Are some groups of scientists trusted more than others and, if so, why?" And there were a number of questions elaborating on that central theme. We made it clear we were not concerned about the education and training of specialist scientists, nor were we seeking to encourage more people to follow science careers. Important as these subjects are, they were already under examination elsewhere.

I was astonished by both the volume and the erudition of the huge mass of written evidence we received. We had certainly found a topic of very wide concern. It is the practice of these Committees to publish the evidence. My friends, here is the published document! It is still in print and available from the Stationery Office – all 426 pages of it!

Based on that evidence, we invited a long list of witnesses to give us oral evidence, when we could examine them in more detail, and between May and December 1999 many dozens of witnesses of widely different opinions and expertise were examined. This oral testimony is included in the volume.

But that was not all. I and a few others visited the US in October 1999. There our programme included meetings with the White House Office of Science and Technology Policy, the National Academy of Sciences, The National Institutes of Health, the National Science Foundation, the Boston Museum of Science, and the Kennedy School of Government at Harvard University. These and other meetings in America had a considerable influence on our recommendations; it was clear that in the United States they faced many of the problems which we did.

After we had completed our hearings and studied the evidence, the Committee then held a series of drafting meetings.

The first draft was provided by our very able Clerk to the Committee – but, my friends, that was only a first draft! With the advice of our Special Advisors and with the wisdom of our really eminent scientists on the Committee, we went through the draft paragraph by paragraph and made numerous improvements and alterations. Indeed, for some sections we produced entirely new drafts

Eventually we finalised our draft and it went to the printers and was published on February 23rd 2000. We made twenty-six

recommendations lettered, conveniently, A-Z. These are all set out in the Summary at the front of the Report and I will not weary you by reading them all out. I can give what I hope is a useful summary.

Turning first to public attitudes, we recognised that people now question all authority including scientific authority; the age of deference is long past! People place more trust in science which is seen as "independent"; secrecy invites suspicion; what seem to be scientific issues in fact involve moral, social, ethical and other concerns and, if these are not recognised, that invites hostility. There is a widespread misunderstanding of risk; and it has to be recognised that underlying people's attitudes are the values which they espouse.

So, our central recommendation was that the crisis of trust which I have described has produced what we called "a new mood for dialogue". It is not only public understanding that is important, scientists must understand the impact of science on society and on public opinion.

We also recognised that scientists must be free to pursue the lines of research they choose, and we discussed how and when the public should be made aware of their work.

So, I come to our principal recommendation. Instead of seeking "the public understanding of science", which we were told very firmly was one-way, top-down, condescending, even demeaning, we recommended a culture of public engagement, and that, my friends, is what lies at the heart of our Report. Engagement must be a two-way process, and, as one of our American witnesses put it eloquently, it requires "ears as well as voices".

We went on to say that all this requires genuine changes in the cultures and constitutions of key decision-making institutions. Public support for science is essential if progress is to be made. The concept that scientists have a licence to practise from the public has to be clearly recognised.

We also had recommendations about science and the media, about science education and schools and time does not allow me to outline them here today; they are there for the reading in the Report.

And what was the outcome? For about a year, there was little response. The reason for this was that the Report was thorough, detailed, and complex and the recommendations had many far reaching implications. Eventually, however, the messages were taken on board. What had hitherto been the one-way process of the public understanding of science gradually gave way to public engagement. One by one all the principal UK scientific and engineering bodies established their "science and society committees" (though they were often under different names).

After a further delay, the Government recognised that they too had to respond to the Report, not just formally which Governments have to do, but by picking up those recommendations made to Government and acting on them. There is now a fully fledged Science in Society activity within Government and Ministers in successive Governments have urged all the departments and bodies for which they are responsible to take full account of the Committee's recommendations.

It must of course be for those who are to follow me today and tomorrow to describe and evaluate what has happened since then. One shortcoming in our Report of which I was quickly made aware is that while we described a large number of different mechanisms and processes by which scientists interact with the public, we did not succeed in defining what we really meant by "engagement". As a result, many scientists have found it very difficult to know what it is that they might actually do to "engage" with the public.

Another problem, at least until recently, is that the communication of science has tended to rank well below research as a worthy activity of someone pursuing a career in science.

I come finally to my last point – it concerns the relatively new field of Synthetic Biology.

When the distinguished American molecular biologist and entrepreneur, Craig Venter, claimed earlier this year to have created the world's first synthetic life form, and said that this success "has changed his view of life and of how life works", his discovery was greeted in the Times here in London with the headline, quoting an eminent UK scientist, "Synthetic life? Synthetic hysteria more like!"

Yet, of course, the science of synthetic biology (or synthetic engineering as it is sometime called) has immense potentialities as well as some intense moral, ethical and social implications – and it is not going to go away!

Two of the leading Research Councils in the UK launched what they called a "Synthetic Biology Dialogue" – have we not heard that word a few moments ago? – involving a series of public workshops and stakeholder interviews on the science and the moral and ethical issues surrounding synthetic biology. Their Report, 90 pages long, is a really fascinating document and is well worth reading; in the few minutes I have left I cannot possibly do justice to it. One key finding is that it is simply not possible to ask the lay public for their views on the moral and ethical implications, unless they understand enough about the science to know what it is that they are being asked about. I am told that much of the time and effort that went into this exercise was spent on doing just that, before exploring attitudes and reactions. This clearly means that instant polling via Facebook or Twitter or any of the other social websites is not only meaningless, but could well be really misleading.

For me, this very recent report has an additional attraction: it revisits a great many of the concepts and issues which were at the heart of the "Science and Society" Report 10 years ago. It asks many of the same questions that we were asking then.

One distinguished scientist said to me that our Report was perhaps the most influential House of Lords Select Committee Report over the previous decade. I have never written an autobiography and I do not intend to do so. But I have sometimes said to my friends that if I ever merit a footnote in history, it might be for our "Science and Society" Report.

DEVELOPMENTS IN THE STANDARDISATION OF OCEAN SALINITY

Paul Ridout
Chairman, Ocean Scientific International Ltd

The salt content or salinity of the oceans is one of the most measured parameters in oceanography. Its importance has long been recognised in studies of water mass movements in the open ocean. Improving knowledge of sea surface salinity is leading to a better estimation of the global hydrological cycle which, ultimately, will contribute towards a better understanding of climate change.

As a result of global warming, increased amounts of fresh water are being evaporated from the ocean surface and transported to higher latitudes, giving rise to increased surface salinities in some areas of the oceans. The Ocean Observations Panel for Climate, OOPC, and its predecessors examined the usefulness of sea surface salinity data in the context of climate change detection. They state that "At high latitude, sea surface salinity is known to be critical for decadal and longer time scale variations associated with deep-ocean over turning and the hydrological cycle. In the tropics and, in particular, the western Pacific, Indonesian Seas and in upwelling zones salinity is also believed to be important."

Salinity is important in other aspects of marine science. SONAR (sound navigation and ranging) is influenced by water density and hence the salinity of the seawater in applications such as seabed mapping, submarine detection and bathymetry. Salinity has a considerable influence as an ecological factor on marine organisms, affecting algal blooms, movement of fish stocks, shellfish productivity and aquaculture.

Early work in measuring the saltiness of the sea involved techniques utilising weighing after evaporation (Boyle,1693; see Birch, 1965), solvent extraction (Lavoisier, 1772) and precipitation (Bergman, 1784). It was Forchhammer (1865) who introduced the term salinity and the concept of measuring one parameter, chloride (in reality total halide), from which the salinity could be calculated. This work was supported further by Dittmar (1884) who analysed over 75 samples from the Challenger Expedition (1872-1876) to establish the theory of 'Constant Composition of Seawater'. Further work by Knudsen et al (1902) resulted in a new definition which stated that Salinity was "The total amount of solid material in grams contained in one kilogram of seawater when all of the carbonate has been converted to oxide, all the bromine and iodine replaced by chlorine and all the organic material oxidised".

Towards the end of the 19th century the Danish physicist and hydrographer Martin Knudsen prepared sealed glass tubes of seawater to standardise the silver nitrate solutions used in Danish hydrographic work. In 1899 when a preparatory conference took place in Stockholm to establish the International Council for the Exploration of the Seas (ICES), Knudsen submitted a proposal for an international institution for the procurement of standard water (Conference Internationale, 1899). Key features of his proposal were the collection of open Atlantic seawater, detailed determination of the total salinity and testing of sealed glass tubes for maintaining the integrity of the standard. The Norwegian explorer, Fridtjof Nansen

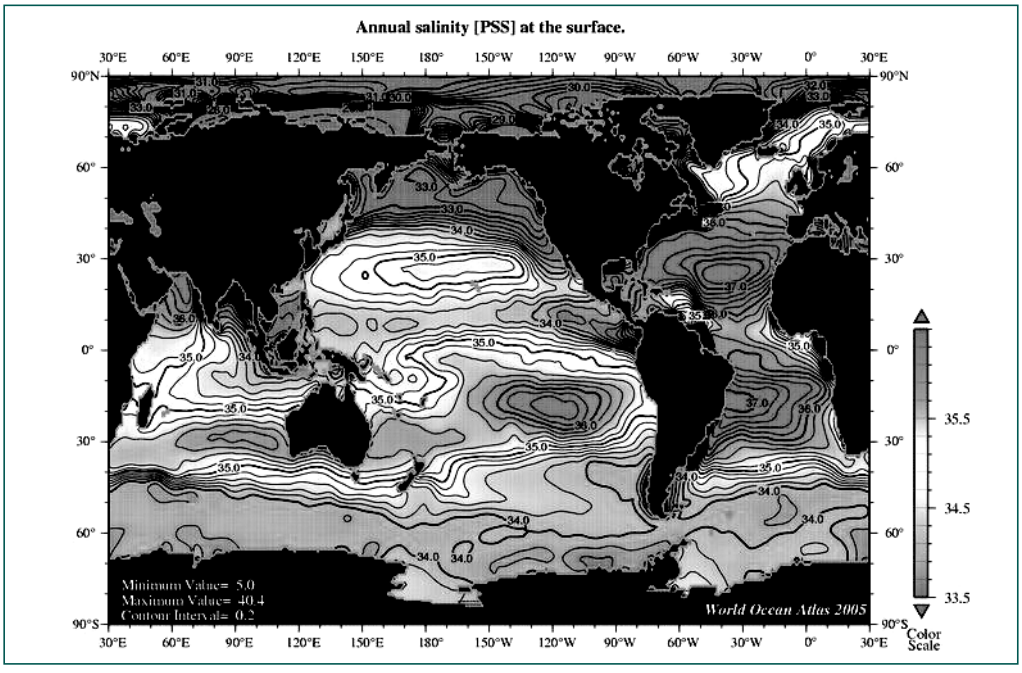

Fig 1 Sea surface annual salinity (Antonov et al, 2006)

proposed to the Conference that a Central Laboratory be set up in connection with ICES for the supply of standard seawater. In April 1900 about 80 tubes of 'Standard Water No VI' and random samples were investigated for chlorinity and specific gravity by the Danish chemist, Sørensen. When Nansen relinquished this responsibility in 1908, Knudsen agreed to direct the Standard Seawater Service on behalf of the Council and then in 1914 he assumed personal responsibility for its operation.

Fig 2 An ampoule of Standard Seawater from 1902 (© P Ridout)

In 1947, at the age of 76, Knudsen suggested that the Association Internationale d'Oceanographie Physique (AIOP) take over responsibility for the Service in order to secure its future. His foresight was appreciated soon after when Knudsen died and, at the request of AIOP, Helge Thomsen took over administrative responsibility with Knudsen's assistant, Frede Hermann, preparing and calibrating the standards. When Thomsen retired in 1960 Hermann took over full responsibility and the requirement for standards increased dramatically as oceanographic science expanded around the world. Scaling up of the seawater collection, processing and calibration was necessary to meet the demand which peaked at around 30,000 ampoules of standard per annum. Hermann retired in 1974 and responsibility for the Service passed to Fred Culkin, a UK marine chemist who had collaborated with him on chlorinity titrations for several years. With support from IAPSO (formerly AIOP) all the equipment, which included a 5000 litre tank, circulation pumps, filling manifold and stocks of ampoules were transferred to the Institute of Oceanographic Sciences (IOS) in Wormley, Surrey, UK. Much of the knowledge and analytical techniques involved in the production of this important standard had been transferred via word of mouth and handwritten notes so when Hermann died a year or so later Fred Culkin essentially was the only person who had the knowledge to produce Standard Seawater. By way of mitigation and to ease the workload, IOS employed Paul Ridout to understudy Fred Culkin and take over the day-to-day operation of the service with Culkin remaining as its director. At that time Standard Seawater was still calibrated using a high precision potentiometric titration of the seawater total halide with silver nitrate solution to give Chlorinity.

In 1978 the break with chlorinity was sealed with the introduction of a new conductivity-based definition of salinity by the Joint Panel on Oceanographic Tables and Standards (JPOTS). This new definition states that 'a seawater of salinity 35 has a conductivity ratio of unity with a solution of 32.4356 grams of Potassium Chloride in 1 kilogram of solution at 15 C and 1 atmosphere'. The standard concentration of KCl was derived from measurements carried out on one batch of Standard Seawater, weight diluted and evaporated (Lewis,1980; see Unesco Technical Papers No 37, 1981). Also included were measurements of absolute conductivity carried out at the Institute of Oceanographic Sciences, Wormley, UK (Culkin and Smith, 1980).

Fig 3: Fred Culkin and Paul Ridout at OSIL.

This gave rise to the introduction of the Practical Salinity Scale 1978 (PSS78) and the term Practical Salinity.

With the change in definition to Practical Salinity in 1978 came the need to determine the calibration of Standard Seawater in conductivity ratio. This was achieved using high precision weighings of KCl and measurement of conductivity ratio on a modified laboratory salinometer (Guildline Autosal). For a while the standard seawater label showed both conductivity ratio (K15) and chlorinity until Batch P113 (1990) when chlorinity was discontinued and replaced with the calculated value for Practical Salinity. In 1989 the Service was transferred, for the first time in its history, to a private company, Ocean Scientific International Ltd (OSIL) and the company's founder, Paul Ridout, took over as Director of the IAPSO Standard Seawater Service. Fred Culkin retired from IOS but continued in a consultancy role with OSIL until his death in February 2011. There were some concerns in 1989 with regard to the long-term stability of a commercial operation but in effect the Service has never been more secure with now, 22 years on, 3 analysts trained in the calibration and the methodology fully documented under an ISO9001:2008 quality system. In 2000, following almost a decade of testing, the traditional glass ampoule was replaced by a pharmaceutical grade glass bottle which offered an improved shelf-life (to 3 years) and a more robust container which required less packaging and was easier to use.

OSIL has continued to publish the results of ageing on the batches of P-series (Culkin and Ridout, 1997) and the statistical uncertainty of the calibration (Bacon et al 2007) and continues to archive samples from each batch. This archive contains seawater collected from the Atlantic Ocean since 1901.

Standard Seawater is identified by a batch number with the prefix 'P'. This originates from Knudsen's early work when in 1905 a new Primary Standard was established by direct comparison with Knudsen water VI. In the following two years, four more batches (P1-P4) were prepared. In the early years the demand was somewhat limited with Batch P17 being produced in 1948. The Service operated by OSIL has now reached Batch P153 and supplies the standards to marine scientists in over 75 countries. Seawater chemist, Nigel Higgs, carries out the day-to-day preparation and calibration of the standards with Paul Ridout as the Service Director. (More information is available at www.osil.co.uk).

Some countries (eg Japan, Russia, China) have produced

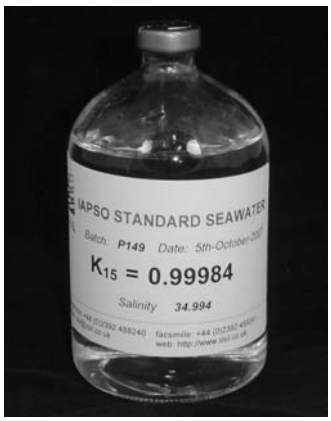

Fig 4: IAPSO Standard Seawater (© P Ridout)

their own standards for various reasons. The Japanese standard manufacture was discontinued in favour of the IAPSO standard which is now imported from OSIL and distributed in Japan. Seawater salinity standards have also been produced in Russia and China as secondary standards, calibrated against the IAPSO standard, for distribution only in those countries. The IAPSO Standard Seawater Service (at IOS and OSIL), with some support from the World Ocean Circulation Experiment (WOCE), the International Oceanographic Commission and Unesco, has worked closely with scientists from both the Russian and Chinese laboratories to maintain comparability between the primary (IAPSO) standard and these secondary standards.

Recent work by the SCOR/IAPSO Working Group 127 (WG127) has resulted in improved algorithms and descriptions of the thermodynamic properties of seawater (TEOS-10). In order to achieve higher accuracy a salinity variable was required which more accurately represented Absolute Salinity than the conductivity-based Practical Salinity. Absolute Salinity essentially represents the total dissolved salts whereas Practical Salinity is calculated from only the conductive components. This can lead to density anomalies (for example due to silicate which is non-conductive) between different oceans which affects high precision mathematical models of water mass movement models widely used in climate studies. As a result of the WG127 work the term Reference Salinity (SR) has been introduced which represents the best available estimate of the Absolute Salinity (SA) of an artificial seawater solution with a Reference Composition that has stoichiometry in molar fractions based on the most accurate determinations of IAPSO Standard Seawater constituents and the 2005 atomic weights of IUPAC (Millero et al, 2008). From a practical point of view the value of SR can be related to the Practical Salinity, SP by ….

$$SR = (35.16504/35)\ g\ Kg^{-1} \times S_P$$

Absolute Salinity offers several advantages over Practical Salinity for oceanographic purposes including its expression in SI units (g Kg^{-1}), no limitations by scale (as in PSS78), improved ocean models (as SA is truly conservative), reduced density errors in the Equation of State for seawater. Hence, new algorithms have been formulated for density, enthalpy, entropy, potential temperature and sound speed in terms of Absolute Salinity, temperature and pressure (Feistel, 2008).

Practical Salinity remains the preferred parameter for measuring and storing salinity data. This maintains the link with measurements made in the past and reduces the possibility of mislabelled salinity data from a wide range of sources. All instrumentation (*in situ* and laboratory) for the measurement of Practical Salinity are conductivity based and the algorithms in software and firmware can remain in place thereby reducing the potential for confused datasets. Reference Salinity is calculated as an SI-based extension of Practical Salinity and as a best estimate of Absolute Salinity by practising research oceanographers. With regard to the IAPSO Standard Seawater Service, work is currently under way in a joint European project to profile the density of each new batch.

Our understanding of global salinity depends largely on data from laboratory salinometers and instruments at sea such as buoys, drifters, towed platforms, autonomous underwater vehicles and moorings. The WOCE programme involved scientists from 33 countries and produced the largest salinity dataset ever, so comparability of that data was crucial to its success. As subsequent ocean circulation projects related to climate change (eg CLIVAR) collect even more salinity data, the need for comparability remains a top priority.


Fig 5: An instrument buoy used to measure salinity at sea.

The NASA satellite mission Aquarius SAC-D, due to be launched in June 2011, has an overarching scientific goal to quantify and understand the linkages among ocean circulation, the global water cycle, and climate by accurately measuring sea surface salinity. The accuracy and subsequent value of these satellite data will depend crucially on the high quality data produced by *in situ* sampling and measurement.

Data centres contain the results of millions of salinity determinations carried out and used by chemists, physicists, biologists and engineers from all over the world. The comparability of these data is largely due to the widespread use of a single source calibration standard for salinity, IAPSO Standard Seawater.

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References

Antonov, J. I., R. A. Locarnini, T. P. Boyer, A. V. Mishonov, and H. E. Garcia, 2006. *World Ocean Atlas 2005, Volume 2:* Salinity. S. Levitus, Ed. NOAA Atlas NESDIS 62, U.S. Government Printing Office, Washington, D.C., 182 pp.

Bacon, S., F. Culkin, N. Higgs and P. Ridout. (2007). IAPSO Standard Seawater: Definition of the Uncertainty in the Calibration Procedure, and Stability of Recent Batches. Journal of Atmospheric and Oceanic Technology, 24:10, 1785-1799

Bergman, T., 1784. Physical and chemical essays (translated by Edmund Cullen) Murray, London, 2 vol.

Birch, T. (ed.), 1965. The works of Robert Boyle. Georg Olms, Hildeschiem, 6 vol.

Boyle, R., 1693. An account of the honourable Robert Boyle's way of examining waters as to freshness and saltness. Phil. Trans. Roy. Soc. Lond., 17, 627-641.

Culkin, F., and N.D. Smith, 1980, Determination of the Concentration of Potassium Chloride Solution having the same Electrical Conductivity, at 15ºC and Infinite Frequency, as Standard Seawater of Salinity 35.0000%0 (Chlorinity 19.37394%0).

Culkin, F. and P.S. Ridout, 1997, Stability of IAPSO Standard Seawater, J. Atmos. Oceanic. Technol., 15, 1072-1075.

Dittmar, W., 1884. Physics and Chemistry, Rept. Scient. Res. H.M.S. Challenger 1873-76, 1, 251 pp.

Feistel, R., (2008). A Gibbs Function for Seawater Dynamics for -6 C to 80 C and Salinity up to 120g/Kg. Deep Sea Research I, 55, 1639-1671.

Forchhammer G. (1865) On the composition of seawater in different parts of the ocean.

Philos. Trans. R. Soc. London. 155, 203-262.

Knudsen, M., C. Forch and S.P.L. Sorensen, 1902. Bericht uber die chemische und physikalische Untersuchung des Seewassers und die Aufstellung der neuen hydrographischen Tabellen Wiss. Meeresunters, n.f., 6, 13-184.

Lavoisier, A. 1772. Memoire sur l'usage de esprit-de-vin dans l'analyse des eaux minerales, Mem. Acad. Roy. Sci. (Paris), 1772, 555-563.

Lewis, E.L., 1980. The practical salinity scale 1978 and its antecedents. J. Oceanic Engineering, 5, 3-8.

Millero, F.J., R. Feistel, D.G. Wright, T.J. McDougall, (2008). The Composition of Standard Seawater and the Definition of the Reference-Composition Salinity Scale. Deep Sea Res., I, 55, 50-72.

Unesco 1981, Background Papers and Supporting Data on the Practical Salinity Scale 1978, Unesco Technical Papers in Marine Science, No.37, Division of Marine Sciences, Unesco, Place de Fontenoy, 75700, Paris, France.

THE INTELLIGENT COLLEGE – STIMULATING THE STEM SKILLS SYSTEM

Professor Sa'ad Medhat
CEO, New Engineering Foundation (NEF)

There are currently 351 Colleges in England, including 227 further education (FE) colleges. Colleges educate 831,000 young people compared with 423,000 in schools, academies and city technology colleges.

The achievements of colleges are mixed. By 2010 the proportion of students who successfully achieved their qualification aim had risen to 81%, the highest ever rate. But in the same year Ofsted commented: "Of the 79 colleges inspected 44 are good or better. However, too many colleges remain satisfactory with capacity to improve"[1].

The Wolf Review of Vocational Skills[2] picked up the underlying problem that by measuring success rates the value of the qualifications themselves was not recognised. This is not seen as caused solely by colleges: the Review cited the "deceit" and "dishonesty" of a system where short-term institutional incentives (such as funding and accountability) caused colleges and schools to direct young people into dead-end courses that provided little chance of progression. Amongst these incentives was the pressure to recruit target numbers of students and to get them through courses. The number of qualifications taken was the measure, not where they led to, or what they enabled a person to do or achieve. Such incentives Wolf called "perverse".

The paradox of the "market" in FE is that when the Government becomes the customer, the drive is to secure funding and pass Ofsted. The consequence is that the crisis in Science, Technology, Engineering and Mathematics (STEM) areas persists: in the 2010 report, Ofsted identified science and mathematics as the "least positively inspected area". An equally important concern is strategy or agility in working with employers. There is a mixed track record here too. Across the country there are some marvellous examples of colleges working with employers on innovative projects. Most general FE colleges came into being to meet the need of industries and most today will be able to identify hundreds of employers with whom they work. Many of these interactions are viewed very highly by employers and reflected by on-going relations. However, there remains criticism from employers' groups that the FE system is too complex and too unresponsive to meet the needs of business.

For all their achievements – improved inspections, greater success rates, engaging with industry, responding to short-term changes – there remains a problem. The prime aim of colleges is to help generate prosperity through developing people's skills. They struggle to do this in a way that is "strategic, agile and market-led". So what can be done?

THE INTELLIGENT COLLEGE

There is a broad political consensus about what colleges should be doing. It is encapsulated by the Coalition Government's vision of "a customer-focused locally accountable system whose strength is that it consists of competitive public and private businesses with a social mission"[3].

There are some encouraging signs in the new policies that will govern the way colleges operate. The Government intends to strip out micromanagement and to "free up" colleges. It is even possible that austerity itself will become the mother of invention.

The current situation prompted the New Engineering Foundation, which is leading the transformation of the UK STEM performance, to develop its idea of the Intelligent College.

The Intelligent College builds on existing outstanding practice but also takes a big step in a new direction – from colleges reacting to funding, inspection and initiatives to that of colleges inventing the future through the dynamism of horizon-scanning, enterprise, innovation and civic leadership. At the heart of the Intelligent College concept is the "golden thread" of innovation. Innovation in colleges primarily means the capacity to understand the needs of the future; translate that into curriculum planning and generate the market for new qualifications and skills in partnership with employers and other civic leaders.

Innovation must also mean re-inventing the college. This is not the "institutional" obsession with size, structure, acquisition or efficiency. Rather, it is to see the role of the college in terms of its asset base. Colleges enjoy the benefits of charitable status: their beneficiaries are individuals, employers and communities. The assets at their disposal in providing for these groups are of two main kinds: intellectual and physical.

On the intellectual side, the prominent currency is training through courses that lead (mainly) to qualifications. But there is more to it. Colleges also have the potential for horizon-scanning and knowledge transfer; research, design and development of products and services as well as for "incubation services" for entrepreneurs.

And then there are the physical assets – learning space, equipment and access to internet resources. Colleges can turn these assets into generating new products with and for SMEs and entrepreneurs. Together with the intelligent use of intellectual

assets, colleges can build on their strengths, and their experience, to become an indispensible first-choice partner to employers and entrepreneurs.

An Intelligent College approach would be to shape the way a college can:

- Realise the potential of their resources and equipment and provide business development services for entrepreneurs and SMEs
- Horizon-scan industrial sectors in partnership with key employers to develop relevant training
- Help to address the difficulties in providing apprenticeships with SMEs
- Contribute to effective information, advice and guidance about vocational and occupational education so that more young people, in particular, can make intelligent choices about careers
- Work with employers to develop a curriculum that promotes enterprise, entrepreneurship and the attributes needed for success at work

The Intelligent College will innovate in this way and work with employers to generate prosperity and provide the skills needed for the economy. This is critical to STEM industries which are among the industries of Britain's future: high-value engineering and manufacturing, biotechnologies and low-carbon technologies. They need a good supply of skills of the right kind in the right place at the right time.

Running a college for the point of view of generating these benefits means the college needs to be:

- Enterprising: in the way it is run, in its people, its action and its impact
- Pioneering: on skills, as a horizon-scanner and transferor of knowledge
- Designing: courses, training and partnerships that deliver new skills and experiences
- Innovating: making the connections that make change happen
- Leading: on ideas and initiatives with partners

Putting all this together would place Intelligent Colleges centre-stage as partners for prosperity. Intelligent Colleges would not come about by chance or by small changes – a shift to customer focus, enterprising "knowledge transfer" professionals and lean, integrated business systems is challenging.

ASSURING A STRATEGIC APPROACH TO STEM SKILLS PROVISION

Ensuring that FE colleges can respond to the STEM challenges posed by market dynamics and technology advancement, particularly where technologies are converging and require knowledge, understanding and competence in multi-disciplined areas (eg technologies for low carbon and sustainability), requires a strategic approach to STEM. The New Engineering Foundation has developed STEM Assured, a unique standard that assures the quality of STEM education and training to validate colleges' ability to meet the needs of business and industry. It encourages a cross-curricular approach to course design and delivery in STEM.

The elusive gain of colleges as major catalysts for innovation and socio-economic health is the prize that can be attained. The New Engineering Foundation, with its rich experience of productive partnerships with colleges, is geared to help colleges define and achieve their true value as Intelligent Colleges.

Professor Sa'ad Medhat explains the benefits of enhanced STEM education to HM The Queen Elizabeth II at City and Islington College that was presented with the STEM Assured award, London 30 March 2011

References:

1. Ofsted, The Annual Report 2009/2010 (http://www.ofsted.gov.uk/Ofsted-home/Annual-Report-2009-10/Learning-and-skills)
2. Wolf, A., Review of Vocational Education – The Wolf Report, March 2011 (http://www.education.gov.uk/publications/eOrderingDownload/The%20Wolf%20Report.pdf)
3. Russell, G., Keynote Speech at the LSIS Annual Governance Conference (https://www.lsis.org.uk/AboutLSIS/MediaCentre/NewsArticles/Pages/Greater-freedom-means-greater-responsibility-says-agency-CEO.aspx)

STEM ASSURED – A CASE STUDY FROM CITY AND ISLINGTON COLLEGE, LONDON

City and Islington undertook STEM Assured with a focus on their Centre for Applied Sciences. They were aware of some pockets of best practice in their STEM provision, particularly in forensics, optics, and health- and medical-related provision. The college wanted to highlight those areas that were developed with very close engagement with industry. These courses, not surprisingly, also have a high impact in terms of progression to Higher Education and employment.

The Validation Panel, which draws senior industry representatives, agreed that some of City and Islington courses set a benchmark for the sector in those subjects. Other highlights of the submission include: the innovative work in developing a flexible and work-based apprenticeship programme with local employers; the approaches by Science and Optics to improve learning opportunities and development of online seminars to drive scholarly activity. Although use of Alumni is not common practice in FE, the Alumni from the forensics courses have been encouraged to stay in contact, thereby enabling measurement of impact. Dr Steve Jones, who heads the Centre for Applied Sciences, said during the formal presentation of the award by HM The Queen: "STEM Assured helped us to focus our efforts and build an integrated STEM strategy to enable a long term growth for the centre and the college."

WELDING IS FUN, EXCITING AND REWARDING!

Eur Ing Chris Eady BSc(Hons) MSc CEng MRAeS MWeldI
Associate Director, Professional Affairs
The Welding Institute

How do you get young people interested in and enthused about welding?

Simple, a good dose of inspiration, a measure of excitement, a lot of fun, and some treats!

The Welding Institute, one of the smaller Professional Engineering Institutions, delivered a novel and highly popular attraction at the Big Bang UK Young Scientists' and Engineers' Fairs in Manchester in March 2010, and again in London from 10 to 12 March this year.

With the 'Welding with Chocolate' experiment, designed by TWI Ltd structural integrity engineer Dr Philippa Moore, as the cornerstone of our welding engineering outreach programme, how could we fail to delight?

A Cambridge University Materials Science and Metallurgy graduate, Philippa's PhD investigated the microstructures and properties of laser and laser/arc hybrid welds in pipeline steels, and her work has been published through a number of conferences and journals. In addition to her role in the Fracture Integrity Management section at TWI in Cambridge, which involves her in fracture toughness testing and fitness-for-service assessments of welded structures, mostly in support of the oil and gas industry, Philippa is always generating new ideas to create hands-on, inspirational, interactive engineering activities that can be used to promote engineering, technology and science to young people. Philippa has participated in numerous educational outreach activities, the most recent of

Dr Philippa Moore receives her Leslie Lidstone Medal from Steve Yianni of Network Rail, and Chairman of Council of The Welding Institute

which is her Welding with Chocolate experiment.

Having developed the Welding with Chocolate experiment in her own time, Philippa has taken it from a school-based experiment trialled at Science Week at the University of Cambridge in 2009, to the Big Bang Science Fairs in Manchester and London, SkillsLondon at the Excel Centre, and SkillsCymru in Cardiff, reaching out to over 100,000 young people in 2010 and approximately 29,000 so far this year.

For her client-focused project work as well as her exceptional engineering outreach contributions, The Welding Institute awarded Philippa its 2010 Leslie Lidstone Medal, sponsored by ESAB Group UK, which is awarded annually to the person under 40 years of age who is deemed to have made the most significant contribution (not associated with the manufacture and supply of welding consumables and equipment) to the advancement of welding technology during the period of five years preceding the year of the award. Philippa was the first female recipient of this award in its 30-year history.

Whilst superficially 'fun with food', Welding with Chocolate is a brilliantly simple engineering experiment that communicates the principles of fusion welding and the benefits of welded fabrication in structural engineering, all in a safe and highly enjoyable hands-on activity. Using beams of low melting point engineering material (chocolate), hot plate welding is used to create fillet welds between four beams to fabricate a box girder structure. The heat source is from bottles filled with hot water and no safety equipment is required by the welder, although sticky hands often need a good wash once they have been licked clean of chocolate!

The experiment encourages participants to load a single plain beam with weights until failure. The load bearing capacity of the beam is noted and the failure mode and appearance of the fracture face can be discussed to develop understanding of overload and brittle failure, or ductile failure in the case of those girder-like composite confectioneries. In speculating over the potential load carrying capacity of four beams welded into a box girder, participants often forecast four, five or six times the weight to failure compared to the plain beam; although one visitor to our stand confidently stated that it would be much more than four times, otherwise we wouldn't be doing the experiment, which was more of a comment from experience of life than experience of GCSE Physics!

Surprisingly for most is that the box girder is often able to support twenty to forty times the load that caused the plain beam to fail, providing an impressive visual confirmation of the performance benefit of welded fabrications. When the box girder eventually fails there is much chocolate to be eaten but not before some discussion on the location of the fracture and the effects of fit up, distortion and weld quality, of course.

As deliverable on the domestic kitchen table as it is in the science laboratory, the Welding with Chocolate experiment is an exceptional hands-on experience that brings real engineering practices and principles within the sticky (often literally) grasp of learners from age 7 to 17.

With significant reliance on manufacturing to generate UK economic growth, there is much concern amongst employers that the image of welding dissuades potential new entrants from joining the industry but it is not so much that welding has a poor image, more that it is rarely seen at all. Anglo-Saxon and Viking pattern-welded swords were the superior technology of their ages, and their blades were etched to highlight the "serpents" in the steel. Having gained the status to own one of these outstanding pieces of craftsmanship, the owners wanted the welding to be seen and, unfortunately for their opponents, most likely the last thing to be seen. Today's materials joining and welding is hidden in the finished product, painted, clad or covered, and is rarely seen or appreciated by the end-user. More commonly it is the scale of the structure, or the light it permits into or through a space that observers find impressive without any concern for how the construction was fabricated.

You're only as good as your last weld, and they look pretty pleased with this welded chocolate box-girder bridge!

Many visitors to The Welding Institute's exhibition stands and engineering outreach events have little knowledge of welding or how welding has made their world and the products within it; through the Welding with Chocolate experiment they have learned about the process and application of welding and it has sparked their enthusiasm for engineering and technology. Above all, Welding with Chocolate has shown that engineering, and specifically welding engineering, is fun!

HAS GOVERNMENT FORGOTTEN THE "E" AND "T" OF STEM EDUCATION?

Dr Tony Whitehead
Director of Policy at the Institution of Engineering and Technology

When the new Government was formed a year ago, they put "re-balancing the economy" at the heart of their agenda. They recognised that an important element of achieving this would mean increasing the numbers of young people becoming engineers and technicians. Inevitably there is always more than one agenda in politics, and reassuring rhetoric about the importance of engineering and technology needs to be complemented by effective action. So, one year in, how is engineering education faring under the Coalition?

For schools, the change of Government has seen a renewed focus on traditional subjects, not least Maths and Science. As Maths and Science are "gateway" subjects that provide the underpinning knowledge for many students who go on to study engineering (and indeed other subjects) at a later stage, the focus on these subjects is very welcome. However, this focus should not come at the expense of other subjects that underpin development and appreciation of engineering skills, such as Design & Technology (D&T). The introduction of D&T in the mid 1980's enabled young people to have first-hand experience of practical work that translates science and innovation into the products that people use in their daily lives. Universities clearly recognise the value of D&T, an A-Level which is listed as essential or useful for entry to most engineering degrees.

For the Coalition to now sideline D&T by excluding it from the English Baccalaureate and through future changes to the National Curriculum would be a huge mistake. Moreover, it would put the UK out of step with international trends. The UK's introduction of D&T as a separate subject has been copied in leading economies across the world, including parts of the USA, Australia, New Zealand, Finland, Sweden, the Netherlands, Taiwan, Germany and South Africa.

Across all levels of education, we need to do more to sell engineering careers to girls and women

Whilst practical technology subjects risk being sidelined in many schools, the Government has recognised their importance through support for University Technical Colleges (UTCs). UTCs are a new type of school in which students between 14 and 19 years of age will receive teaching in specialist subjects like engineering. Crucially, each UTC is linked to a university, as a means of ensuring the provision of a high quality, academically challenging education, which will ensure that students are well equipped when the time comes for them to make the transition from school to university. Given the unfortunate British tendency to underestimate the value of practical education, unlike many other leading economies, maintaining this reputation for high quality will be vital to UTCs' success – and, encouragingly, the early signs are very good indeed.

The Coalition deserves credit for not decimating the Further Education budget and instead facing the bad press resulting from cuts to university funding. Nonetheless, colleges have to deal with significant reductions, and these will impair their ability to train the next generation of technicians – who are so critical to science and engineering enterprises. As the severest engineering skills shortages are at technician level, this poses a significant challenge and continuing threat to our economic recovery. Against the backdrop of overall reductions in Further Education funding, the Budget included £180 million of extra money for 50,000 new apprenticeships. Whilst this is welcome, reading the small print in the Budget makes clear that the main purpose of this funding is addressing the NEET problem – those who are not in education, employment or training – and the majority of these new apprenticeships will not be at the level required for roles as engineering technicians.

The Wolf Review included many welcome proposals for reform, but the remit of the review was limited to 14-19 year olds. With the rise in university tuition fees, young people may be open to alternatives to university, including engineering apprenticeships. However, for alternative routes to be attractive they need truly to be a route to future employment and not seen as second best or even a dead end. Most large companies make career progression following an apprenticeship possible, for example by offering sponsored HNDs, HNCs or Foundation Degrees for those that wish to pursue further qualifications. However, the same is not always the case in SMEs, who find it more difficult to support the overhead costs of training. The current and continuing financial pressure on employers increases the onus on the Government to support and streamline training between technician and graduate levels – a point which the Coalition has not yet taken on board.

Since the election, much of the fiercest debate about education has focused on universities. Engineering departments, many of which take on high numbers of foreign students, will be badly hit by changes to the immigration system. At this stage, it is less clear how engineering departments will be affected by rising tuition fees. From the point of view of students, who will increasingly want to get value and better employment prospects from the investment degree, engineering may seem a more attractive option than it has been in the past – reflecting, for example, recent research which shows the significantly higher lifetime

Whilst practical technology subjects risk being sidelined in many schools, the Government has recognised their importance through support for University Technical Colleges

earnings of engineering graduates compared to graduates with other qualifications. Four of the top ten graduate salaries are in engineering subjects. From the point of view of universities, it seems likely that, for the next year at least, Vice Chancellors will favour subjects which still bring in a teaching grant, which includes engineering. In the longer term, though, and especially if the teaching grant sees further cuts, it may be that expensive subjects like engineering become burdensome. In this case, universities will either cut engineering or they will try to recoup the money by charging higher fees for engineering than for subjects which are cheaper to deliver.

The IET's most recent survey of engineering and technology companies found that 5% of professional engineers and 4% of engineering technicians currently working in industry are female. These are disturbingly low figures. Across all levels of education, we need to do more to sell engineering careers to girls and women. The IET's Young Women Engineer Award forms a key part of the profession's own effort to address this problem. However, while there are clearly roles here for educators and employers, there is also a vitally important role for government. The Coalition has dramatically reduced state funding for science and engineering diversity activities, which suggests that they do not see this area as a priority.

Overall, engineering has held its ground in education since the Coalition came to power, but it has yet to achieve its full potential in contributing to the progress needed to "re-balance the economy". The IET, alongside partner organisations in the Education for Engineering initiative, will continue to press the case. "STEM" means different things to different people, but Ministers should not hear STEM and just think about Science and Maths. The "T" and the "E" matter too.

The UK's introduction of D&T as a separate subject has been copied in leading economies across the world

WHY IS HOMEOPATHY SO CONTROVERSIAL?

Dr Peter Fisher
Clinical Director, Royal London Hospital for Integrated Medicine

Homeopathy has attracted a lot of attention lately: the Commons Science and Technology Committee report published in February 2010 called for it to be banned from the NHS and for no further research to be conducted. But this report was heavily criticised, not least for its failure to take evidence from a single patient who had experienced homeopathic treatment and from only one practitioner (me), while calling a number of well-known sceptics including representatives of Sense about Science, a lobby group which has campaigned stridently against homeopathy. An Early Day Motion (EDM 908 session 2009/10) highly critical of the report was signed by 70 MPs. The Government's response rejected the suggestion that the Department of Health take the 'unusual step of removing PCTs' flexibility to make their own decisions', and declined to rule out further research funding.

These are far from being the first attacks on homeopathy in its 200-year history, yet it refuses to go away. Sales are steadily rising and its popularity is international: over 50% of the French use it, and the Germans are not far behind. There are some 250,000 homeopathic doctors in India while in countries as diverse as the USA and the former communist bloc, homeopathy appeared to be in terminal decline for much of the 20th century, only to stage a dramatic recovery at the end of the century. Our hospital, the Royal London Hospital for Integrated Medicine (until September 2010 the Royal London Homoeopathic Hospital), is the most recommended hospital in the entire NHS, according to the NHS Choices website.

What is behind this sharp lack of consensus? Homeopathy is a form of complementary medicine based on the idea of 'Like cures like', founded by the German physician Samuel Hahnemann in the early 19th century, although similar ideas can be found earlier in the history of medicine. This idea is reflected in toxicology and pharmacology: hormesis, rebound effects and paradoxical pharmacology are all paradoxical effects of drugs and toxins as a function of dose or time. They depend on the body's reaction rather than the primary effect of the drug. Homeopathy is based on the systematic exploitation of such effects. But the controversial aspect of homeopathy is its use of very dilute medicines, including so-called 'ultramolecular' dilutions, diluted beyond the point at which (according to Avogadro's Law) the starting substance persists.

This is a fundamental scientific problem, and some scientists argue that homeopathy 'doesn't work because it can't work' so any apparent effects must be due to placebo. Yet there is provocative evidence from clinical trials that homeopathy is effective in conditions including diarrhoea, fibromyalgia, 'flu, hayfever, osteoarthritis, sinusitis and vertigo, and that these are not due to placebo. But clinical trials are a clumsy way to deal with the basic scientific questions, and there has been a rapid growth in test tube research. The best established is the effect of histamine in the Human Basophil Degranulation Test, a test tube model of allergic response. Histamine is part of the allergic response, but in homeopathic dilutions damps it down, a finding which has been repeatedly verified by different scientific teams. Beyond this is the question of how these effects are mediated. Although the work is preliminary many believe that 'nanostructures' in water may be involved. Supporters of this view include the Nobel Laureate Luc Montagnier, who has published remarkable results supporting this hypothesis, although these await independent replication.

There are three main public policy issues relating to homeopathy: regulation of practitioners, regulation of medicines and NHS provision. Much criticism of homeopathy arises from irresponsible advice given by unregulated practitioners, for instance on malaria prophylaxis. The Faculty of Homeopathy, which admits only statutorily registered health professionals, takes a firm line on this. But many practitioners are not regulated health professionals and standards vary widely. As long ago as 2000, the Lords Science and Technology Committee, chaired by Lord Walton, recommended that acupuncturists and medical herbalists be regulated and that homeopaths might follow. Andrew Lansley announced in February that medical herbalists are to be regulated by the Health Professions Council; there may be a precedent here for homeopaths.

The MHRA has launched an informal consultation on regulation of homeopathic medicines as part of its

response to the Commons Select Committee report. This focuses on its obligations in European legislation and the future of homeopathic Product Licences of Right (PLRs) as part of the consolidation of the Medicines Act.

Finally, NHS provision: the NHS has always provided homeopathy and demand remains strong. Significant numbers of GPs use it, although the numbers are far below western European countries where the system is more sensitive to patient demand. The specialist centres: the Bristol and Glasgow Homeopathic Hospitals, a department in Liverpool and the Royal London Hospital for Integrated Medicine, have diversified beyond homeopathy, adopting integrated medicine: bringing together conventional medicine with high quality complementary medicine to achieve the best results for patients. Integrated Medicine emphasises the patient-doctor relationship, patient choice and control and support for natural healing before resort to high impact, high cost interventions. At a time when the NHS badly needs non-drug treatments and to encourage self-care these centres have a vital role to play. Integrated Medicine is an international movement, the US Consortium of Academic Health Centers for Integrative Medicine comprises 46 academic medical centres, including Stanford, Yale, Johns Hopkins, Harvard and the Mayo Clinic.

It is no accident that homeopathy is popular and resilient, and the scientific debate lively. Parliament should not interfere with the preferences of consumers or patients except where there are public protection issues. It should encourage investigation of scientific anomalies such as homeopathy.

Letter to the Editor

Sir,

The debate over the United Kingdom Centre for Medical Research & Innovation (UKCMRI) demonstrates a need for the Science & Technology Select Committee to widen its brief.

The new centre, with considerable support from the Wellcome Foundation, brings together the Medical Research Council's National Institute for Medical Research (NIMR), University College London (UCL) and Cancer Research UK. Its task is to reduce the time taken to bring newly developed drugs into use. This is during a period when the large pharmaceutical companies, faced with stiffer competition and the rising cost of developing new drugs, are cutting back on in-house research.

How far does the new set-up change the status of the NIMR? Is the MRC's largest single scientific facility now a private or public body? What are the implications of merging the three bodies for the role of the MRC as a public body? Few would disagree with the consortium's objective of speeding up the process of getting research 'from bench to bedside', but the use of this phrase implies shortcuts at the expense of the longer-term goals of medical science and research practice.

The claim that it will act as a catalyst speeding up the application and take-up of scientific research is not in itself sufficient justification for a major change of direction. How are we to identify and measure this change? None of the partners to the deal were able to give the Select Committee a convincing account of how research will be transformed into results. Yet without this there can be no justification for spending £200 million of public money on the new centre. Increasingly, it seems, corporate research is outsourced and academics are encouraged to set up companies whose intellectual property rights are then sold on to the large brands. To the extent that we can talk of a 'model' for UKCMRI, it seems suspiciously similar to the unattractive face of the industry at large.

What is the precise relationship between the four partners? What ethical constraints arise from potential conflicts of interest? What models of international competition are relevant in developing a centre of this kind? What is so novel about the enterprise to justify the move from its existing premises in Mill Hill? Not least, will the Science & Technology Committee be able to subject all activity within UKCRMI Ltd to future scrutiny? And, following from this, is the Select Committee in a stronger or weaker position to protect the public interest?

Yours faithfully,

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STRATEGICALLY IMPORTANT METALS

The authors believe that there is merit in the UK aiming to become 'World Leaders' in resource efficiency since this will ultimately lead to more competitive product performance, less impact on the environment and a greater level of materials security in the future.

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Louis Brimacombe
Chairman, Sustainable Development Group, IOM3

One problem of tackling the issue of 'Strategically Important Metals' is first in trying to define what is meant by the term. One dictionary provides three definitions of 'strategic':

important or essential in relation to a plan of action,

essential to the effective conduct of war,

highly important to an intended objective

What is important to one organisation might be unimportant to another but the word strategic itself already suggests something that is important/essential and in so being will require a plan of action, or campaign, to address the potential risks or opportunities that relate to any specific metal.

In a non-military situation the objectives of organisations and nations can be difficult to define or reach consensus. Nevertheless, since the publication of the Bruntland Report, (*Our Common Future*) in 1987, there has been a recognition that we need to consider the impact of our current behaviour on the wellbeing of future generations. A trend towards more sustainable global development can be adopted from an altruistic stance or through recognition that a more sustainable use of resources will be more stable.

Given the UK Government's objective to be the 'Greenest Government ever' perhaps we can consider the sustainability of UK society as the objective and then consider metals in this context.

Recent media interest in Rare Earth Metals has prompted some to make the analogy with the concept of Peak Oil. However there is a significant difference between the use of materials for functional purposes, such as a food container made from glass, steel or aluminium and the use of fossil hydrocarbons as fuels. When fuel is utilised it is consumed in the process – it is converted into gaseous species which are dispersed into the atmosphere. However, when a food container has been utilised the material can be recovered and re-used. The relative merits of using glass, steel or aluminium for food containers is not the subject of this discussion – that is a matter for a detailed comparative life cycle assessment for all of the options relating to food packaging. If managed correctly the production of new products from secondary materials can have a lower impact on the biosphere than producing the same products from primary raw materials. Here it is also important to remember that there can be no production from secondary source unless some primary production has occurred somewhere. However the main point that we want to highlight here is that consideration must be given to the 'end-of-life' fate of materials and the best way to deal with this is to ensure that these issues are addressed at the design stage so that the recovery of resources at end-of-life can be optimised.

The average consumption rate of metals for different nations varies according to their level of industrial development. The consumption rates for developed economies are significantly higher than the least developed countries. As consumption rates increase in the fast growing BRIC economies (Brazil, Russia, India & China) the global average rate is increasing (see USGS Publication 'The Global Flow of Metals and Minerals', 2008). When the fact that the global population is still increasing is also taken into account the 'business as usual' projection is for the global demand for minerals and metals to continue to increase for the foreseeable future. This will put pressure on supply of materials and so it makes sense to analyse these trends in order to be in a position to adopt strategies that prevent resource constraints becoming a developmental constraint or a cause for disputes.

The huge expansion of the British economy following the Industrial Revolution was built on coal, enabling large increases in the development of iron and steel and the production of machines and infrastructure to support a wide range of mechanised manufacturing systems. If the supplies of the materials required were inadequate or the markets for the manufactured products were too small these were sought elsewhere on the globe. This led to the discovery of many mineral deposits that were more economic to exploit than those in the UK and many other parts of Europe. Initially, minerals were shipped to the UK (Europe) for processing but as economies in the host countries develop the tendency has been for them to move down the supply chain in order to recoup more added value. The UK has retained the production of some primary metals (Steel and Aluminium) but not as many as other economies with a strong manufacturing base (Germany, Japan, France, Sweden, etc). In the past 25 years facilities to process and produce the following metals have been shut down: primary copper, tin and

other metals from complex tin ores, primary zinc and lead, ferro-manganese and other ferro-alloys, etc, and the primary capacity for producing iron, steel and aluminium has fallen over the same period.

The UK is not in a position to produce all of the metals that are required in a modern economy based on advanced technologies. However, to retain a share of global markets it is important that we retain the ability to develop new materials, to optimise the performance and utilisation of the materials in the economy. We must invest in the appropriate facilities and skills necessary to produce some of the special materials that are required to support the manufacturing industries that are based in the UK or are currently serviced by products from the UK. To build on the existing specialist knowledge that serves the aerospace, automotive, power generation, chemical and other sectors we must ensure that we encourage R&D across the materials supply chain and ensure that we train sufficient numbers of designers, scientists, engineers and metallurgists with knowledge of the principles of sustainable materials management. We also need to enhance the level of awareness in the general public of the social value of materials and how materials have played, and will continue to play, a major role in our technology based societies. The goal must be to use materials in more intelligent ways so that, in relative terms, we can achieve more with less.

This is not another scare story. We are not suggesting that we are going to run out of anything in the near future. What we are saying is that we need to monitor the quantities of all of the resources that we utilise and ensure that we implement programmes that encourage more sustainable materials management. This is a logical way of addressing global issues that arise from the impact of an increasing human population and growth in national GDPs. We must strive for continuous improvement in the way we design, manufacture utilise and reprocess materials and products. In fact there is merit in becoming 'World Leaders' with regard to resource efficiency since this will ultimately lead to better and more competitive product performance, less impact on the environment and a greater level of security with respect to materials availability in the future. However the solutions are not purely technical; we need to understand more about the environment and our interactions with all levels of the biosphere. We need to consider social cohesion and sustainability on a global scale and debate how we can develop systems that promote human wellbeing. To date technical advances have kept the predictions of Malthus and Boulding at bay. If we try to understand and address the issues that humanity may face in the future we will have a chance of addressing them but if we adopt a *'laissez-faire'* approach we are gambling with the prospects for the future and we would not be using lessons that we should have learned from history.

SHORTAGE OF RARE EARTHS

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The multi-£B market in precision surfaces (lenses, mirrors, windows, semiconductor wafers, prisms, fibres etc) underpins high-value products in numerous sectors – aerospace, semiconductor, defence, security, telecom, scientific and medical instrumentation, ophthalmic, automobile, computer, consumer durables, point-of-sale etc. The entire digital communications network depends on optical fibres and associated photonic devices. These materials all require polishing during the manufacture of the respective devices.

Polishing of precision glass and similar materials depends strategically on a particular polishing compound – Cerium Oxide. Cerium is a rare earth element extracted predominantly in China. This class of elements is in increasingly short supply worldwide, with soaring prices due to increasing demand and intervention of the Chinese government in the market. Whilst market dynamics may restore the position in time, our high strategic dependence on Cerium over numerous sectors, and the evident instability of its supply, does not present a short or long term position that is secure.

I invite the Parliamentary and Scientific Committee to take due cognisance of this situation, and recommend that the UK industrial and academic sectors should co-operate to develop effective alternatives to Cerium-based processes. This will also provide the opportunity to explore alternatives that may be technically superior, enhancing competitiveness.

SUPPORTING EXTRACTS:

Report of US Government Accountability Office, Briefing for Congressional Committee, April 14, 2010, Belva M. Martin, Acting Director , Acquisition and Sourcing Management
"Most rare earth material processing now occurs in China. In 2009, China produced about 97 per cent of rare earth oxides."
"A 2009 National Defense Stockpile configuration report identified lanthanum, cerium, europium, and gadolinium as having already caused some kind of weapon system production delay and recommended further study to determine the severity of the delays."
According to government and industry data, the future availability of materials from some rare earth elements – including neodymium, dysprosium, and terbium – is largely controlled by Chinese suppliers. China's dominant position in the rare earths market gives it market power, which could affect global rare earth supply and prices. In addition China has adopted domestic production quotas on rare earth materials and decreased its export quotas, which increases prices in the Chinese and world rare earth materials markets. China increased export taxes on all rare earth materials to a range of 15 to 25 per cent, which increases the price of inputs for non-Chinese competitors.

Bloomberg news, August 29 2010
"China cut its export quotas of rare earths by 72% for the second half of this year, according to data from the Ministry of Commerce on July 8. Shipments will be capped at 7,976 tonnes, down from 28,417 tonnes for the same period a year ago."

Paul Kingscot, Sales Director, Engis UK Ltd, Sept 16 2010
"I am getting gloomy reports about the price and availability of cerium oxide. Apparently the manufacturer of cerox has run out of raw material to process. I advise alternative polishing methods are explored as a plan 'B'"

Bloomberg news, Sept 17 2010
"Aggregate prices for rare earths have risen to $51 a kilogram, from about $15 a kilogram in April"

Bloomberg news, Oct 21 2010
"Prices have climbed sevenfold in the last six months for cerium oxide contributing to the rise in prices is an expectation of further restrictions. China will probably tighten export controls on rare earths next year"

Bloomberg news, Feb 17 2011 "The price of cerium, a rare-earth mineral used in magnets, will drop to $10 a kilogram by 2013 from more than $60 currently as additional production creates a 'vast oversupply,' a mining exploration company said"

For further information contact Professor Walker at: ddwlkr@aol.com

MEDICAL PHYSICS

Dr Stephen Keevil
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Vice President for External Affairs, Institute of Physics and Engineering in Medicine

When parliamentarians glance across the river at St Thomas' Hospital, how many of them are aware that the basement of the hospital houses what is in effect an applied particle physics facility: a place where particle accelerators, smaller siblings of the Large Hadron Collider at CERN, provide world-class diagnosis and treatment for cancer patients?

Yet this is the every-day world of medical physics, applying the fruits of basic physics research to clinical problems in a way that combines applied science, translational research and highly developed problem-solving skills.

Physics has been applied to the understanding of human physiology and disease for at least a thousand years. Over the centuries it has provided the basis of many medical techniques and devices that we take for granted, from the iconic stethoscope to a simple pair of spectacles. Of course, physicists themselves do not need to be involved every time a stethoscope is used or glasses are prescribed: as is the case in many areas of technology, physics provides the tools and then slips quietly into the background. However, a new situation arose in the early years of the twentieth century, when increasing use of radiation and radioactive materials in medicine created a need for physicists to become engaged directly in clinical work.[1] These early medical physicists used their knowledge, for example, to help standardise radiotherapy techniques and prescriptions and ensure the safety of both patients and staff working with radiation. Once medical physics had been established as a profession in this way, it was able to grow and diversify as new physics-based imaging and clinical measurement techniques were introduced.

Medical physics today is a diverse field, concerned with the application of a wide range of physics-based principles, techniques and technologies in medical diagnosis, treatment and research. This application takes place in several overlapping contexts.

- Support for clinical services where safety and quality depend on an advanced knowledge of physics, eg interaction of radiation with the human body in radiotherapy and x-ray imaging.
- Development and implementation of new techniques that require an understanding of complex physics, eg advanced MRI techniques.
- Research into new physics-based methods of diagnosis and therapy, eg optical imaging and measurement.

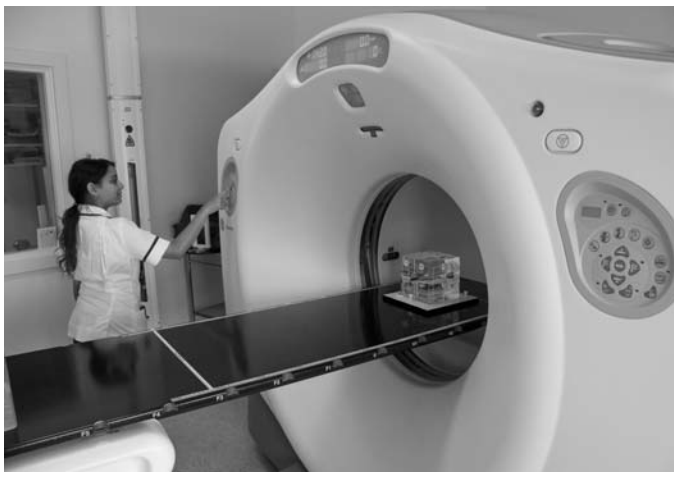
There are currently around 2,000 medical physicists working in the NHS as part of the clinical scientist workforce. New recruits need good degrees in physics or a closely-related area and undergo a four-year vocational training, combined with study for an MSc, to achieve registration with the Health Professions Council (HPC). Trainees study specialist areas of applied physics, and also relevant areas of medical science and clinical practice that will allow them to function effectively as members of multidisciplinary teams of healthcare professionals. Entry is highly competitive: some recruits have acquired PhDs before beginning their training, and many more aspire to do so in post. It is also possible for scientists who have pursued careers in academia to move into the profession if they can show that they have fulfilled the training requirements in other ways. This ensures that the NHS is able to access scientists with cutting-edge experience in emerging areas of science that are ripe for translation into the clinic.

Clinical technologists work alongside medical physicists in a variety of roles, including patient-facing work in areas such as nuclear medicine and radiotherapy, as well as less visible but nevertheless essential roles such as medical equipment management. They have traditionally come from a wide range of technical backgrounds, but graduate entry is increasingly common and vocational degree programmes are under development.

Modified training arrangements are currently being introduced by the Department of Health as part of the Modernising Scientific Careers (MSC) project.[2] This involves the development of new training programmes for the entire NHS healthcare science workforce (some 50,000 staff), including a shortened three-year programme for medical physicists and, for the first time, standardised training arrangements for technologists. The first trainees who will undertake these new programmes are currently being recruited. It is important to

ensure that academic strength and flexible recruitment are maintained as the new arrangements are implemented.

The origins of medical physics lie in the medical applications of ionizing radiation, and this remains at the core of the profession. It is here that the particle accelerators mentioned earlier come into play. Linear accelerators (or 'linacs') form the mainstay of radiotherapy treatment, while cyclotrons are used to produce the short-lived radioisotopes needed for positron emission tomography (PET), an advanced form of nuclear medicine imaging. As well as radiotherapy and nuclear medicine, significant numbers of medical physics staff are involved in diagnostic radiology and radiation protection, and smaller numbers in more specialist areas such as ultrasound, magnetic resonance imaging (MRI) and clinical measurement. Medical physicists often work closely with biomedical and clinical engineers, and the blurred boundary between the disciplines is reflected in the name and activities of the Institute of Physics and Engineering in Medicine (IPEM), the professional body and registered charity that aims to advance these fields for the public benefit.



There is also thriving medical physics activity in UK universities. In 2008 the Wakeham Review[3] identified medical applications of physics as an important area for growth, but reported a 30% reduction in the number of medical physics academics since 2001. However, the review was concerned only with academics based in mainstream university physics departments, those whose work was submitted to the physics unit of assessment in the Research Assessment Exercise (RAE). Elsewhere, the report acknowledged that 48.3% of academic physicists are not located in physics departments. We believe that this figure includes a significant number of medical physics researchers who were submitted to medical units of assessment. For example, the staff of the Division of Imaging Sciences and Biomedical Engineering at King's College London, where I am based academically, includes four physics professors, and there are plans to recruit several more. Rather than declining, it may well be that medical physics research is simply moving into a more multidisciplinary translational research environment.

Whilst this move towards translational research is to be welcomed, it is important to recognise that crucial developments in medical physics are often serendipitous and entirely unpredictable spin-offs from basic science research. When Wilhelm Röntgen discovered x-rays in 1895 he was working in a basic physics laboratory investigating electrical discharge through vacuum tubes, with possible medical applications presumably far from his mind. But once the discovery had been made the implications were obvious, and within three months it had been translated into a diagnostic tool of unprecedented importance. Translation into clinical practice is rarely so obvious or so immediate: Edward Purcell and Felix Bloch discovered nuclear magnetic resonance (NMR) in 1946, again in the context of fundamental physics research, but it was the early 1970s before Paul Lauterbur and Peter Mansfield developed MRI, which is based on the NMR phenomenon and would not have been possible without the earlier blue-skies work. It is important to bear in mind the serendipitous and frequently long-term nature of these basic science spin offs in the debate about using anticipated impact to inform research funding decisions.

The medical physics profession is approaching its first centenary, and the future looks bright. There is no sign of an end to innovations in established areas such as radiotherapy and MRI. At the same time, entirely new areas are opening up, such as optical imaging, which promises to have an important role in post-genome personalised diagnosis and treatment. These areas are explored in more detail in accompanying articles. The role of medical physics staff remains crucial in ensuring that new physics-based technology is developed and deployed effectively to provide the high quality and cost effective outcomes that our patients need and deserve.

1 Keevil SF (2011) Physics and medicine: an historical perspective. The Lancet (in press)

2 http://www.dh.gov.uk/en/Aboutus/Chiefprofessionalofficers/Chiefscientificofficer/DH_086661 [accessed 2nd March 2011]

3 Research Councils UK (2008) Review of UK Physics. (Swindon: RCUK). Available at http://www.rcuk.ac.uk/documents/reviews/physics/review.pdf [accessed 2nd March 2011]

HARNESSING THE POWER OF LIGHT TO PROVIDE REAL-TIME NON-INVASIVE MOLECULAR DIAGNOSTICS

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This short article has been written as a brief overview of the field of Biophotonics, with a focus on cancer detection. The objective is to highlight the potential of a rapidly advancing field, likely to have a significant impact on the way clinical diagnostics of the future are performed. The UK has a major role to play in this development and the impacts on the NHS and patient care are likely to be considerable.

WHAT IS BIOPHOTONICS?

Biophotonics is the term for all techniques that deal with the interaction of biological material and light. This refers to emission, detection, absorption, reflection, modification, and creation of radiation from living organisms and organic material. Here we discuss the prospects of utilising light as a diagnostic tool to provide a way of testing individuals for the presence of early cancerous cells.

There are a number of competing or complementary techniques currently being investigated. These include fluorescence, Raman and infrared spectroscopies, elastic scattering and diffuse reflectance spectroscopy. They each have their pros and cons and depending on the application some may be selected above others.

THE CLINICAL NEED FOR EARLY OBJECTIVE CANCER DIAGNOSIS

The primary requirement for successful treatment of any malignancy is early detection. Although the pathogenesis of most malignancies is not fully understood, some cancers are known to develop through a pre-malignant state. Current methods of detecting early malignancies rely upon surveillance of at-risk populations or diagnostic investigations following presentation with suspicious symptoms. By the time symptoms are present tumours are usually of a significant size, and it is often too late to facilitate a full cure.

Biochemical changes within cells and tissues may either initiate disease or occur as the result of the disease process. The qualitative analysis of such changes provides important clues in the search for a specific diagnosis and the quantitative analysis of biochemical abnormalities is important in measuring the extent of the disease process, designing therapy and evaluating the efficacy of treatment. The conventional method for detection of malignancy using histopathological examination of biopsy samples relies upon the subjective assessment of tissue architecture, which is likely to demonstrate abnormal changes at a later stage than would analysis of biochemistry. Furthermore, histopathological analysis requires tissue to be removed with possibly undesirable consequences. Evidently, the development of a rapid, non-invasive, qualitative histochemical analysis technique, enabling objective biochemical analysis of tissue, would be of great value. This may be possible with a variety of optical techniques.

Over the past few years a number of groups have been working towards real-time, non-invasive techniques that utilise light to study abnormalities in tissue. Recent technological developments have made it possible to obtain significant amounts of biochemical or architectural data from extremely complex biological tissue in very short time scales (milliseconds to seconds). Optical diagnosis

relies upon measurement of the interaction of light photons with the constituents of biological tissue. The resultant data can provide an evaluation of histochemistry or morphology. This information can aid with the deduction of the pathological state of the tissue, and hence lead to a diagnosis.

Light can interact with tissue in a number of ways, including elastic and inelastic scattering; reflection off boundary layers; and absorption, leading to fluorescence and phosphorescence. All of these can be utilised in some way to measure abnormal changes in tissue. Many authors have used the term 'Optical Biopsy' when describing these techniques. Optical biopsy is a misnomer because no tissue is removed in the analysis, however it does help to convey to the lay-person the general principle of using light to detect cancerous transformations in tissue.

Early forms of optical biopsy systems, utilising tissue fluorescence, have been used as an adjunct to current investigative techniques, mainly to improve targeting of blind biopsy. Some such as that shown in Figure 1 utilise agents to provide an enhanced disease specific signal. Future prospects utilising molecular-specific techniques may lead to the possibility of complete replacement of biopsy with objective optical detection providing a real-time, highly sensitive and specific measurement of the tissue histological state. However until its efficacy is proven it is most likely that optical detection will be used as a complementary technique to improve targeting of biopsy selection.

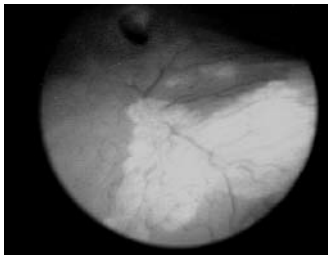

Figure 1: An image taken during fluorescence bladder cystoscopy following administration of a drug which is differentially accumulated in abnormal tissues. Illumination of the tissue with blue light produces a strong red fluorescence from these regions of accumulation. This can enhance the performance of biopsy selection and tumour margin removal.

The clinical requirements for an objective, non-invasive real time probe for the accurate and repeatable measurement of tissue pathological states are overwhelming. There is a clinical need for optical diagnosis in a number of important areas:

1. Situations where sampling errors severely restrict the effectiveness of excisional biopsy, such as the high failure rates associated with blind biopsies, whereby the clinician has to randomly select sites for sample collection. This method is used to screen for pre-malignant conditions such as ulcerative colitis and Barrett's oesophagus.
2. Where conventional excisional biopsy is potentially hazardous, examples of vulnerable regions include the central nervous system, vascular system and articular cartilage.
3. An immediate diagnosis during an investigative procedure would eliminate the need for many secondary procedures by enabling treatment to take place directly following diagnosis. This is especially useful with the development of treatments utilising light energy, such as photo-dynamic therapy and laser ablation. This is likely to improve patient outcomes and decrease waiting times by reducing the number of costly procedures required.
4. Tumour margins could be identified during surgical resection, thus enabling a more accurately targeted resection to be performed.
5. A surgeon with any doubt over a diagnosis could cross-validate a previous diagnosis prior to excision of an organ or lesion using a non-invasive optical probe.

Techniques such as Raman spectroscopy (RS) and Fourier-Transform Infra-red absorption spectroscopy (FTIR) have recently provided evidence of discrimination between multiple pathology groups within each organ.[1] Raman spectroscopy, which can be performed endoscopically at any excitation wavelength, is most likely to provide *in vivo* diagnosis.[2] FTIR currently shows the greatest promise for rapid *in vitro* diagnosis and spectral imaging, where water content of tissues does not prove problematic.

Other techniques such as optical coherence tomography and optoacoustic imaging are demonstrating potential for high spatial resolution *in vivo* imaging which may one day provide similar information to histology, although in real time. Whereas imaging techniques are always eye-catching, it should be noted that these techniques still provide information only about structure and cellular morphology. To provide real information about early molecular changes and disease prognosis those techniques that provide extra-value information on tissue biochemistry associated with disease will be the way forward. In the longer term the use of contrast agents able to provide significant signal enhancement of low concentration molecules of interest, for diagnosis and monitoring, may enable signals to be probed from outside the body.[3]

SUMMARY

There are significant benefits for UK patients and the NHS in improving diagnosis of disease at an early stage. While conventional medicine of the 20th century treated the effects of disease, molecular medicine in the 21st century will treat its causes. This leads to the requirement for personalised medical treatment selection and monitoring – with clinical decisions based on patients' own tumour expression, enabling the selection of effective treatments for the individual and hence minimising unnecessary procedures.

The impact of technology for patient care can be immense, but so can the cost to resources. This must be carefully managed and health economic arguments regarding benefits versus opportunity costs are vital. Novel diagnostic technologies, such as those found in the Biophotonics arena can provide UK plc with significant income if we can exploit these disruptive technologies in International healthcare markets.

1 2009 Kendall, C, Isabelle, M, Hutchings, J, Babrah, J, Orr, L, Baker, R, Bazant-Hegemark, F, Stone, N, *'Vibrational spectroscopy: a clinical tool for cancer diagnostics.'* Analyst, 134, 1029-1045.

2 2009 J C C Day, R Bennett, B Smith, C Kendall, J Hutchings, G M Meaden, C Born, S Yu and N Stone, *'A miniature confocal Raman probe for endoscopic use.'* Phys. Med. Biol. 54 7077-7087.

3 2011 Stone, N, Kerssens, M, Lloyd, GR, Faulds, K, Graham, D, Matousek, P, *'Surface enhanced spatially offset Raman spectroscopic (SESORS) imaging – the next dimension,'* Chemical Science, DOI: 10.1039/c0sc00570c.

THE ROLE OF MEDICAL PHYSICISTS IN THE DEVELOPMENT OF WORLD CLASS RADIOTHERAPY FOR THE UK

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Radiotherapy Physics Group Leader,
The Christie NHS Foundation Trust

Approximately 1 in 3 people will develop some form of cancer during their lifetime and around 1 in 4 people die from cancer. Cancer is a disease of the genome where damage accumulates over time. With the ageing population profile in the UK it is expected that by 2025 there will be an additional 100,000 cases of cancer diagnosed each year. Although the incidence of cancer has steadily increased over the past 30 years, the positive news is that survival rates from cancer have improved year on year.

There are three pillars of cancer treatment; namely surgery, radiotherapy and chemotherapy. The management of cancer involves using a combination of treatment options such as surgery followed by radiotherapy. It is 100 years since Marie Curie won her second Nobel prize for the isolation of radium. The discovery of radium led to the first treatments of cancer with radiotherapy. 100 years on and approximately two in every five patients cured of their cancer will have received radiotherapy as part of their treatment. Radiotherapy is also cost effective, 13 times more cost effective than chemotherapy *(http://www.bbc.co.uk/news/health-12299533)*. Although the main principles for treatment with radiotherapy have been established for some time the technology and application of radiotherapy continues to evolve to improve survival and reduce side effects of treatment.

For a number of reasons there has, for many years, been a national under-provision of radiotherapy in the UK compared to international standards. It is estimated from international best practice that 52% of all cancer patients should receive radiotherapy, but in the UK approximately 40% of cancer patients are given radiotherapy. This means that 30,000 patients a year are not receiving the best cancer care. *(https://www.sor.org/news/files/images/FAQs_about_the_campaign.pdf)* To achieve comparable rates of survival from cancer to those in leading western countries it is likely that the gap in the provision of radiotherapy will need to be closed.

Medical physicists are crucial to radiotherapy services. The role of the medical physicist is threefold; they are central to patient safety, they develop new radiotherapy treatments, and they are involved in research and development of radiotherapy equipment and techniques. Medical physicists ensure that the radiotherapy machines are working optimally, and that the correct amount of radiation is given as precisely as possible to the cancer. This is crucial to the success of radiotherapy treatment and the high levels of safety are maintained by approximately 800 medical physicists working in UK hospitals. Medical physicists are also involved in the development of a radiotherapy plan where sophisticated computer programs are used to determine how to give radiation to the tumour whilst protecting normal

healthy tissue from harm. For many years, UK based medical physicists have been involved in the development of new treatment techniques for radiotherapy aimed at improving the effectiveness of treatment as well as reducing the potential side effects. A recent example is the development of Volumetric Modulated Arc Therapy by Elekta, an internationally leading manufacturer of linear accelerators used in radiotherapy treatments. Elekta worked closely with medical physicists at the Royal Marsden Hospital in Sutton to develop the radiotherapy technique and the hospital treated the first patient in the world with this technique in February 2008.

The UK has a long history of scientists contributing to the field of medical physics and to radiotherapy. Sir Godfrey Hounsfield received a Nobel prize for Medicine in 1979 for the invention of the CT-scanner, whilst Sir Peter Mansfield received the same prize in 2003 for the invention of the MR scanner. Both CT and MR scans are now routinely used to define the size and location of a patient's tumour and normal healthy tissue prior to designing radiotherapy treatments. Professor Steve Webb, at The Institute of Cancer Research, was an early pioneer in the development of intensity modulated radiotherapy, a modern form of radiotherapy that is better able to spare healthy tissue, leading to fewer side effects from treatment. In 2008, Medicare in the US spent $1billion on intensity modulated radiotherapy treatments *(The Wall Street Journal – A Device to Kill Cancer, Lift Revenue, 7th December 2010).*

Where are the next advances in radiotherapy treatment in the UK? Proton radiotherapy is a clear example of blue skies research leading to patient treatments. Proton radiotherapy was first proposed in 1946 as a way to treat cancer (*Wilson, Radiology (1946)*). Early treatments with protons were performed by pioneering physicists in particle accelerator laboratories in the US and Sweden in the mid 1950s. Despite the early promise of this treatment technique it took until 1990 for the first hospital-based proton radiotherapy centre to be opened at Loma Linda in California. By the end of 2010 there were 29 proton radiotherapy centres worldwide. Why are protons expected to improve the radiotherapy treatment for cancer patients? Figure 1 shows the way radiation dose is deposited as energy in human tissue by a proton radiotherapy beam and a traditional photon radiotherapy beam (10MV x-rays – dashed line). The tumour is shown at some depth within a patient and it is clear that the proton beam gives up most of its energy where the tumour is located, and delivers less radiation on the way to the tumour. In comparison the traditional radiotherapy beam is less suited to treating the tumour with a single beam as more radiation is deposited prior to reaching the tumour. Therefore a number of radiation beams are required from different angles to create a cross-fire effect at the tumour. The better characteristics of the proton radiotherapy beam make it much more suitable for reducing the amount of radiation the healthy tissue receives.

The survival of childhood cancers has improved over the past 30 years and continues to do so. However, as the tissue and bones of children are still developing they are more sensitive to radiation than adults. Childhood cancer survivors also live with any potential side effects of treatment for much longer. Oeffinger et al (*NEJM (2006)*) found that a childhood cancer survivor is three times more likely to have multiple health conditions than a sibling that did not have childhood cancer. Proton radiotherapy is highly likely to reduce the side effects of treatment for childhood cancers and therefore reduce the burden of life-long health conditions for these patients.

Proton radiotherapy is currently available to UK patients via a specialised commissioning service of the NHS for a limited number of clinical indications. An expert reference panel receives patient referrals for treatment abroad at one of three centres: the Paul Scherrer Institute, Villigen, Switzerland, the Centre-Protontherapie, Orsay, France, or the University of Florida Proton Therapy Institute, Jacksonville, USA. This national service has been available since April 2008 and has resulted in more than 70 UK patients being treated abroad to date. Although providing a necessary and important clinical service, treatment abroad for several weeks can provide significant challenges for patients and their carers. The treatment of patients abroad provides a service only for those who will benefit most from this form of treatment. However, in its current form the number of patients receiving this form of radiotherapy is unlikely to meet fully the UK demand. An early estimate of the number of patients that could benefit from proton radiotherapy in England alone is in excess of 1700 cases per annum (*Improving Outcomes: A strategy for cancer. Department of Health (2011)*). Treating this number of patients at facilities abroad would be a significant logistical challenge associated with substantial costs. It is therefore highly likely that UK based proton radiotherapy facilities will be required in the next five years. Medical physicists will be essential for the safe and effective development of proton radiotherapy services within the UK. Technical developments and innovations made by these scientists, in collaboration with clinical colleagues and industry, will enable further improvements in the treatment of cancer with proton radiotherapy, enhancing treatments for future cancer patients.

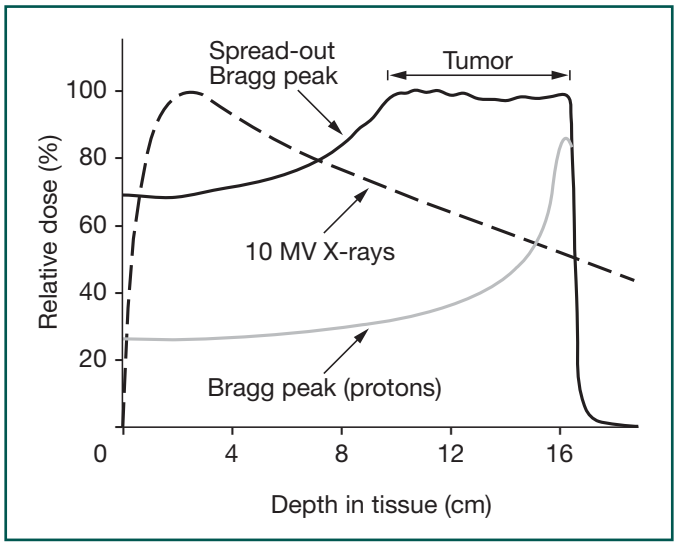


Figure 1: Reprinted with permission from *'Technology Insight: proton beam radiotherapy for treatment in pediatric brain tumors' Torunn I Yock and Nancy J Tarbell,* Nature Clinical Practice Oncology (2004) 1, 97-103

MAGNETIC RESONANCE IMAGING – A WINDOW INTO THE BODY FOR PATIENT CARE AND A RESEARCH TOOL FOR UNDERSTANDING THE BRAIN

Dr Andy Simmons BSc MSc PhD CSci FIPEM

Reader in Neuroimaging and Consultant Clinical Scientist, King's College London Institute of Psychiatry, South London and Maudsley NHS Foundation Trust and NIHR Biomedical Research Centre for Mental Health

Dr Simmons was unfortunately prevented from speaking at the meeting due to family illness, but has prepared this paper for publication.

INTRODUCTION

Magnetic resonance imaging (MRI, Figure 1) is a sensitive and flexible technique for clinical imaging and a remarkably powerful tool for research in both disease and health. Medical physicists were the driving force behind the development of the technique and continue to play a key role in both clinical applications and cutting edge research.

Figure 1 – A modern magnetic resonance imaging system.

THE DEVELOPMENT OF MAGNETIC RESONANCE IMAGING

The UK played a pivotal role in the development of magnetic resonance imaging, in particular led by physicists from Nottingham, Aberdeen and London. Professor Sir Peter Mansfield won a Nobel prize in 2003 for his contribution to this work. The technique builds on the analytical chemistry technique of nuclear magnetic resonance which produces spectra representing the chemical constituents of small samples, but gives no spatial information. The basic phenomenon of nuclear magnetic resonance imaging involves a patient lying in a large powerful magnet while harmless pulses of radio waves are transmitted into the body. The MRI scanner then records the weak radio waves which are subsequently emitted by the body and uses these to create detailed images of the body.

The technique relies on a property of some nuclei termed spin and the fact that these nuclei take one of two energy states – a low or high energy state – when placed in a magnetic field. By transmitting radio waves at a specific frequency it is possible to excite nuclei from the low energy state to the high energy state. After some time these nuclei then drop back from the high energy state to the low energy state, emitting bursts of radiofrequency energy which are detected by carefully designed radiofrequency coils surrounding the anatomy of interest.

In order to create an image of the human body we need to be able to spatially localise the weak nuclear magnetic resonance waves emitted by the body. This is done by applying a magnetic field gradient created by applying electrical currents through carefully designed coils of wire known as gradient coils. By spatially varying the magnetic field this changes the resonant frequency or Larmor frequency of the protons.

CLINICAL MAGNETIC RESONANCE IMAGING

Some of the first clinical magnetic resonance imaging systems were installed in UK hospitals with early applications to the brain and body. The area of MRI has been a remarkably exciting field to work in with almost every year bringing an expansion of both magnetic resonance techniques and applications. Indeed there are now more than 40 million MRI scans acquired every year.

The strength of magnetic resonance imaging flows from

two characteristics – the impressive soft tissue contrast and the flexibility with which images demonstrating different image contrast can be displayed. As an example Figure 2 shows how areas of tissue damaged by vascular dementia can be chosen to appear as bright compared to the surrounding intact brain tissue and dark cerebrospinal fluid which surrounds and cushions the brain.

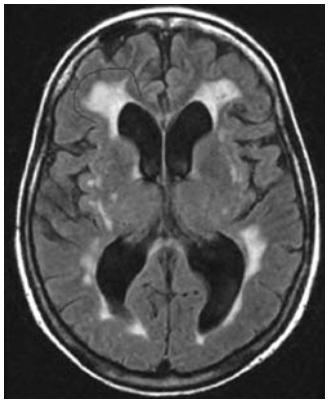


Figure 2 – One of the strengths of MRI is excellent soft tissue contrast. The image above shows bright areas of vascular damage surrounding the dark ventricles filled with cerebrospinal fluid.

Brain and spine imaging are the most frequent use of MRI, but improvements in basic physics and engineering have meant that MRI is now used widely in musculoskeletal imaging, abdominal imaging, cardiac imaging and beyond.

The basic technique of magnetic resonance imaging has been expanded and augmented by a series of methodological improvements driven by physicists and engineers. These include magnetic resonance angiography (MRA) which demonstrates the movement of flowing blood in vessels throughout the human body, diffusion tensor imaging which studies the random movement of water molecules which are changed by diseases such as stroke, and magnetic resonance spectroscopy which studies metabolites in the brain and body. Magnetisation transfer imaging and perfusion MR imaging further expand the range of techniques available for medical imaging, all driven by the enquiring minds of physicists and engineers.

THE ROLE OF THE MEDICAL PHYSICIST IN MAGNETIC RESONANCE IMAGING

The role of a medical physicist in magnetic resonance imaging is both varied and exciting. Typically they will have a leading role to play in the safe use of magnetic resonance imaging. The powerful magnet that the patient lies in is strong enough to pull any ferromagnetic item out of a careless user's hands or pockets, and some medical implants mean that not all patients can be scanned. As with any piece of medical equipment it is important that magnetic resonance imaging systems are regularly tested as part of a planned programme of quality control work which the medical physicist will normally lead on.

A mainstay of a medical physicist's working life is the development of new techniques for clinical use and magnetic resonance imaging is no exception. Programming the highly complicated MRI scanners to perform new techniques requires years of training and a substantial degree of skill and we are fortunate that the NHS has so many talented medical physicists who are eager to rise to this particular challenge. As well as programming the scanners the medical physicist also has a leading role to play in designing tools for the analysis of images using either the manufacturer's analysis computers, or other computer workstations.

Finally the NHS has a key role to play in medical research, particularly via the National Institute for Health Research (NIHR) which aims to improve translational, organisational and health service research.

A POWERFUL TOOL FOR MEDICAL RESEARCH

While magnetic resonance imaging is an excellent clinical imaging technique, it has a parallel role to play in basic and translational research with applications in oncology, cardiology, psychology, psychiatry, obesity and musculoskeletal research.

My own role bridges the area between research and clinical, aiming to use MRI to answer new research questions in the area of psychiatry, neurology, psychology and neuroscience and to translate new research techniques into clinical practice as the neuroimaging coordinator for the NIHR funded Biomedical Research Centre for Mental Health.

Two examples of this include new techniques to minimise the impact of patient motion on the quality of images and developing tools to aid clinicians in diagnosing Alzheimer's disease, a priority for the nation and the government. Figure 3 shows the key areas at the base of the brain where patients first lose grey matter as the cortex thins. I was delighted when the Department of Health chose to use some of my work to publicise the launch of the latest NIHR funding round in early March.

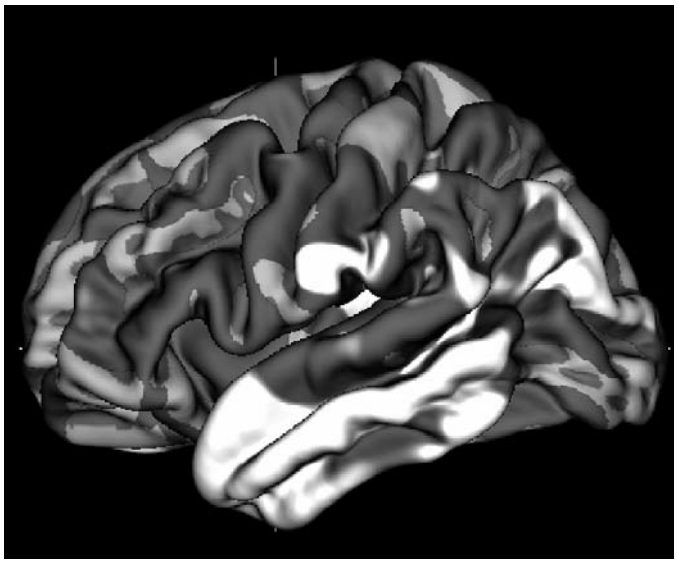


Figure 3 – Image illustrating the loss of grey matter in the human brain in Alzheimer's disease. The areas in white demonstrate thinning of the cortex towards the base of the brain, particularly in the temporal lobe.

SUMMARY

Medical physicists have played a key role in the development of magnetic resonance imaging and now that the technique is established continue to do so through both clinical and research work.

THE MERSEY GATEWAY BRIDGE PROJECT: CHARGING AHEAD AND REDUCING CARBON EMISSIONS

Steve Nicholson
Project Director, Mersey Gateway

A major new road building scheme that is largely paid for by its users, has survived the Government Spending Review and is set to reduce carbon emissions sounds too good to be true. The Mersey Gateway Project proves otherwise.

The disciplines of engineering, architecture, and traffic management are regular partners when it comes to constructing new bridges.

Add to that regeneration, management of contaminated land and the creation of a 28.5 hectare nature reserve and you have a complex project.

The Mersey Gateway Project is a major scheme that is bringing together all these disciplines to build a new six-lane toll bridge over the Mersey between the towns of Runcorn and Widnes.

The two towns both lie in the borough of Halton, in north west England, which is somewhat unusual amongst local authorities in that it is effectively split in two by a major geographical feature (in this case the River Mersey), with the two halves currently linked by just a single road bridge.

Therefore, when there is any kind of problem with this bridge, the two halves of the borough are effectively cut off from each other. The idea of adding a second bridge to boost capacity and provide greater resilience to the road network has been around for the best part of two decades.

Since successfully negotiating the Spending Review and being granted Planning Approval in the last two months of 2010 the project stands at the cusp of delivery.

Halton Borough Council, which is the main promoter of the Mersey Gateway project, has launched the first stage in its procurement strategy that will lead to the appointment of a Design, Build, Finance, and Operate contractor who will work in partnership with the Council in a relationship expected to last for thirty years.

The challenging project is to be funded through toll revenue supported by government grants, which are sufficient to keep toll charges affordable in a region of relatively high social deprivation. This mix of funding has proved to be resilient against the economic downturn and the deficit reduction measures now taking place.

THE PROBLEM

Halton, and its neighbours in south Merseyside and north Cheshire, straddle the river but currently only have one bridge (the Silver Jubilee Bridge) covering the 30 miles between the tolled tunnels connecting Liverpool with the Wirral, and the crossings near Warrington, which include the M6 motorway viaduct at Thelwall. Improvements to this failing transport system are now well overdue.

The existing crossing was originally built in 1961 and, despite work to upgrade it in 1977 (hence its name), still carries daily volumes in excess of 80,000 vehicles. Congestion is, therefore, a frequent occurrence, which causes obvious problems in terms of pollution, as well as delays to the general public and businesses. There are also problems associated with the fact that, as a borough split in two by a major river, Halton tends to have its major resources (such as its main hospital) on either one side of the Mersey or the other, leading to access issues if there is any problem with the existing bridge.

The poor resilience of the local transport system is also a

serious concern to the region's emergency planning team that routinely assesses risk arising from 20 significant industrial sites in the area. If there is an incident at one of these sites and the existing bridge is unavailable due to an accident, or congestion, then this has a significant impact for the fire and police services. The chief constables of both Merseyside and Cheshire are consequently very strong supporters of the new bridge.

The poor transport performance and reliability concerns combine to produce a powerful economic case for the new bridge. There are also considerable environmental benefits by keeping traffic moving and by managing the growth in traffic through the tolling proposals.

Tolling even at the relatively modest cost we envisage, at £1.50 for a car journey – which will have resonance with users as it is the same as today's Mersey Tunnel rates – does moderate the use of the private car, particularly reducing the number of the short distance car trips crossing the river. To improve the alternative public transport options, part of the project funding will be used to support bus services. Overall, the combination of removing congestion and moving some car travel to improved public transport is expected to reduce carbon emissions – perhaps a unique outcome for a major road project in the UK?

The Council's enthusiasm for the economic benefits of the new bridge is backed up by several major business enterprises in the region. One of the UK's biggest road haulage and logistics companies, Eddie Stobart, for example (which is the owner of a major intermodal terminal – the Mersey Multimodal Gateway – in Halton), is a prominent advocate of the new bridge (tolls and all), as is Peel Holdings, the owner and operator of the Manchester Ship Canal (which the new bridge would span) and Liverpool's John Lennon Airport.

The new bridge will:

- be scheduled to open in 2016
- be over 70% funded by the private sector through toll revenues
- mean an estimated 4,640 new jobs through direct employment, regeneration activity and inward investment
- be a tolled crossing with a speed limit of 60mph
- allow the creation of a green, sustainable transport corridor across the existing Silver Jubilee Bridge
- be a major strategic new transport route linking the Liverpool city-region and the north west to the rest of the country.

PROCUREMENT BEGINS AS PLANNING APPROVAL IS GRANTED

In December 2010, Halton Borough Council received planning approval from the Secretaries of State and the Council is in the process of concluding final funding considerations with the Department for Transport. Procurement preparation commenced in spring 2011, following a final consultation with interested suppliers. We expect to begin the dialogue phase in September of this year and appoint a partner in April-June of 2012.

The plan is to commence construction with the advanced works starting towards the end of next year and the new bridge opening in 2016.

The delivery cost, of over £600m, will support the construction sector and a private sector led economic recovery in an area likely to feel the spending cuts more than most. The Council and Government are about to embark on a much needed infrastructure scheme funded mainly by those benefiting from the improvements.

Exhaustive contaminated land studies, traffic modelling and legal procedures were required to get this far, but as our thoughts turn towards the construction period itself the focus returns to the practical impact that this project will have on the ground. Disruption is inevitable during construction, and we must prepare and work with local communities to ensure they are involved and forewarned about the detailed plans.

The successful private sector partner will have a key role to play in working alongside the Council to ensure that the delivery of the project meets the aspirations of the authority and the demands of local people.

Mersey Gateway has the potential to be a great example of science and technology combining with policy innovation and on the ground regeneration to create jobs and revive local communities. This could be an example of modern localism that can be considered elsewhere. Our challenge over the next four years is to take that potential and make it a reality.

You can find out more about the progress of the Mersey Gateway Project at www.merseygateway.co.uk.

PROJECT SUNSHINE – THE SCIENCE BEHIND FOOD AND ENERGY SUSTAINABILITY

Professor Tony Ryan OBE
Pro-Vice-Chancellor, University of Sheffield (Project Sunshine Director)

Professor Peter Horton FRS
Emeritus Professor of Biochemistry, University of Sheffield (Project Sunshine Research Director)

The world is entering a period of crisis: there is not enough energy or food and their costs are rising; there is environmental destruction and loss of biodiversity at an accelerating rate; and there is increasing evidence of potentially catastrophic climate change. A common feature is the unsustainable nature of most human activity. The University of Sheffield has realigned its science research, creating Project Sunshine, to discover sustainable routes to food and energy security through collaborative research and innovation, uniting scientists across the traditional boundaries in both the pure and applied sciences.

Prior to the industrial revolution, limits on population and human activity were set by the sun, and by the productivity of the land. The discovery and use of fossil fuels changed everything – rather than being constrained by the supply of energy from the sun, mankind could use the energy of the sun's action that had been accumulated and "stored" underground for hundreds of millions of years. This apparently limitless supply of energy drove an unprecedented period of growth in human population and technological development. Our use of fossil fuel thus creates a massive historical anomaly: unsustainable growth in demand for energy and food; unsustainable drain on the earth's finite natural resources; unsustainable environmental degradation; unsustainable pollution of our atmosphere. Only by re-making the link between the sun and human activity can we again establish sustainabilty. This will involve the development and deployment of new technologies and systems that use the sun's energy more efficiently and more extensively to increase food production and provide renewable energy at the same time reducing carbon emissions, decreasing environmental degradation and stabilising atmospheric CO_2 levels.

THE TRANSITION TO A SUSTAINABLE ECONOMY

Achieving this goal of sustainability will not be easy. In the case of food, analysis of population growth, agricultural productivity and environmental sustainability presents a bleak scenario – too many people, not enough yield, not enough land, not enough water, too much pollution, increased energy (and carbon) costs, and the uncertain consequences of global warming. According to the Global Food and Farming Futures Report, world food production will need to increase by at least 50% in the next 20 years, a massive rise in harvestable yield per hectare of the major crops such as rice and wheat. In the case of energy, similar analyses suggest the requirement to increase energy supply by an incredible 2-3 times, to around 30 TW by 2050. In this new scenario, there is no alternative but to dramatically change the way we use and produce energy and food, to adapt to the already changed climate and to ameliorate the extent of future change. All levels of human activity in all parts of the world will be affected. The United Kingdom should position itself, just as it did in the industrial revolution, to lead this change – easing the transition to a sustainable economy by scientific research and technological innovation.

SOLUTIONS PROVIDED BY INTERDISCIPLINARY SCIENCE AND NEW TECHNOLOGY

Whilst some view science as the enemy of sustainability, it is only by scientific research and

technological innovation that we can achieve such sustainability whilst at the same time preserving and enhancing the quality of life for all the citizens of the world. In Project Sunshine we identify the problems of food and energy sustainability and global change as being inextricably linked, thus requiring integrated approaches. Solutions to the global problems of energy and food security will emerge from the integration of knowledge to examine complete systems – approaches derived from the expertise of biologists, physicists, chemists, engineers, and mathematicians, in the context of the perspective offered by geographers, psychologists, sociologists and economists. The complete system extends all the way from physical, chemical and biochemical mechanisms at the atomic and molecular levels to the processes, operations and technologies embedded in our socio-economic system. Furthermore, whilst investigation of some specific aspects of food or energy production might be distinct, the common underlying theme (of using science to provide sustainability) will serve to unite scientists, give extra urgency to their work and be a key driver of the all-important process of public engagement. Project Sunshine thus provides a model for the route from basic research to impact. Let us set out some examples of the approaches being taken.

AGRICULTURAL IMPROVEMENT

Modern agriculture, in essence, converts oil into food, consuming vast quantities of water and producing a variety of pollutants. Replacing oil with renewable energy would only solve part of the problem – we also need to reduce consumption of water and decrease the amount of fertiliser applied to the land. This will require improved varieties of crops with not only higher yields per unit land area, but also with more efficient use of water and fertiliser, and less reliance on pesticides. There will not be a single solution – different crops in different geographical locations under different management conditions will demand a range of different solutions. In Project Sunshine we are engaged in research aimed at fundamentally increasing the efficiency with which cereal crops use light, water and fertiliser by changing the basic biochemical pathway of photosynthesis – this work comprises a large consortium of researchers in Europe, USA and Asia. In other projects research into the mechanisms that determine how the leaves of plants respond to environmental stress will provide the knowledge needed to make crops more resistant to the effects of extremes of weather. Similarly, another major aim is understanding the mechanisms of resistance of crop plants to the invasive parasites that drastically reduce crop yield in many areas of the world. A further strand of research concerns the sustainable and efficient provision of nutrients by the soil, in particular understanding the complex interactions between plants and soil microbes, knowledge that could lead to an agriculture less dependent on fossil-fuel based inputs and with much lower impact on the environment.

SOLAR ENERGY

With the same theme of utilising solar energy more efficiently, physicists and chemists in Project Sunshine are developing new materials for the next generation of photovoltaic solar cells. At the same time it is important to establish exactly how efficient these will be compared to existing technology, and a Solar Farm has been built to provide a test bed, producing readily accessible standardised datasets of solar cell performance under everyday conditions. Bringing in new ideas generated in biology is also an important aspect of our work. The collection of light energy in natural photosynthesis in plant and microbes is highly efficient and robust, and integration of biomolecules into semiconductors to create hybrid devices is a particularly exciting innovation that has great promise. Direct use of plants and microbes to produce biofuel and other useful feedstocks is another important area of activity. Microalgae are particularly suitable for this purpose. Here our process engineers are collaborating with biologists to develop commercial scale systems in which algal cultures convert the CO_2 emitted from industrial steel plants into bio-diesel, a technology that could find widespread use and contribute to reducing CO_2 emissions by means of carbon capture.

GLOBAL CHANGE

All of this work is set against the backdrop of significant studies into global change. A major activity is understanding the role of the terrestrial biosphere in the contemporary and future carbon cycle, and especially the use of satellite (and ground data) to constrain carbon cycle calculations by models. We also do basic science on the interrelations of organisms and environment. How have ecosystems responded to past episodes of global change, what effects do plants have on the Earth System, and what are the impacts of contemporary climatic variation and anthropogenic global change on plants? Armed with this understanding we are able to evaluate the likely impacts of contemporary global change on the world's flora. We examine how people respond to climate change. What are their fears? How do they respond to low carbon-generating technologies and change their behaviour to reduce individual environmental impact? Alongside such large scale international research we also carry out small scale but equally significant projects with more immediate practical application. eg developing new material for living architecture, such as foams which can be used to make green walls and roofs.

ENGAGEMENT AND COMMUNICATION

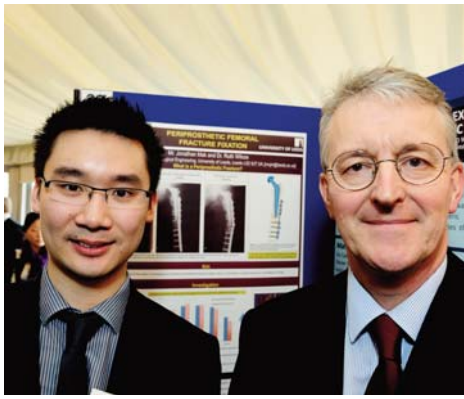
Project Sunshine, along with activities of a similar nature in other institutions in the UK and worldwide, provides a model for a new way of thinking about and doing science, which is focused on innovative pure science, but at the same time geared toward providing practical solutions. A vital part of this process is engagement and communication with individuals and organisations from across areas of academia, business and the public sector, and with the general public. With this aim in mind, in September we are hosting a major event, the Shine 2011 International Conference, which will be supported by the UK Research Councils and a number of commercial organisations including BP.

http://shine.sheffield.ac.uk/

SET FOR BRITAIN 2011

On Monday 14th March 2011 Andrew Miller MP, Chairman of the Parliamentary and Scientific Committee, acted as host for SET for BRITAIN, the annual poster competition and exhibition for early-career researchers. The competition had attracted just under 300 entries in three separate sections, and the top sixty entrants in each section brought their posters to Westminster for display and judging in the House of Commons Terrace Marquee.

Overall Winner
Mrs Sue Wharton; Professor Brian Cox; Andrew Miller MP; Andrew Treharne, winner of the Westminster Medal; Dr Stephen Benn, Royal Society of Chemistry; and the Lord Krebs.



The competitors came from all over the United Kingdom and during the course of the day some 86 Parliamentarians from the House of Commons and House of Lords visited the exhibition, meeting the presenters and seeing at first hand the high quality research being undertaken in British institutions.

The posters in each section, which were of a very high standard, were judged by distinguished panels of experts from the Royal Academy of Engineering, the Institute of Physics, the Royal Society of Chemistry and the Society of Biology.

Thanks to generous support Gold, Silver and Bronze Awards of cash prizes were made in each section, and the winner of each Gold Award also received a medal. These awards were made possible by donations from E.ON and the IET (Engineering); Plant Impact plc, International Agri-Technology Centre and Eli Lilly (Biological and Biomedical Sciences): and BP, AgChemAccess and Oxford Instruments (Physical Sciences).

At the end of the final session the winners of the Gold Awards in each section competed for the Westminster Medal, donated by the SCI in memory of Dr Eric Wharton. The posters were judged by Lord Krebs and Andrew Miller MP, Chairmen respectively of the House of Lords and House of Commons Science and Technology Select Committees, assisted by Professor Brian Cox; and the medal was awarded to the poster which they felt best communicated the scientific concept involved.

Biological Sciences Group
Peter Blezard, Plant Impact Plc; Dr Owen Wallace, Eli Lilly; Jay Stone (Silver Award); Dr Stephen Benn, Royal Society of Chemistry; Louisa Jeffery (Joint Bronze Award); Dr Robert Sansom (Joint Bronze Award); Andrew Miller MP; Talia Atkin (Gold Award); Dr Mark Downs, Society of Biology; Paula Twinn, International Agri-Technology Centre Ltd.

Winner of the Cavendish Medal, Dr Ian Chapman, with Professor Ellen Williams, Chief Scientist, BP, and Dame Jocelyn Bell Burnell, Institute of Physics.

Chemistry Silver Award winner Dr Rachael Miles with Gary Phillips, AgChemAccess; and Professor David Philips, Royal Society of Chemistry.

Dr Tony Whitehead, Institution of Engineering and Technology; the Rt Hon Lord Jenkin of Roding; Martin Carter, Head, Engineering Academy, E.ON; Dr Stephen Benn, Royal Society of Chemistry; Dr Tim Stevenson, University of Leeds (Gold Award); Andrew Miller MP; the Lord Browne of Madingley; Manuel Martinello, School of Engineering and Physical Sciences, Heriot-Watt University (Silver Award); James Popper, Honda Engineering Europe, Swindon (Bronze Award).

Winner of the Roscoe Medal, Andrew Treharne, with Professor Ellen Williams, Chief Scientist, BP, and Professor David Phillips, Royal Society of Chemistry.

Physics Bronze Award winner Katerina Falk with Lynn Shepherd, Oxford Instruments; and Dame Jocelyn Bell Burnell, Institute of Physics.

PRIZE-WINNERS

12.30pm - 2.30pm
ENGINEERING SESSION

Gold Award: £3,000 and Engineering Medal: Dr Tim Stevenson, University of Leeds
MAGNETOELECTRICS; SPARKING NEW INTEREST INTO A PHENOMENA ONCE THOUGHT TO BE POLES APART

Silver Award: £2,000: Mr Manuel Martinello, School of Engineering and Physical Sciences, Heriot-Watt University
3D INFORMATION FROM ONE SINGLE 2D IMAGE

Bronze Award: £1,000: Mr James Popper, Honda Engineering Europe, Swindon
COOKERSMART: FIRE DETECTION FOR THE KITCHEN

3.30pm - 5.30pm BIOLOGICAL AND BIOMEDICAL SCIENCES

Gold Award: £3,000 and Mendel Medal: Miss Talia Atkin, Neuroscience, Physiology and Pharmacology, University College London
SCHIZOPHRENIA ASSOCIATED PROTEIN, DISC1, REGULATES INTRACELLULAR TRANSPORT OF MITOCHONDRIA IN NEURONS

Silver Award: £2,000: Miss Jay Stone, Institute of Ophthalmology, University College London
IDENTIFYING A NOVEL ROLE OF LBP IN EYE DISEASE

Joint Bronze Awards: £500:
Miss Louisa Jeffery, Immunity and Infection, University of Birmingham
CAN VITAMIN D, THE SUNLIGHT-ACQUIRED VITAMIN, CONTROL INFLAMMATORY DISEASE?
and
Dr Robert Sansom, Department of Geology, University of Leicester
STUDIES OF DECAY REVEAL BIAS IN FOSSIL INTERPRETATION

6.30pm - 8.30pm PHYSICAL SCIENCES (CHEMISTRY AND PHYSICS)

Chemistry

Gold Award: £3,000 and Roscoe Medal: Mr Andrew Treharne, School of Chemistry, University of Southampton
TOWARDS A CURE FOR RETINAL DEGENERATIVE DISEASES: DEVELOPING POLYMERIC SCAFFOLDS FOR IMPROVED CELLULAR ADHESION

Silver Award: £2,000: Dr Rachael Miles, Department of Chemistry, University of Bristol
IMPROVING OUR UNDERSTANDING OF CLOUDS AND CLIMATE: MEASURING THE CONDENSATION RATE OF WATER AT AN AQUEOUS DROPLET SURFACE

Bronze Award: £1,000: Miss Anna Barnard, Department of Chemistry, University of York
AN AMICABLE BREAK-UP: LIAISONS BETWEEN DEGRADABLE DENDRONS AND DNA

Physics

Gold Award: £3,000 and Cavendish Medal: Dr Ian Chapman, Theory and Modelling, Culham Centre for Fusion Energy
STABILITY OF TOKAMAK FUSION PLASMAS

Silver Award: £2,000: Dr Jesse Petersen, Department of Physics, University of Oxford
ULTRAFAST MOVIES OF ELECTRONIC STRUCTURE IN COMPLEX MATERIALS

Bronze Award: £1,000: Mrs Katerina Falk, Department of Physics, University of Oxford
INFERRING THE EQUATION OF STATE OF SHOCKED LIQUID DEUTERIUM

WESTMINSTER MEDAL IN MEMORY OF DR ERIC WHARTON (OVERALL WINNER):
Mr Andrew Treharne, School of Chemistry, University of Southampton
TOWARDS A CURE FOR RETINAL DEGENERATIVE DISEASES: DEVELOPING POLYMERIC SCAFFOLDS FOR IMPROVED CELLULAR ADHESION

BOOK REVIEW

Power Politics: Political Encounters in Industry and Engineering

By Francis Tombs

Published by I.B.Taurus & Co.Ltd 2011

We have all come to rely on electricity being available on demand and in an ideal world one would like to think that the Government had a duty to ensure the country enjoyed a secure and continuous supply of electricity, a duty second only to the security of the state. In this entertaining new book Lord Tombs explains how, on the contrary, political decisions by successive governments since the war "have resulted in a situation where the reliability of electricity supply throughout the UK will be in serious jeopardy for many years to come". Lord Tombs is particularly well qualified to make such a judgment.

Born in Walsall he left school at 15 and started work at GEC in Birmingham. After gaining his qualifications in electrical engineering, followed by a degree in economics and accountancy and a distinguished career in industry he eventually became Chairman of the South of Scotland Electricity Board, the larger of the two electricity supply boards in Scotland, and later became Chairman of the Electricity Council.

His advice was then sought (but seldom followed) by a succession of energy ministers who sought to re-organise the industry by apparently relying on political dogma (sometimes nationalisation, sometimes privatisation) rather than using technical knowledge and experience.

He now sits as a Cross Bench Peer in the House of Lords.

The first chapter is an account of how the re-organisation of the electrical supply industry was mis-handled after the war. Before the war the construction of the National Grid in the 1920s and '30s, which allowed for the first time the nation-wide transmission of electricity, had been a major technical achievement which replaced the previous system of expensive and inefficient local generation and distribution.

In 1947 the Government nationalised the industry under the control of the British Electricity Authority. The subsequent Conservative government followed the recommendations of the Herbert Committee of 1957 to separate generation (in England and Wales) from distribution and sales. Lord Tombs describes this as an "odd" decision which was "entirely political, with little or no thought for the practical managerial consequences".

Thus was created the Central Electricity Generating Board, which had a monopoly of generation until privatisation in 1988, and 12 local boards responsible for the separate job of distribution and sales. Lord Tombs identifies one consequence of this inefficient arrangement in that the CEGB promoted the construction of "gold plated" power stations in this country which the contractors found were not competitive for overseas customers.

His recommendation was to implement a Bill which proposed the formation of an Electricity Corporation with a potential division into five autonomous and competing divisions each large enough to finance and build large power stations. But apparently the Conservative Government of 1979 found it politically impossible to implement this proposal which had been favoured by the previous administration, and they chose a different route for privatisation, one consequence of which has been that a number of our electricity utilities have passed into foreign ownership.

The advent of cheap gas was probably a mixed blessing. Gas fired power stations are quick and cheap to build but we have very little gas storage capacity to cover interruptions in supply and the reliance on one fuel (which we now have to import) has led to a decline in our traditional industries building turbo–generators and combustion plant, which we will have to buy abroad in future.

Lord Tombs is also critical of the Labour Government's "love affair" with wind power which he describes as expensive to build and their potential value has been greatly exaggerated. He quotes the Government's estimate of the subsidy required by wind power, £30 billion by year 2020 ("a stealth tax in all but name") and says it is a sum more than sufficient to meet the cost of replacing the nuclear power stations.

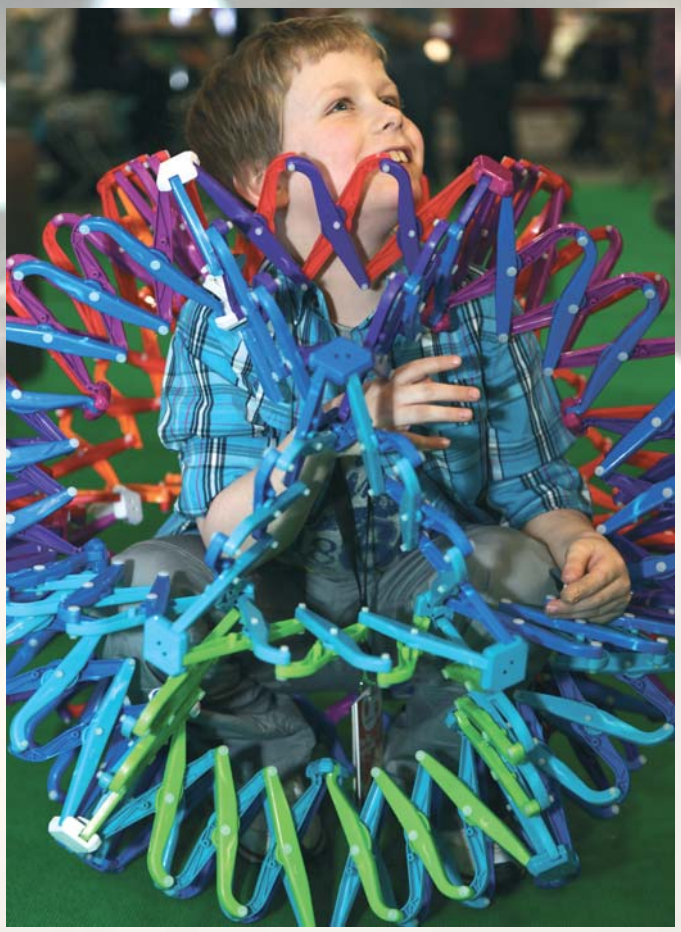
He sees the "visceral opposition of the Labour Government to nuclear power and the accompanying obsession with wind power" as a threat to our future supplies, and for the solution he says "we sorely need a technically competent and independent body capable of long-term strategic planning for a national electricity supply".

This chapter should be essential reading for all interested in our electricity supply, especially the young, to explain why we are in the present situation and what to avoid in the future.

The political horizon is too short for an industry which has to plan for 30 years ahead, and at the end of this book the reader is left with the clear conviction that planning the national electrical supply system is best guided by engineers.

Robert Freer

AN EVEN BIGGER BANG IN 2011



Around 29,000 people flocked to the UK's largest single celebration of science, technology, engineering and mathematics for young people at London's ExCeL Centre from 10-12 March.

The Big Bang UK Young Scientists & Engineers Fair 2011 brought together 150 different organisations with the shared aim of inspiring the next generation of scientists and engineers, and represented an unparalleled partnership between Government, education, industry and the wider science and engineering communities. Demonstrating the Government's support for the programme, Secretary of State for Business, Innovation and Skills, Vince Cable, was among a number of constituency MPs and senior civil servants to visit The Fair.

Mr Cable said: "The Big Bang is a terrific example of what can be achieved through the collaborative efforts of the STEM community. It is heartening to see so many businesses and organisations, from the UK and from right across the world, coming together to encourage our future scientists and engineers. We are proud to support The Big Bang as an effective and exciting way of inspiring the scientists and engineers of tomorrow."

A SERIOUS MESSAGE BEHIND A SERIOUSLY FUN DAY OUT

Behind the fun of The Fair, The Big Bang has a vital mission to promote STEM careers to

young people and address related skills gaps across the UK. Although research shows that parents would like their children to go into science and engineering careers, lack of knowledge about the diverse and rewarding jobs available in these areas stops them from encouraging their children to pursue these routes. The Big Bang explodes outdated perceptions by bringing the reality of science and engineering careers to life.

"The Big Bang exists to give young people and their parents a better understanding of how just fun and inspiring science and engineering can be," said Professor Brian Cox OBE

NATIONAL SCIENCE & ENGINEERING COMPETITION

The Fair plays host to the finals of the National Science & Engineering Competition, which this year saw several hundred young people compete for a range of prizes, including the UK Young Scientist and UK Young Engineer of the Year. The Awards Ceremony was presented by Professor Brian Cox and Dr Kate Bellingham, who were among an impressive list of celebrity Competition judges, including Professor Jim Al-Khalili, Professor Colin Blakemore, Professor Marcus du Sautoy, Vivienne Parry, Dr Maggie Aderin-Pocock, Dr Chris Elliot and Rear Admiral Al Rymer.

The UK Young Scientist and UK Young Engineer of the Year received their prizes from Government Chief Scientific Adviser Sir John Beddington.

He said: "The next generation of scientists and engineers will play a fundamental role in tackling the global challenges we face in the 21st century. These include the issues of climate change and the management of essential natural resources, and dealing with the threats to our world from diseases, floods, volcanoes and earthquakes. That's why this competition is so important – it inspires the scientists and engineers of tomorrow and is a great example of the exceptional young talent we have in the UK."

Hannah Eastwood from Loreto College in Coleraine was awarded UK Young Scientist of the Year and is the first girl to be awarded a senior title in the Competition. Her project explores how chromium can be removed from drinking water in order to purify tap water and reclaim it for the steel industry where it is a valuable resource.

Andrew Cowan from Sutton Grammar School for Boys is the only competitor to have won a prize in each age category across three years of the Competition. Following his previous successes in the Junior and Intermediate categories, this year Andrew was awarded the accolade of UK Young Engineer of the Year for his Search and Rescue Robot.

Paul Jackson, Chief Executive of EngineeringUK, said: "The Big Bang goes from strength to strength and its third year has

been the biggest and best yet. The Fair is all about inspiring young people to consider a career in science or engineering, and it works. Not only do the young people who visit have a great time but our early evaluation of the 2011 event backs the results we found last year, that young people who attend the Fair are more likely to choose a career that will require a qualification in science, technology, engineering or maths and view careers in science and engineering more positively as a result of their visit. Without a doubt, The Big Bang is winning hearts and changing minds!"

The Big Bang is much more than a one-off event; it's a year-round conversation with young people, their parents and teachers. Big Bang Regional Fairs take place around the country in the summer and provide an opportunity for more young people to experience close to home the excitement and opportunities available through science, technology, engineering and maths, and ongoing communication using traditional and new media, including Facebook and Twitter, means that more young people than ever can feel part of it.

Some comments from those who visited The Fair:

"The Big Bang was absolutely outstanding, fantastic…words can't explain".
A pupil from Ferry Lane Primary School, Tottenham, London

"There are really big stands from a lot of big, famous companies that we wouldn't normally get a chance to see."
Edward Breakenridge, Student Teacher, Sydenham School, London.

The Big Bang 2012 will take place from 15-17 March at the NEC in Birmingham and promises to be bigger again. To find out more about The Big Bang and how to take part in a Fair near you go to www.thebigbangfair.co.uk

THE VALUE OF THE NATIONAL MEASUREMENT SYSTEM TO THE ECONOMY

Dr Brian R Bowsher
Managing Director of the National Physical Laboratory, the UK's National Measurement Institute

Measurement has helped define societies, governments and progress since the dawn of civilisation. Length, area, volume, weight and time all had to be quantified and systematised when dividing up goods or land, trading, building and keeping records. One of the earliest measurement devices was the cubit, fundamental to building the pyramids. Our own Magna Carta in 1215, set out some early rules for measurement: "there is to be one measure of wine and ale and corn within the realm, namely the London quarter, and one breadth of cloth and it is to be the same with weights". Eventually such local laws and standards gave way to an internationally agreed system of units in 1875 and it is this system that the National Measurement System upholds for the UK.

All our science and technology depends upon the largely unknown work of Measurement Scientists. These scientists, known as metrologists, define scientific measurement and standards that other scientists then rely on to compare their findings with research done elsewhere or at a different time. Provision of this measurement capability is part of the technical infrastructure that underpins the UK's science, engineering and technology landscape for government, industry, and academia.

Standards help everyone to talk in the same language when something is being measured, a dictionary explains the meaning of a word and how to spell it; in a sense, we do the same for measurement.

Measurement underpins the welfare of a modern society and touches almost every part of daily life. It ensures consistency of international time standards so we can communicate reliably and navigate accurately throughout the world; ensures safety and efficacy of healthcare diagnostics and treatments; quantifies emissions of greenhouse gases to help understand and mitigate climate change; and measures the composition, energy value and quantity of gas piped to our homes, and fuel to our vehicles.

MEASUREMENT IN INNOVATION

It is generally acknowledged that the economic recovery will emerge from innovative and forward-thinking businesses in the UK. New measurement techniques and technologies stimulate and support innovation in products, processes and services.

Today measurement plays a fundamental part in the innovation process. To develop new products and processes, companies need to measure quantity, quality and performance. To trade successfully, companies must have a regulatory framework based upon measurement confidence, which ensures global markets are fair and open by eliminating unnecessary barriers to trade. Supporting this is an established infrastructure of traceable measurement linked seamlessly to the national standards maintained on behalf of the UK.

In some industries the need for accurate measurement is critical. Companies manufacturing precision engines work to tight specifications in which parts must be measured for size, material composition and performance to very accurate levels. Rolls-Royce, for example, employs over 200,000 measuring devices on their production lines.

For many of us a visit to a hospital may not be desirable, but knowing that the treatment has been appropriately measured throughout its development, trials and finally its delivery to the patient is vital to confidence in its application and effectiveness. The National Measurement System directly works with hospitals, underpinning over 200,000 radiation treatments each year for cancer diagnosis and treatment. Indeed, the work undertaken by the National Physical Laboratory (NPL) has been shown in international comparisons to provide the most accurate measurements, resulting in the most accurate doses of radiation, and the saving of hundreds of lives.

Measurement needs are ever changing. Measurement scientists are at the forefront of developing technologies that will drive future growth such as low carbon, nano and quantum technologies. Indeed, work at NPL on graphene was cited in support of this year's Nobel Prize for Physics. Measurement also plays a vital role in ensuring that standards and legislation are based upon robust yet practical measurement practices.

At the heart of the measurement infrastructure there are multi-disciplinary teams of skilled scientists, engineers, mathematicians and

support staff. The UK measurement system attracts talent from across the world and nurtures this talent to be the very best – many of these scientists are world leaders in their field. The National Measurement System invests in knowledge transfer to ensure that their know-how is shared within the UK for economic and social benefit.

The National Measurement System is the collective infrastructure of national facilities, expertise, knowledge, science, research and legal framework in the metrology field. Together these elements combine to provide traceable measurement, new measurement standards and techniques and the regulatory system to control trade, based on defined quantities. Equally, they provide a national asset base of skills and knowledge that is essential to developing and nurturing innovation in products and services.

Thousands of businesses each year gain measurement know-how and support through the National Measurement System. In a survey of 1,200 companies who had been supported by NPL, annual profitability gains of circa £700m were achieved in one year through product and process innovation, and improved measurement.

It is critical to ensure that investment in measurement delivers real economic and social impact. This is particularly the case when the investment involves public money. The National Measurement System invests approximately £60m per year across a portfolio of programmes whose role it is to respond to well-defined public, legislative or industrial needs, undertaking R&D to uphold and improve national standards, providing traceability for accredited measurement services or reference materials, as well as developing new measurement capabilities in support of strategic national priorities and the next generation of primary measurement standards. Measurement scientists also represent the UK on the international measurement stage, ensuring that measurement standards and legislative requirements are legal, accurate and fair to the buyer and seller. (NPL scientists support approximately 750 national and international committees and working groups).

The balance and content of these programmes is identified through extensive consultation with input from a wide range of stakeholders and overseen by independent working groups, with members from industry, government and academia, that ensure they remain fit for purpose.

NATIONAL PHYSICAL LABORATORY

The National Physical Laboratory (NPL) is the UK's National Measurement Institute and sits at the heart of the National Measurement System as the main provider of the measurement research programmes and infrastructure. NPL is one of the UK's leading science and research facilities and a world-leading centre of excellence in developing and applying the most accurate standards, science and technology available. We occupy a unique position sitting at the intersection between scientific discovery and real world application, at the point where science is translated into solutions – a place we have been proud to occupy for over 110 years.

When NPL was established in 1900, Lord Rayleigh expressed its charter, on behalf of the Royal Society, to its first Director, Sir Richard Glazebrook, to "bring scientific knowledge to bear practically upon our everyday industrial and commercial life, to break down the barrier between theory and practice and to effect a union between science and commerce". That remains as true today as it was then.

NPL's role beyond the work for the National Measurement System is to take the knowledge gained and provide companies with access to world-leading support and technical expertise, inspiring the absolute confidence required to realise competitive advantage from new materials, techniques and technologies; as well as supporting organisations and services in a wide range of social applications – helping to save lives, protect the environment and enable citizens to feel safe and secure. Support in areas such as the development of advanced medical treatments and environmental monitoring helps secure a better quality of life for all. Our approach is simple – all that we know we transfer – we do not retain our knowledge for knowledge's sake. Each year we support UK industry by providing a wide range of measurement services and consultancy to over 2,000 industry customers.

NPL has been managed since 1995 on behalf of the Department for Business Innovation and Skills through a government-owned contractor-operated arrangement by Serco. This model has worked very well, bringing to bear the best practices of the private sector whilst sustaining and enhancing the science outputs. Thus, overheads have been reduced by 30%, staff utilisation has increased by 10%, and third-party work has tripled since 2004 (now accounting for over one-third of the lab's revenue); with the number of peer-reviewed publications and citations doubling since 2004.

In 2010 NPL celebrated its 110th anniversary, which provided the opportunity to look back and reflect on some of our achievements. NPL has a rich heritage delivering some outstanding contributions to the prosperity of the UK, including the invention of radar, support to the 'bouncing bombs' used in the Second World War, Alan Turing's pioneering work on the first automatic computing engine, Donald Davies' development of packet-switching that provided the basis of the internet, and Louis Essen's work on the first atomic clock.

However, it is vital that, for NPL to continue to provide the maximum impact to the prosperity of the UK and quality of life of its citizens, we do not rest on our laurels.

FUTURE CHALLENGES

The challenges for measurement in the future are many and far reaching, but it will continue to play an important role in our digital economy. Already we are close to new methodologies for measurement of time that will help in the drive to make satellite navigation even more accurate than it is today. We are working closely with many biotechnology companies to discover whether better measurement techniques can reduce the time to market for new drugs. Mathematical modelling is becoming key in areas ranging from predicting climate change to understanding how aircraft engines will react in adverse conditions, and the measurement and measurement assumptions behind these models need to be accurate if they are to provide us with credible information that we can act on with confidence.

One of the most significant challenges lies in the future of energy generation and the use of low carbon technology. NPL is looking to establish a Centre for Carbon Measurement dedicated to this field – providing the measurement infrastructure required to access low carbon technologies, support financial carbon trading and underpin confidence in climate data.

There is rarely an average week at NPL. Recently we have been involved in developing an intelligent harvesting machine that knows when cauliflowers are ripe for the picking, using the high frequency sound of crunching biscuits as a guide to customer satisfaction, measuring the temperature in the centre of an explosion designed to destroy everything in its path, and assessing the performance of wet suits.

But to sum up the importance of measurement to our economy, I draw upon a quote from the British scientist, Lord Kelvin, who developed the temperature scale named in his honour:

"When you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot express it in numbers your knowledge is of a meagre and unsatisfactory kind."

Fine words indeed!

CAN THE ECONOMY SURVIVE WITHOUT A NATIONAL MEASUREMENT SYSTEM?

DEPENDENCE OF INDUSTRY ON THE NMS FOR MANUFACTURE AND INNOVATION

Dr Roger Digby FIMMM CEng FREng

Head of Materials and Processes Integration (Aircraft Programmes), Airbus

The focus presented here is that of an industrialist with an international perspective. It ranges initially from aircraft constructed of wood and linen structures, evolving to metallic frames and aluminium. Indeed, Concorde is the only aircraft ever built and then withdrawn that was not superseded by something better. While initially technically driven, aircraft manufacture from the 1970s was commercially driven and designed to reduce operational costs. Environmental impact from cradle to grave then became more of an impact, though surprisingly, not exceeding two per cent of the overall total. The technology required is driven by 3 key factors: Regulation and Legislation, Environment, and the Airworthiness Authorities.

Airbus currently employs 52,500 around the world, including France, Germany, Spain, the UK, North America, China, India, Japan and Russia of whom 7772 are in the UK. It has a global network of over 323 customers and 341 operators, who delivered 510 aircraft and sold 644 in 2010. In addition 10,060 aircraft have been ordered by 323 customers. It supports 6,194 aircraft in service with 338 operators.

The main driver for change in the early 70's was Freddie Laker, followed by the need for eco-efficiency, new competitors, safety, regulation and REACH. This resulted in demand for the lowest product cost, a minimised recurring cost and the need to maximise the effectiveness of the non-recurring cost in order to reduce cycle time and the product development cycle. This led to demands for the highest product performance and manufacturing capability regardless of material for optimum weight, resulting in extensive use of composite materials and lightweight metals.

This required the need to cost out the production process and product development time in advance, in order to develop the airframe, combined with tests for material properties, with results needed before it was built in order to provide a full analysis prior to construction.

Indeed, the purpose of testing the 32 metre wing in the test frame (as demonstrated on video at the meeting) is to prove that it will take up to 6m bending, with the prior analysis supported by the subsequent tests. With better analysis fewer expensive and time consuming tests will therefore be required. The aircraft wing failed where and how it was predicted from the prior analysis. Hence the procedure can be limited to a single test if the analysis is accurate.

Where will we be beyond 2020? Carbon nanotube reinforcements that are under development currently tend to agglomerate and demand more research. Even large structures such as wings start with tight tolerance, and especially so with flushness at the surface which is essential to reduce friction.

The National Measurement System provides for following key contributions essential for Airbus. These include robust, traceable standards which are essential for manufacturing; cross-sector best practice and knowledge transfer; manufacturing optimisation and product improvement; and innovative metrology for product improvement and new concept development.

Finally, this raises the following key questions requiring a response; Can Airbus survive without a UK NMS? Can Airbus in the UK survive without a UK NMS? Can the UK supply chain for Airbus remain competitive without a UK NMS? Can UK Industry be competitive in the Global arena without an effective NMS?

UK LEADERSHIP IN NEW TECHNOLOGIES THROUGH THE NATIONAL MEASUREMENT SYSTEM

Dr Julian H Braybrook, Director of Strategy, Measurement Research, LGC
on behalf of David Richardson, Chief Executive, LGC

LGC (www.lgc.co.uk) is an international science-based company and market leader in analytical, forensic and diagnostic services and reference standards. LGC operates in a variety of markets which underpin the safety, health and security of the public and the regulation of industry, for both public and private sector clients.

LGC operates internationally through four divisions – LGC Forensics, LGC Genomics, LGC Standards and LGC Science & Technology. The latter includes specialist laboratories delivering contracts for the Department for Business, Innovation and Skills (BIS) and supports LGC's designated role as the UK's National Measurement Institute for chemical and bioanalytical measurement.

With headquarters in Teddington, South West London, the LGC Group employs ca 1,400 staff in 29 laboratories and centres globally. Privatised in 1996 and now majority-owned by funds managed by Bridgepoint, LGC was founded almost 170 years ago as the Laboratory of the Government Chemist – a statutory function maintained by LGC today.

BACKGROUND

The Coalition Government has set out its agenda with strong, sustainable and innovation-oriented balanced growth a key contributor. Innovation is pervasive and not sector-specific, being spread across more than 20 'traditional' or 'high-technology' industries. It is however skewed, with around 10% of highly innovative firms accounting for almost 40% of innovation investment. Innovation is shaped by the knowledge creation and distribution system, the environment for business investment, public sector innovation, and the education and skills system. Within the knowledge creation and distribution system lies measurement science and technology – an infrastructure of measurement standards, dissemination of units, and science-based policy advice.

THE ROLE OF MEASUREMENT

Advanced measurement capabilities are essential to innovation in every economic area and at every stage of the innovation process. Advanced tools and measurements are required to innovate – to design and incorporate new or better features into next generation products or processes necessary for the UK to compete effectively and stay ahead in the global marketplace. In this way, measurement plays an important role in avoiding market failure for innovative new products. Reliable measurement:

- facilitates fair trade through harmonised standards and internationally
- underpins regulation through policy advice and measurement references for Directives, conformity assessment, and verification, such that
- parts manufactured in one country fit into machines in another country
- products tested and approved in one country can be sold in another country, without further technical inspection
- consumer protection is maintained.

Measurement at the technology frontiers enables and drives innovation in advanced production and instrumentation – after all, 'one can manufacture only what one can measure'.

However, there are three commonly accepted areas where innovation is being held back:

- inadequate accuracy
- a lack of accurate sensors
- a lack of standards, benchmarks, metrics and protocols.

CHEMICAL AND BIOANALYTICAL MEASUREMENTS

Issues associated with physical measurement have been addressed for the best part of 50 years by the UK measurement system, but only within the last 25 years have the measurement issues associated with the chemical sciences been addressed in a similar fashion. The issues of biological measurement still remain in their relative infancy. UK leadership in these areas is acknowledged worldwide, but is under threat from measurement initiatives in the US and several of the new entrant developing countries, such as Korea and China.

LGC delivers the designated UK national measurement institute (NMI) role for chemical and bioanalytical measurement. Its model in the private sector differentiates itself from the other UK NMIs. As the first management buy-out (MBO) of a public sector research establishment (PSRE) from Central Government, internal investment and acquisition has increased LGC's public and private sector activities worldwide. Its fundamental approach is centred on:

- leading accurate and traceable measurement in relevant disciplines for the UK
- acting as a solution point for Government, where measurement makes a difference
- acting as a provider of value to UK industry, especially where it creates innovation.

Drawing on its strapline of 'science for a safer world', the following examples highlight where LGC has been providing its leading measurement expertise on behalf of the UK national measurement system (NMS) to bring value to existing and emerging chemical and bioanalytical technologies and industries – especially early support at the small and medium enterprise (SME) level to maximise opportunity for innovation.

GENOMIC MEDICINE

DNA sequencing has long been the 'gold standard' method for analysing regions of the genome, but it is prohibitively expensive and laborious. 'Next-generation' sequencing (NGS) technologies offer orders of magnitude increases in throughput and decreases in costs. However, despite their potential and rapid uptake across multiple disciplines, inconsistencies associated with target preparation mean that NGS technologies have mostly been applied to qualitative studies. Recently, however, the technology is being applied to quantitative profiling, where maintenance of accurate representation of starting material becomes even more critical.

The UK is helping set the lead to establish a measurement capability, within national measurement institutes worldwide, to identify requirements for NGS technologies and initiate development of a framework for standardisation.

CLINICAL MEDICINE

Cholesterol is a fatty substance which is found in the blood and which plays an essential role in how every cell in the body works. However, too much cholesterol in the blood can increase your risk of heart problems. The accurate measurement of small molecules in clinical samples is essential for the safe and efficacious diagnosis/treatment of patients. In the case of cholesterol measurement, a 10% error in its determination means 13% of the population do not receive the treatment they should and 20% receive treatment unnecessarily. The UK is leading traceable purity and mass spectrometry methods to assign reference values to a number of reference materials intended for the clinical sector.

PHARMACEUTICALS

The WHO estimates that counterfeit drugs, which now account for 10% of the global market, cost the pharmaceutical industry US$46 billion annually. For the consumer, it is the missed health benefits associated with any uncertainty over the likely effectiveness of the medicine or, indeed, the potential health risk associated with any unexpected clinical effects arising from the unknowing use of counterfeit medicines. Traditional detection and discrimination of counterfeit drugs rely on visual examination and physical and chemical analysis of goods and packaging, but counterfeiting is becoming more sophisticated.

The UK has taken the lead in developing new approaches based on the measurement of small, naturally occurring isotopic variations in compounds present in the product and packaging and have demonstrated the potential for these high accuracy mass spectrometry techniques to provide the low level of measurement uncertainties required for legal prosecution purposes.

FOOD SUPPLEMENTATION

Providing a sound basis for measuring a vital element in the diet – with long-term benefits for public health – could be enormous. Selenium is known to have important functions in key enzymes and recent studies suggest that selenium supplementation can help protect against cancer, HIV and other diseases. However, selenium is believed to be deficient within the UK diet due to our consumption of European wheat. It is important however for the selenium to be present in the right chemical form/species. The UK has helped establish accurate measurement approaches for detecting the different forms of inorganic and organic selenium for selenium supplementation through the diet.

Additionally, this work developed the analytical basis for the characterisation of organo-selenium compounds that, for the first time, enable pre-clinical and human clinical trials for novel prospective cancer therapies within the UK, Europe and the US.

NANOTECHNOLOGIES

The unique mechanical, thermal and catalytic properties that materials develop when structured at the nanoscale has led to nanomaterials being incorporated into more than 800 commercial products that impact on every aspect of human life. The UK is leading standardisation initiatives in nanotechnology, both in terms of setting an understanding of vocabulary and characterisation methodologies, but increasingly in nanotoxicology as a result of the inconsistent behaviours displayed by nanoparticles in traditional screening models. Employing UK expertise in *in vitro* toxicology assays, a label-free, real time, cell electronic sensing system has been validated. Such continual cell analysis has provided quantitative information about the rates and mechanisms of toxicity which can be missed using traditional assays.

REGENERATIVE MEDICINES

Tissue engineering uses cells, engineering and materials to manufacture functional replacement tissues for clinical application. Regulation is critical for product quality, safety and development. However, the novel aspects that make the technology so promising also make regulatory compliance more of a challenge. New product development and evaluation using high throughput cell imaging capability is being used to overcome the measurement difficulties associated with a more representative 3D (rather than traditional 2D) test environment for cell-based testing. The approach of using fluorescent probe technologies to visualise

cells within 3D systems fills the technology gap.

The UK's pivotal role in the preparation of the first documentary publicly available specifications (PAS) for the cell-based therapeutic industry has been supported by leading measurement capability in single cell and 3D stem cell bioprocessing.

CONCLUDING REMARKS

The international picture for measurement science has never been healthier. UK leadership is reflected in its Chair roles for three (inorganic, bio-analysis and gas) of the six consultative committees, and in its founding role in a fourth, of the *Bureau International de Poids et Mesures* (BIPM). This organisation ensures world-wide uniformity of measurements and their traceability to the International System of Units (SI).

It is clear from the rapid increase in attendance of measurement scientists at the annual meeting of BIPM, measurement science is being seen as underpinning economic prosperity globally and is being invested in substantially in the developing countries and in the US. This is particularly strong in the 'newer' bio-analytical areas.

So whilst the UK currently 'punches well above its weight', the wealth of measurement challenges means European and international partnerships are becoming ever more important to ensure differentiated, but complementary, measurement offerings between NMIs.

100 YEARS OF NUCLEAR PHYSICS

John Roberts
Dalton Nuclear Institute
The University of Manchester

Today the model of an atom with electrons orbiting a central nucleus consisting of protons and neutrons is familiar to many of us and is taught as part of the GCSE science curriculum. One hundred years ago our understanding of the atom was very limited. Based on experiments conducted at The University of Manchester, Ernest Rutherford announced his theory of orbiting electrons and a central nucleus at the March 1911 meeting of the Manchester Literary and Philosophical Society and then published a paper in the May edition of the Philosophical Magazine.

Significant evidence for the Rutherford Model of the atom came from experiments directed by Rutherford and conducted by Hans Geiger and Ernest Marsden. The most famous of these experiments is the alpha scattering experiment where alpha particles (helium nuclei) were fired at thin foils of various metals, including gold. Geiger and Marsden were instructed to use a scintillator to observe the scattering of the alpha particles at various angles around the target. If the prevailing model of the atom (Thomson's plum pudding model with negatively charged electrons dispersed through a central positively charged mass) was correct then some alpha particles, which are positively charged, would be deviated slightly off their incident line.

Slightly deviated alpha particles were duly observed but then Rutherford instructed Marsden to look for any back scattering, ie alpha particles bouncing backwards. Marsden observed a small percentage being scattered backwards, which led to the famous quote from Ernest Rutherford that "It was quite the most incredible event that has ever happened to me in my life. It was almost as incredible as if you fired a 15-inch shell at a piece of tissue paper and it came back and hit you." To explain these results Rutherford proposed that the electrons must be orbiting around a central nucleus which contains most of the mass and is positively charged. This is still the basis of our understanding of the nucleus. For hydrogen 99.9% of the mass of the atom in in the nucleus and the sole electron orbits at a distance equivalent to 100,000 times the diameter of the sole proton.

Due to this remarkable insight Rutherford is known as the Father of Nuclear Physics and our understanding of the nucleus, developed from these initial experiments, over the last 100 years has led to some spectacular achievements. Understanding the nucleus allows us to understand phenomena such as radiation and nuclear fission and develop technologies that are beneficial. X-rays were discovered before Rutherford's experiments but his description of the nucleus shows how electrons moving between energy states, or different orbital sizes and shapes, releases the energy. In the nucleus itself the emission of alpha particles (helium nuclei with two protons and two neutrons), beta particles (electrons) or gamma rays is the basis of many everyday technologies such as smoke detectors and the specialist equipment used for medical diagnostics techniques, for example PET (Positron Emission Tomography) Scanners. Radiation is also used in medicine as a therapy in procedures such as cancer treatment.

Another way we have learned to harness the energy within the nucleus is to provide electricity through nuclear fission and in the future through nuclear fusion. The UK is currently undergoing a nuclear renaissance with new reactors due to come online before the

end of this decade. This is replicated throughout the world. For example, the United States is preparing to build its first reactor since the 1970s; the United Arab Emirates have ordered reactors from Korea; Vietnam has two reactors on order from Russia and many other countries around the world are either considering renewing their nuclear reactor fleet or building reactors for the first time in their history. New detector technology is also helping us decommission our existing fleet of nuclear reactors in a safe, efficient and cost effective manner.

After 100 years of nuclear physics research we have a much more detailed model of the nucleus but the essence of the Rutherford model with a nucleus and orbiting electrons is still at its core. If he could visit The University of Manchester today he would still see a thriving School of Physics and Astronomy, and a dedicated team of nuclear physicists continuing to probe the nucleus and attempting to reveal more of its secrets. Although the UK no longer has a nuclear structure research accelerator, its nuclear physicists are still advancing this fundamental science at international facilities in France, Switzerland, Finland, Germany and the United States.

SHALE GAS – A HOME-GROWN SOURCE OF ENERGY AND FUEL

Professor Mike Stephenson
Head of Energy
British Geological Survey

Mike Stephenson publishes with the permission of the Director of the BGS (NERC)

Shale – usually thought of by geologists as a rather boring, uninteresting rock – might be an important source of methane gas for power and fuel in Britain into the future.

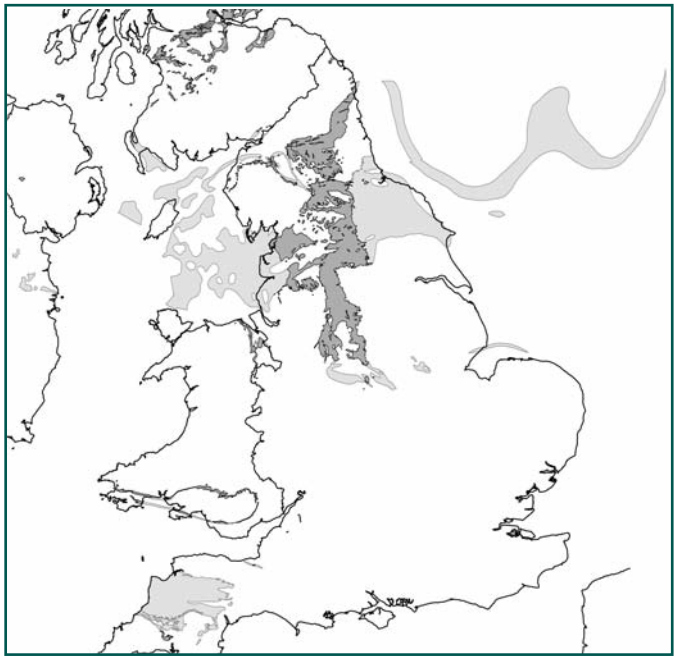
Shale is the most common sedimentary rock, and Britain has a lot of it – in northern England, the Midlands, Wales and southern England. It's a soft rock so often isn't seen at the surface, though it underlies much of the country. The British Geological Survey (BGS) has just finished an assessment of the amount of shale gas that might be present in these areas and has come up with some impressive figures[1]. The shale of the millstone grit rock sequence alone, for example, may contain 4.7 trillion cubic feet (TCF) of shale gas, which is about half of Britain's estimated reserves of more 'conventional' natural gas.

There is so much interest in shale gas that the last few years have been known as the 'dash for gas'. In the United States where much of the technology for shale gas extraction was developed, shale gas production has been a great success story. In 1996, shale gas wells in the US produced 0.3 TCF – only 1.6% of US gas production; but by 2006 production had more than tripled to 1.1 TCF per year, 5.9% of US gas production. One recent study has suggested that natural gas will provide 40% of America's energy needs in the future, from 20% today, thanks in part to abundant shale gas. Many people welcome shale gas particularly because of the increasing security of supply it brings, helping to make the US independent of energy producers in Russia and the Middle East.

The key to getting the gas out is hydraulic fracturing (also called 'fracking' or 'fraccing'). This technique, developed in the US, involves pumping high pressure water (or nitrogen) into the shale to crack it and release the gas. A simple well without fracking will not release much gas. The shale itself is very rich in organic matter from deposition in ancient seas and rivers, but the gas which is generated from the organic matter, can't move easily in the rock because it is so fine grained and impermeable. So fracking is generally essential.

The shale gas business is not so well-developed in Britain. There is only one shale gas well – near Blackpool – drilled by the American company Cuadrilla and there is no gas production yet. However, as the BGS study suggests, there might be shale gas over wide areas of Britain just waiting to be drilled.

The millstone grit is perhaps the best prospect. The millstone grit itself – famous for the millstones of the Peak District – is a sandstone, but between the layers of sandstone are layers of shale. One of these shale layers has been targeted by Cuadrilla. Another area is the Jurassic shale of the Weald and Wessex in the south of England. The BGS estimates that the onshore



Distribution of millstone grit in Britain

part of the Wessex Basin alone could yield up to 30 billion cubic feet (BCF) of shale gas. The very ancient Cambrian-age shale under the Midlands might yield another 300 BCF. Even the hard slates of parts of Wales and south west England might have gas in them.

But commercialisation of shale gas may not be so easy in Britain and Europe. Fracking has recently had a bad press in the United States and there is no denying that drilling for shale gas is an energy-hungry business. Water for fracking is needed in large quantities and there is also the problem of disposing of water that flows back to the well and the drilling rig after the fracking is finished. This water will be very dirty and need special treatment in tanks before it can be released into rivers or the sea.

At present the price of gas means that shale gas is only economic in the US. But for political reasons countries like Poland have their eye on shale gas as a possible secure source allowing them some independence from Russian gas, and a way of generating electricity in a slightly cleaner way than burning coal. Britain has cheap gas from Qatar and Norway, but if Britain's shale gas resource is as big as the BGS thinks, it will be hard to ignore.

1 https://www.og.decc.gov.uk/upstream/licensing/shalegas.pdf

THE MUSICAL BRAIN: IMPLICATIONS FOR EDUCATION AND BEYOND

Dr Ellie Dommett
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The Open University

The APPG on Scientific Research in Learning and Education explores issues at the interface between scientific research and education and few issues fit this remit more so than music, which has been the focus of a recent government review. As such the effects of music were considered by the APPG at a meeting chaired by Baroness Morris and Prof Coen of King's College London, a musician and neuroscientist. The meeting first heard from Prof Philip Sheppard of the Royal Academy of Music. Prof Sheppard outlined the extent of the impact music has on our lives, acknowledging its role in culture and bonding. He cites the example of nursery rhymes, which exist in all cultures, and carry a message about attempting something, failing and trying again – a primal message that is important to communicate to children. He also suggests that certain features of music such as inflection and gesture are critical to higher order communication. He explained how music can be beneficial to learning, citing the example of singing being used to assist learning lengthy material such as the Quran or periodic table. He suggested that there is a level of deep learning that occurs when individuals create music that is not present when you merely repeat what others have created. This creation also helps develop a sense of self and ownership and has strong implications for how we teach music.

Following Prof Sheppard, Dr Lauren Scott, a neuroscientist at Goldsmiths, University of London, outlined the impact music has on the brain. She explained that the brain changes throughout life in response to experiences and learning and that music can be considered a super skill. Unpicking this super skill she stated that music involves a number of different elements including the ability to plan and execute complex movement sequences as well as integrating information across the senses as one reads visual symbols and uses them to create a movement. She provided evidence detailing how the brains of musicians differ, showing enlargements of areas responsible for movement and touch processing as well as alterations to the regions involved in hearing. She states that one area often underestimated is expertise as listeners and how individuals can be educated to hear certain types of music as the brain learns what to listen to and effectively ensures that information is then heard. She outlined current research looking into musicality and what facets are associated with it. Although the research is ongoing, she suspects that not all facets will require formal musical training. From Dr Scott's presentation then, one could conclude that musicality in some form can be found in a large proportion of individuals, including those who have not received music training and that as well as education providing an opportunity to create music; it should consider teaching how to listen to music.

Finally Prof Susan Hallam from the Institute of Education spoke about the wider impact of music. She began with a note of caution that music is so much a part of our lives and so accessible that it is at risk of being taken for granted. She provided evidence of music improving social and personal development as well as language and therefore literacy, physical and intellectual development and attainment. For example, she cited music improving fine movements and therefore improving writing. She reported findings from the "In Harmony" project which demonstrated that music training can result in increased

performance on English and Maths SATs, even when the children have had less time studying these core subjects due to increased time spent on music education. She suggests that music can improve mood, wellbeing and measures such as attention and concentration and that these benefits occur across the whole lifespan.

All speakers were emphatic that music education is critical and that the benefits transfer across the entire curriculum and beyond education. The discussion that followed included debate on the best type of music to start with, accessibility of music to those of lower socioeconomic status and whether group or individual lessons were optimal. Although a number of factors were considered, the general consensus was that beginning with the voice through singing was a sensible choice and that group training was useful, although individual lessons may be necessary as well to achieve particular levels of proficiency. It was clear that music should not be taken for granted and that as education changes, losing sight of music would be a mistake that impacts on development beyond the curriculum.

TIME FOR ACTION ON E-WASTE

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In August 2008 the New York Times described e-waste as "the world's fastest growing and potentially most dangerous waste problem". Yet despite continued criticism over its poor record on tackling the problem the UK Government has been slow to respond to the urgent need to stem the illegal exports of waste electronic equipment to the developing world.

The UK is currently responsible for illegally exporting around 23,000 tonnes of computers alone to Africa each year, the problem has yet to rise far enough up the political agenda to merit serious attention. This means that the UK remains in violation of the Basel Convention, and it is now in violation of a 2009 amendment to the European Waste Shipment Regulation, which effectively brought the Basle Convention into law.

A high profile investigation by the Independent, Sky News and Greenpeace in 2009, highlighted how the public sector remains a source of e-waste that evades customs by being labelled for 're-use' by tagging a TV disposed of at a municipal waste facility in Hampshire and tracking it to Africa. Whilst several recent prosecutions by the Environment Agency have begun to raise the profile of the issue, these merely represent the tip of the iceberg. Both the EA and its Scottish equivalent SEPA provide registers of approved recyclers and exporters but, as is the case with the stretched resources of environmental lobby groups, the sheer scale of the problem and its lack of visibility demonstrate the need for a dedicated organisation. Furthermore, as cowboy operations can undercut the costs of responsible recyclers this lack of support is also hindering the growth of the UK's e-waste recycling industry. Yet given the current economic climate the case for making the relatively small investment that would be needed to provide a significant boost to a mature and profitable industry can be made on economic grounds alone.

In the US, the Basel Action Network administers the e-Stewards initiative (see www.e-stewards.org) and is now expanding it overseas. E-Stewards is a third-party audited accreditation programme that provides certification for responsible recyclers that ensure that no e-waste is dumped in landfills or incinerators, exported to developing countries or sent to prison labour operations, and ensure no release of private data from waste devices. E-Stewards was so popular with industry that it was over-subscribed even in its pilot year. BAN has been able to make this progress due to the backing of leading recyclers in North America, and because it is able to focus solely on tackling the problem.

In response to these needs in Sept 2009 the Photonics and Plastic Electronics and Resource Efficiency Network Knowledge Transfer Networks backed and published my call for a new independent, industry-led organisation to provide the following:

- Easily accessible and informed advice on e-waste
- Awareness-raising through targeted advice to the public and private sectors, and to consumers
- A platform for lobbying to end the UK's illegal exports of e-waste
- An independent, industry-backed registration system for responsible recyclers, based on e-Stewards

Since then little has changed and the call remains a live document. However, given the continued economic downturn and the significant potential for growth in the UK's e-waste recycling industry, let alone the environmental benefits this would bring, there are now more reasons than ever for the UK Government to support this call.

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

Strategically important metals

On 11 November 2010 the Committee announced an inquiry into strategically important metals. The Committee held three oral evidence sessions.

On 26 January the Committee took evidence from Professor David Manning, Secretary, Professional Matters, Geological Society, Dr Bernie Rickinson, Chief Executive, Institute of Materials, Minerals and Mining, Dr Mike Pitts, Industry Technology Division, Royal Society of Chemistry, Ian Hetherington, Director General, British Metals Recycling Association, Sophie Thomas, Council Member, The Design Council, Tony Hartwell, Knowledge Transfer Manager, and Louis Brimacombe, Head, Environment & Sustainability Research Team, Tata Steel.

On 16 February the Committee took evidence from Charles Emmerson, Senior Fellow, Chatham House, Dr Jonathan Di John, Lecturer in Political Economy, School of Oriental and African Studies, Anthony Lipmann, Managing Director, Lipmann Walton & Co Ltd, and former Chairman, Minor Metals Trade Association, and Charles Swindon, Chair of the Trade and Lobby Committee, Minor Metals Trade Association.

On 2 March the Committee took evidence from Professor Robert Watson, Chief Scientific Adviser, Department for Environment, Food and Rural Affairs, Professor David Clary, Chief Scientific Adviser, Foreign and Commonwealth Office, and Rt Hon David Willetts MP, Minister of State for Universities and Science

UK Centre for Medical Research and Innovation

On 18 November 2010 the Committee announced an inquiry into the UK Centre for Medical Research and Innovation (UKCMRI). The Committee held three oral evidence sessions.

On 9 February the Committee took evidence from Professor Malcolm Grant, President and Provost, University College London, Harpal Kumar, Chief Executive, Cancer Research UK, Professor Sir John Savill, Chief Executive, Medical Research Council, Sir Mark Walport, Chief Executive, Wellcome Trust, and Natalie Bennett, Chair, Rob Inglis, Press Officer, and Frankie Biney, St Pancras and Somers Town Planning Action.

On 16 February the Committee took evidence from Sir Paul Nurse, Chief Executive and Director, Sir David Cooksey, Chairman, and John Cooper, Chief Operating Officer, UK Centre for Medical Research and Innovation.

On 2 March the Committee took evidence from Rt Hon David Willetts MP, Minister of State for Universities and Science, and the Earl Howe, Parliamentary Under-Secretary of State for Quality, Department of Health

Astronomy and Particle Physics

On 26 January 2011 the Committee announced an inquiry into Astronomy and Particle Physics. The Committee invited written submissions on the following issues by 16 February 2011:

1. the impact of reduced capital funding on UK capability;
2. the impact of withdrawal from international ground-based facilities (for example the Gemini Observatory and Isaac Newton Group of telescopes) on the UK's research base and international reputation;
3. whether the Science and Technology Facilities Council (STFC) has sufficiently engaged with its research community in these two areas on its strategic direction and impacts of budget reductions; and
4. opportunities for, and threats to, outreach and inspiring the next generation of astronomers and particle physicists.

The Committee visited CERN near Geneva on 2-3 February 2011 in connection with this inquiry.

The Committee held two oral evidence sessions.

On 9 March the Committee took evidence from Anna Barth, Camden School for Girls, London, Jack Bliss, Allerton Grange School, Leeds, Jessica Grainger, Saints Peter and Paul Catholic College, Widnes, Hilary Lamb, Stroud High School, Gloucestershire, James May, Castell Alun High School, Hope (nr. Wrexham), and Charlie Palin, Neston High School, Cheshire, Dr Maggie Aderin-Pocock, Space Scientist, Astrium Ltd and Science Innovation Ltd, and Professor Jim Al-Khalili, Professor of Physics, Professor of Public Engagement in Science, University of Surrey, Professor Dame Jocelyn Bell-Burnell, President, Institute of Physics, and Professor Roger Davies, President, Royal Astronomical Society.

On 16 March the Committee took evidence from Professor Phil Allport, Head of Particle Physics and Director of the Liverpool Semiconductor Detector Centre, University of Liverpool, Professor Mike Bode, Director of the Astrophysics Research

Institute, Liverpool John Moores University, Professor Robert C Kennicutt Jr, Plumian Professor of Astronomy and Experimental Philosophy Director, Institute of Astronomy, University of Cambridge, Professor John Peacock, Head of the Institute for Astronomy, University of Edinburgh, Professor Steve Rawlings, sub-Department of Astrophysics, Oxford University, and Professor Andrei Seryi, Director, John Adams Institute for Accelerator Science, Professor Keith Mason, Chief Executive of the Science and Technology Facilities Council, and Sir Adrian Smith, Director General, Knowledge and Innovation, Department of Business, Innovation and Skills.

Forensic Science Service

On 19 January 2011 the Committee announced an inquiry into the Government's decision to wind down the Forensic Science Service. The Committee invited written submissions on the following issues by 14 February:

1. What will be the impact of the closure of the Forensic Science Service on forensic science and on the future development of forensic science in the UK?
2. What will be the implications of the closure on the quality and impartiality of forensic evidence used in the criminal justice system?
3. What is the financial position of the Forensic Science Service?
4. What is the state of, and prospects for, the forensics market in the UK, specifically whether the private sector can carry out the work currently done by the Forensic Science Service and the volume and nature of the forensic work carried out by police forces?
5. What are the alternatives to winding-down the Forensic Science Service?
6. So far as they are known, are the arrangements for closing down the Forensic Science Service, making staff redundant and selling its assets adequate?

The Committee visited the Forensic Science Service in Lambeth on 22 March 2011, and a member of the Committee visited LGC in Teddington in a representative capacity on 6 April 2011 in connection with this inquiry.

On 23 March the Committee took evidence from Bill Griffiths, Chairman, Dr Gillian Tully, Research and Development Manager, Forensic Science Service, and Steve Thomas, Officer for Forensic Science Service, Prospect Union.

On 30 March the Committee took evidence from Professor Jim Fraser, Director, Centre for Forensic Science, University of Strathclyde, David Hartshorne, Commercial Director, Cellmark Forensic, Professor Sir Alec Jeffreys, Professor of Genetics, University of Leicester, David Richardson, Chief Executive, LGC, Dr Simon Bramble, Head of Police Science and Forensics, National Policing Improvement Agency, Roger Coe-Salazar, Chief Crown Prosecutor, Crown Prosecution Service, Gary Pugh, Director of Forensic Services, Metropolitan Police Service, and Chief Constable Chris Sims, Association of Chief Police Officers.

The Committee took further evidence on Wednesday 27 April from Professor Bernard Silverman, Chief Scientific Adviser, Andrew Rennison, Forensic Science Regulator, Home Office, and James Brokenshire MP, Parliamentary Under-Secretary of State for Crime Prevention, and Stephen Webb, Director of Finance and Strategy, Crime and Policing Group, Home Office.

The written evidence received on all these inquiries is on the Committee's website.

Peer review

On 26 January 2011 the Committee announced an inquiry examining the peer review process. The Committee invited written submissions on the following issues by 10 March 2011:

1. the strengths and weaknesses of peer review as a quality control mechanism for scientists, publishers and the public;
2. measures to strengthen peer review;
3. the value and use of peer reviewed science on advancing and testing scientific knowledge;
4. the value and use of peer reviewed science in informing public debate;
5. the extent to which peer review varies between scientific disciplines and between countries across the world;
6. the processes by which reviewers with the requisite skills and knowledge are identified, in particular as the volume of multi-disciplinary research increases;
7. the impact of IT and greater use of online resources on the peer review process; and
8. possible alternatives to peer review.

The Committee expects to hold oral evidence sessions in May and June. The written evidence received is on the Committee's website.

Spending Review 2010

On 24 November 2010 and 19 January 2011 the Committee took oral evidence on the Spending Review 2010. 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 will be placed on the Committee's website.

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 on the following issues by 11 May 2011:

1. How important are practical experiments and field trips in science education?
2. Are practical experiments in science lessons and science field trips in decline? If they are, what are the reasons for the decline?
3. What part do health and safety concerns play in preventing school pupils from performing practical experiments in science lessons and going on field trips? What rules and regulations apply to science experiments and field trips and how are they being interpreted?
4. Do examination boards adequately recognise practical experiments and trips?
5. If the quality or number of practical experiments and field trips is declining, what are the consequences for science education and career choices? For example, what effects are there on the performance and achievement of pupils and students in Higher Education?
6. What changes should be made?
7. Is the experience of schools in England in line with schools in the devolved administrations and other countries?

The Committee expects to take oral evidence in June and July 2011. The written evidence received will be placed on the Committee's website.

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].

Pfizer's decision to close its research and development facility at Sandwich

On 4 February 2011 the Committee announced that it would take oral evidence on Pfizer's decision to close its research and development facility at Sandwich. The Committee held two oral evidence sessions.

On 28 February the Committee took evidence from Dr Richard Barker, Director General, Association of the British Pharmaceutical Industry, Dr David M Hollinshead, Royal Society of Chemistry, Richard Blackburn, Managing Director, Pfizer UK, Dr Olivier Brandicourt, President and General Manager of Pfizer's Primary Care Business Unit, Dr Rod MacKenzie, Senior Vice President and Head of Worldwide Research for PharmaTherapeutics Research and Development, and Dr Ruth McKernan, Senior Vice President and Site Head, Sandwich, and Chief Scientific Officer for Pfizer Regenerative Medicine.

On 2 March the Committee took evidence from Rt Hon David Willetts MP, Minister of State for Universities and Science.

Following the evidence session the Committee wrote to the Government on 16 March and the Government replied on 25 March 2011. These letters and the associated written evidence received is on the Committee's website.

REPORTS

The Reviews into the University of East Anglia's Climatic Research Unit's E-mails

On 25 January 2011 the Committee published its First Report of Session 2010-11, *The Reviews into the University of East Anglia's Climatic Research Unit's E-mails,* HC 444.

Technology and Innovation Centres

On 17 February 2011 the Committee published its Second Report of Session 2010-11, *Technology and Innovation Centres*, HC 619.

Scientific advice and evidence in emergencies

On 2 March 2011 the Committee published its Third Report of Session 2010-11, *Scientific advice and evidence in emergencies*, HC 498.

GOVERNMENT RESPONSES

The Committee awaits a response to one of its predecessor Committee's Reports of Session 2009-10, *Bioengineering*, Seventh Report (HC 220); the response is expected shortly. The Committee is also expecting to receive shortly a response to its First Report of Session 2010-12, *The Reviews into the University of East Anglia's Climatic Research Unit's E-mails* (HC 444). It is expected that both responses will be published as Special Reports in May 2011.

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, Glenn McKee, 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 COMMONS LIBRARY SCIENCE AND ENVIRONMENT SECTION

Research Papers produced for Members of Parliament are summarised opposite. Papers can be accessed at http://www.parliament.uk/business/publications/research/research-papers/

The Section produces a series of frequently updated notes on a wide of topics. Overleaf 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

Localism Bill: Committee Stage Report
Research Paper 11/32

This is a report on the House of Commons Committee Stage of the Localism Bill. It complements Library Research Papers 11/02 (Local Government and Community Empowerment) and 11/03 (Planning and Housing) prepared for the Commons Second Reading.

The Bill covers a wide range of topics in local government, planning, housing and the governance of London. The Bill was not substantially amended in Committee, although there were some minor technical Government amendments. However, at several points, Ministers agreed to look again at certain issues and consider whether to introduce amendments at Report Stage.

Energy Bill
Research Paper 11/36

This briefing was prepared for the Second Reading Debate on the Bill in the House of Commons. The flagship policy in the Bill is the framework for a Green Deal; a scheme whereby energy efficiency measures in households and non-domestic properties could be paid for upfront by a finance package, which would then be repaid by savings made through lower energy bills. The Bill also provides for a new obligation on energy companies to help certain groups of consumers with saving energy and money on heating costs, particularly those who may not qualify for the Green Deal.

The Bill also introduces a range of other measures designed to improve energy efficiency;

facilitating the roll-out of smart meters, widening access to energy performance certificates and making information on energy bills clearer. It also provides measures designed to help improve energy security, to encourage low carbon generation and to grant additional powers to the Coal Authority to charge for certain services.

The Bill has completed all of its stages in the House of Lords. One of the particular concerns raised was the large number of provisions for further delegated legislation provided for in the Bill. This paper explains all the elements of the Bill and reaction to them in more detail.

Japanese quake: nuclear power SN/SC/5900

This note sets out official information from the International Atomic Energy Agency (IAEA) about the nuclear power plants in Japan following the earthquake and tsunami, 11 March 2011, with comments about what is happening and why. The note also covers the effect of the crisis on the nuclear energy policy of the UK, the EC and other countries.

Carbon Price Support SN/SC/5927

Fluctuations in the price of carbon in the form of EU ETS allowances have resulted in uncertainty for investors in low carbon technologies. This has contributed to a lower level of investment in these technologies, below what is required to meet UK carbon reduction and renewable targets.

The Coalition Government committed to introduce a floor price for carbon and published a consultation on carbon price support in December 2010. Following this it announced in the March 2011 Budget that it would be introducing price support via the Climate Change Levy and fuel duty with a target price of £30 per tonne of carbon dioxide in 2020. The floor price will start at about £16 per tonne. The trading price in March 2011, which was higher than it has been for some time, was around £15 per tonne.

Renewables: Feed-in Tariffs and The Renewables Obligation SN/SC/5870

The Renewables Obligation (RO) and Feed-in Tariffs (FITs) are part of the Government's strategy for increasing renewable electricity generation. This is necessary because the UK has an EU target for renewable energy of 15% by 2020, a significant proportion of which is expected to come from electricity.

The Renewables Obligation, as originally introduced in 2002, was criticised for being too complicated, particularly for small generators, and not distinguishing between different technologies in need of varying levels of support. These issues have now been addressed. The first by the introduction of FITs for generators of less than 5 MW; the second by introducing banding for the different technologies, which will be reviewed regularly. The main criticism that has been made of FITs, which is not limited to the UK, is that they are an expensive way of stimulating renewable generation.

The first review of FITs was due in 2013 but has been brought forward. The Government was concerned about the increasing number of large photovoltaic projects under FITs and the low level of anaerobic digestion schemes so far. The Government has published a consultation in which it proposes a scaled reduction of the tariffs for solar projects of above 50kW. Changes would be made in July 2011 and take effect from 1st August 2011.

The review of banding for RO Certificates is also under way. The Government intends to announce the changes to the RO, to be implemented in 2013, by the end of 2011 to ensure greater investor certainty.

Carbon capture and storage SN/SC/5086

Carbon capture and storage (CCS) is a new, developing, technology that would capture the carbon dioxide from fossil fuels either before, during or after combustion in energy generation. The CO_2 would then be transported and stored long-term in underground geological formations, such as saline aquifers and depleted oil and gas reservoirs.

In Budget 2007 a competition was announced for government funding for one post-combustion CCS demonstration plant, originally due to be operational around 2014. There is now only one entrant left in the competition and completion is expected in 4-6 years time. A process to select a further three demonstration projects is due to be announced later in 2011.

This note sets how CCS might work, along with some of the concerns. It also outlines Government proposals for an emissions performance standard on coal-fired power.

Consents for Wind Farms – Onshore SN/SC/4370

Wind farms require either planning permission or consent under the Planning Act 2008. This note discusses why so many applications for onshore wind farms have been rejected, and whether the system is resulting in unacceptable delays.

Many applications for onshore wind farms were rejected under the Labour Government. The main reason was concern that a large wind farm would damage the landscape. Some applications were approved, partly because their visual impact was normally considered to be limited and partly because of Labour Government targets to encourage the use of more renewable energy.

The Localism Bill would abolish Regional Spatial Strategies, including regional targets for renewable energy. This intention can already be taken into account in determining planning applications. Another scheme will offer a local community benefits from hosting a wind farm. As an incentive, it will be allowed to retain the additional business rates generated.

How UK farmers could reduce greenhouse gas (GHG) emissions SN/SC/4340

It is generally accepted that the emissions of greenhouse gases (GHG) need to be sharply reduced. This note considers how agriculture could contribute to this objective.

A report by Stanford University in 2010 concluded that intensive farming contributed to reduction in carbon emissions, because the alternative would be to use much more land at a lower productivity. The researchers found that agricultural advances between 1961 and 2005 spared a portion of land larger than Russia from development and reduced emissions by the equivalent of 590 Gigatonnes of carbon dioxide – roughly a third of the total emitted since the start of the Industrial Revolution.

Some people argue that a vegan diet is necessary to reduce emissions of methane from ruminants. Others argue that changes to feeding practices can achieve considerable reductions.

In November 2010 the Government announced increased funds for research into measuring the effect of specific agricultural practices on GHG emissions. On 29 March 2011, the UK farming industry launched a Greenhouse Gas Action Plan.

Bees and Varroa SN/SC/446

There has been a dramatic decline in bee numbers worldwide. The reasons for the decline are unclear. Possibilities include some environmental stress, pesticides, combined with weakness from diseases like varroa. The decline could seriously affect pollination of orchards.

Defra launched a Bee Health Plan in 2009, including £10m to be spent on research into pollinators, including honey bees. A Public Accounts Committee report in 2009 – after the launch of the Bee Health Plan – called for a higher priority for honey bees. Varroa has

spread through the British bee population since about 1990. Treatments have been developed but the bees may be left seriously weakened.

News from the USA in May 2010 of further extensive losses has raised concerns that honey bees might be in terminal decline. The British Beekeepers Association reported further losses in the 2009/10 winter, but less than in 2008/9.

US research suggests that colony collapse results from a combination of a virus and a fungus. UK research suggests that the decline in pollinators is partly caused by certain wild plants being out-competed by other plants, so that less nectar is available for bees.

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. Lord Alderdice, Lord May of Oxford, Baroness O'Neill of Bengarve and Lord Sutherland of Houndwood have been co-opted to Sub-Committee I for the purposes of its inquiry into behaviour change policy interventions.

Nuclear research and development capabilities

In March 2011, the Science and Technology Committee, under the Chairmanship of Lord Krebs, launched a short inquiry into the UK's nuclear research and development (R&D) capabilities.

The inquiry will focus on what the Government should be doing if they are to ensure that the UK's R&D capabilities are sufficient to meet our nuclear energy requirements into the future. It will examine, 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.

Whilst the Committee decided to undertake the inquiry before the recent events in Japan at the Fukushima Daiichi nuclear plant, health and safety R&D capability is within the scope of the inquiry and the Committee is inviting evidence on these matters.

A call for evidence was released on 17 March 2011 with a deadline for submission of 28 April 2011. The Committee held a workshop with Government officials and key stakeholders on 5 April to start off the inquiry. The Committee will hold public meetings from 10 May 2011 and the report will be published later in 2011.

Behaviour change policy interventions

The Select Committee has 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.

As governments across the world attempt to meet societal challenges such as reducing carbon emissions and alleviating the burden on health services caused by smoking, drinking and the rise in obesity, 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 sub-committee will consider 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 will also be looking 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.

As part of its inquiry, the sub-committee is also conducting two case studies. The first will look at behaviour change interventions designed to reduce obesity. The second will focus on travel-mode interventions to reduce car use in towns and cities.

A call for evidence was published on 28 July 2010 with a deadline for submission of 8 October 2010. A second call for evidence on the travel-mode interventions case study was published on 10 December 2010 with a deadline for submission of 21 January 2011. The Committee held a seminar as part of the obesity case study on 19 October 2010 and a second seminar on travel-mode interventions on 26 January 2011. The Committee began taking oral evidence in November 2010 and finished in March 2011. The Committee is due to report in the summer.

Public procurement as a tool to stimulate innovation

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 is focused, in particular, on the Department for Transport and related public bodies, as a working example of the current procurement practices within departments. The inquiry seeks to investigate the extent to which the current procurement practices and processes are effective in encouraging innovation within industry and supporting the development and diffusion of innovations.

A call for evidence inviting written submission was published on 22 October 2010 with a deadline of 13 December 2010. The Committee began taking oral evidence on 21 December and is due to report in May 2011.

OUTSTANDING ACTIVITIES FROM THE PREVIOUS PARLIAMENT

Setting Priorities for Publicly Funded Research

An inquiry into the setting of science and technology research funding priorities was launched in July 2009. The inquiry was undertaken by the Select Committee under the chairmanship of Lord Sutherland.

Cuts in overall public spending due to the current economic climate will lead to some difficult decisions about how to allocate public funds for science and technology research. Effective mechanisms for allocating funds are vital if the United Kingdom science base is to remain healthy, both now and in the future, and is able to continue to meet societal needs. The Committee investigated a range of issues including how decisions about funding research are made across Government and within Government departments and other public bodies, whether the balance between funding for targeted research and unsolicited response-mode curiosity-driven research is appropriate, and how research is commissioned.

The Committee published its report on 1 April 2010. The Government response to the report was published on 30 July 2010. The report is likely to be debated in the House during the current session.

Radioactive Waste Management: a further update

The Select Committee appointed a Sub-Committee to conduct a short follow-up inquiry into the management of radioactive waste, following the Committee's previous reports on the subject, the last of which was published in session 2006-07.

The inquiry focused on the role and performance of the Committee on Radioactive Waste Management (CoRWM) which provides independent scrutiny and advice on the implementation of the Government's Managing Radioactive Waste Safely programme. The Committee held a one-off evidence session with representatives from CoRWM, Lord Hunt, Minister of State for Energy and Climate Change, and representatives from the Department of Energy and Climate Change and the Nuclear Decommissioning Authority in February 2010, and published its report on 25 March 2010. The Government's response was received on 9 November 2010 and the report was debated by the House on 10 February 2011.

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

Environmental Limits

March 2011 *POST Long Report 370, 159 pages*

An environmental limit is usually interpreted as the point or range of conditions beyond which there is a significant risk of abrupt irreversible, or difficult to reverse, changes to the benefits derived from natural resource systems with consequent impacts on human well-being. Natural resources such as land, water, soil, plants and animals should be used and managed within boundaries that allow the resource to renew itself. Otherwise, well-being, for present and future generations, will be affected. This POST long report on environmental limits sets out the challenges to achieving this aim, while considering the complex trade-offs between social, economic and environmental objectives.

Housing and Health

January 2011 *POSTnote 371*

The Decent Homes Programme aimed to refurbish all social sector homes to a minimum standard between 2000 and 2010. The Government will invest a further £1.6 billion to improve housing in the public sector. However, housing quality is poorest in the private rented sector; homes in this sector housing people on benefits are not supported under the new initiative. This briefing looks at the impact of poor housing on health and examines the implications for housing policy.

Future Electricity Networks

February 2011 *POSTnote 372*

Ongoing reforms of regulation and the electricity market aim to transform the electricity system and its operation. This will require many billions of pounds of investment in the UK's electricity networks to:

- renew ageing networks;
- make networks 'smarter', particularly at the regional level;
- build and reinforce networks both inland and offshore.

This note examines the possibilities and challenges for network development in the UK.

Water Adaptation in Africa

April 2011 *POSTnote 373*

Africa is one of the world's regions most vulnerable to climate change. Potential impacts of climate change on the continent are multiple but are mostly connected through the medium of water. Historically, the continent has unpredictable rainfall and climate patterns which are likely to be exacerbated by future climate change. This briefing, the latest in POST's series on science and technology for development, discusses adapting water resource management to climate change.

Unconventional Gas

April 2011 *POSTnote 374*

Unconventional sources of gas have recently gained much attention due to the significant contribution they are making to US gas production. This POSTnote examines the potential for unconventional gas exploitation in the UK, the regulatory regimes covering such activity, and the issues surrounding the extraction and use of the gas.

Deception Detection Technologies

April 2011 *POSTnote 375*

Deception detection technologies such as polygraphs have been available for decades, although their use is controversial. Newer techniques are being developed that aim to detect deception based on facial imaging or brain activity. This briefing outlines the scientific basis for deception detection technology and considers the implications of its use in different contexts.

Mental Capacity Act

April 2011 *POSTnote 376*

Adults with learning disabilities or suffering from dementia, brain injuries or mental illness may be unable to make health decisions for themselves. At such times, others (surrogates) will need to decide in their place. The Mental Capacity Act (2005) provides a surrogate decision-making framework. It exists alongside another such framework – the Mental Health Act. While the Mental Health Act is restricted to compulsory treatment for mental disorders, the Mental Capacity Act has a broader scope. It applies to physical and mental health as well as welfare, finances, property and research participation. This POSTnote outlines how the Mental Capacity Act is being interpreted in healthcare and how it works alongside the Mental Health Act.

CURRENT WORK

Biological Sciences – Animal Health and Biosecurity, Personal Genomics, Improving Livestock, Clinical Trials, Review of Stem Cell Research, An Ageing Workforce.

Environment and Energy – Update to Carbon Footprint of Electricity Generation (POSTnote 268), Energy Security, Future Landscapes, Evidence Based Conservation, Invasive Tree Pathogens, Algal Biofuels, Anaerobic Digestion, Marine Spatial Planning, Embedded Water in Products.

Physical sciences and IT – Solar Technologies, Technologies for Clean Water, Opening Up Public Sector Data.

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

CONFERENCES AND SEMINARS

Radio Spectrum Licences

On 20th January POST hosted a seminar to explore critical decisions on radio spectrum licensing. The daily usage of wireless devices contributes an estimated £42 billion to the UK economy, with uses ranging from smart-phones to air traffic control. Consumer demand for wireless technology has increased dramatically, as has the demand for radio spectrum licences. Ofcom, the spectrum regulator, now auctions licences, and allows licences to be traded. With the Government's commitment to universal broadband access expected further to increase demand for spectrum and a major auction of licences due in early 2012, radio spectrum management is now a key issue for UK industry and consumers. At the event, the issues were discussed by a panel which included Matthew Conway, Director of Government and Parliamentary Business, Ofcom; Julian McGougan, Head of Public Policy & Regulatory Affairs, Arqiva; Martin Sims, Managing Editor, Policy Tracker and Raj Sivalingam, Associate Director for Telecoms and Spectrum, Intellect.

Biodiversity Offsetting

On 25th January POST hosted a seminar on biodiversity offsetting and the potential benefits and risks of market-based conservation strategies within a UK context, with representatives of key groups involved. Environmental legislation protects endangered species and habitats, but does not protect the low-priority biodiversity that supports the functioning and processes of ecosystems. Such biodiversity is being depleted rapidly as a result of human development activities, including agriculture, forestry, transport, industry, and housing development. Conceptually similar to carbon credit schemes, biodiversity offsets are market-based conservation strategies that place economic value on low-priority habitats by measuring human impacts on nature as credits and debits. Angela C Smith MP, Chair of the Conservation and Wildlife All-Party Parliamentary Group, chaired the seminar at which invited guests heard presentations from Bronwen Jones, Head of the Biodiversity Offsetting Team in Defra; Dr Jo Treweek, Partner, Treweek Environmental Consultants; Professor David Hill, The Environment Bank Ltd and Michael Oxford, Project Officer, Association of Local Government Ecologists.

Foresight Project Global Food and Farming Futures

On 9th February POST, in conjunction with the All Party Parliamentary Group on Agriculture and Food for Development and the House of Lords EU Subcommittee D, Agriculture, Fisheries and Environment, hosted the parliamentary launch of the government Foresight project – Global Food and Farming Futures. This has considered how a future global population of 9 billion people can all be fed sustainably and healthily, based on five critical future challenges:

- balancing future demand and sustainable production;
- addressing the threat of future volatility in the food system;
- ending hunger;
- meeting the challenges of a low emissions world; and,
- maintaining biodiversity and ecosystem services while feeding the world.

Lord Carter of Coles, Chair of EU Subcommittee D, Agriculture, Fisheries and Environment, chaired the seminar at which invited guests heard presentations from the Minister of State for International Development at DFID, Stephen O'Brien MP; Professor Sir John Beddington, Government Chief Scientific Adviser and Professor Charles Godfray, Hope Professor at Oxford University. This meeting had the largest attendance of any 'conventional lecture' occasion that POST has ever hosted in its 22-year history, with the largest committee room in the Palace being filled to over-capacity.

Staff, Fellows and Interns at POST

Conventional Fellows (name, institution and sponsoring organisation)

Beth Dyson, Manchester University, Natural Environment Research Council
Eleanor Kean, Cardiff University, British Ecological Society
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
Heather Riley, Birmingham University, Biotechnology and Biological Sciences Research Council
Clare Dyer-Smith, Imperial College London, Royal Society of Chemistry
Anders Aufderhorst-Roberts, Cambridge University, Engineering and Physical Sciences Research Council
Zoe Freeman, Edinburgh University, Biotechnology and Biological Sciences Research Council
Natalie Banner, Kings College London, Wellcome Trust Medical History and Humanities division

Joanna Edgar, Bristol University, Institute of Food Science and Technology

Special Fellow

Dr Mara Almeida, Medical Research Council, Functional Genomics Unit, Oxford University, on a special Portuguese Government one year scholarship to study the functioning of parliamentary science offices.

INTERNATIONAL ACTIVITIES

Lectures and Presentations

On 27th January POST intern Seil Collins, a fluent French speaker, was invited by POST's sister organisation at the French Parliament, the Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques to take part in their planning seminar on a forthcoming study on *"Les Sauts Technologiques en Médecine"*, held at the Assemblée Nationale in Paris.

On 7th March 2011 the Director was a panellist, along with members of the Japanese Parliament's Houses of Representatives or Counsellors, including the chair of the newly-created parliamentary committee that will promote science and technology assessment in Japan, at a special symposium on "How Can Technology Assessment Contribute to Government Policy and Society in Japan". This was organised by the University of Tokyo. A second seminar, held on 11th March, to present the work of POST's Dutch sister organisation, the Rathenau Institute, was regrettably disrupted by the major earthquake that occurred that afternoon.

On 8th February POST Board member Chinyelu Onwurah MP and the Director received a delegation from the Asamblea Legislativa of Costa Rica, led by its Speaker. The delegation had specifically requested a briefing on science and technology issues during its more general mission to the UK Parliament.

In terms of inbound delegations, requests to inform missions from China continue to arrive regularly. In March a delegation of environmental scientists from the north-east province of Shandong requested a briefing on Parliament's long involvement with policy for local air and water quality. They were particularly interested in the circumstances leading to the 1956 Clean Air Act.

POST African Parliaments Programme

Elections have just taken place in Uganda so most project work is directed towards the planning of activities which will take place in the new Parliament, from May onwards. These will include a third round of MP-scientist pairing, the setting up of a "remote mentoring" scheme for Ugandan parliamentary staff working on scientific issues and a parliamentary internship scheme for Ugandan scientists.

SELECTED DEBATES

Opposite is a list of a selection of Debates on matters of scientific interest which took place in the House of Commons, the House of Lords or Westminster Hall between 10 January and 5 April.

HOUSE OF LORDS

10 January	Parkinson's Disease	HoL 1239
11 January	Revised Draft Overarching National Policy Statement for Energy	HoL GC115
13 January	NHS: Front-line and specialised services	HoL 1611
10 February	Radioactive Waste Management: Science and Technology Committee Report	HoL 425
24 March	Adapting to Climate Change: EU Agriculture and Forestry (EUC Report)	HoL 913
31 March	NHS: Standards of Care and Commissioning	HoL 1396

HOUSE OF COMMONS

12 January	Biotechnology and Food Security	HoC 69WH
13 January	Umbilical Cord Blood	HoC 707
25 January	Neonicotinoid Pesticides	HoC 67WH
26 January	UK Internet Search Engines	HoC 133WH
2 February	Myalgic Encephalomyelitis	HoC 323WH
8 February	Student Visas	HoC 271
10 February	Onshore Wind Energy	HoC 147WH
15 February	Wave Power	HoC 258WH
16 February	Renewable Energy The Humber	HoC 322WH
17 February	Rail Investment	HoC 341WH
7 March	Pfizer (Sandwich)	HoC 747
8 March	University Admission	HoC 188WH
8 March	Eco-island Strategy (Isle of Wight)	HoC 207WH
8 March	Humanitarian Disasters	HoC 879
9 March	East London Tech City	HoC 239WH
29 March	Solar Power and Feed-in Tariffs	HoC 47WH
29 March	Rail Engineering (Jobs)	HoC 313
31 March	High-Speed Rail	HoC 147WH
5 April	Net Neutrality	HoC 253WH

PROGRESS OF LEGISLATION

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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Natural History Museum
Royal Society of Chemistry

Industrial Policy and Research
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C-Tech Innovation
Economic and Social Research Council
GAMBICA Association Ltd
Institution of Civil Engineers
Institution of Engineering and Technology
The Royal Academy of Engineering
Semta
STFC

Information Services
AIRTO
CABI

IT, Internet, Telecommunications, Computing and Electronics
EPSRC
Institution of Civil Engineers
Institution of Engineering and Technology
National Physical Laboratory
STFC

Intellectual Property
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The Chartered Institute of Patent Attorneys
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NESTA

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Eli Lilly and Company Ltd
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Physical Sciences
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National Physical Laboratory

Physics
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Pollution and Waste
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AMSI
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National Physical Laboratory
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Plymouth Marine Sciences Partnership

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Biochemical Society
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NESTA
Prospect
Royal Society of Chemistry
Society of Biology

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GAMBICA Association Ltd
LGC
National Physical Laboratory

Radiation Hazards
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LGC

Science Policy
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Biochemical Society
The British Ecological Society
British Nutrition Foundation
British Pharmacological Society
British Science Association
CABI
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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
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Plymouth Marine Sciences Partnership
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Society for Applied Microbiology
Society for General Microbiology
Society of Biology

Wildlife
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The Food and Environment Research Agency
The Linnean Society of London
Natural History Museum
Royal Botanic Gardens, Kew
Society of Biology
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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 is the UK's principal public funder of research and research training across the biosciences. BBSRC provides institute strategic research grants to eight centres, as well as supporting research and training in universities across the UK. BBSRC's research underpins advances in a wide range of bio-based industries, and contributes knowledge to policy areas which include: food security, climate change, diet and health and healthy ageing.

Economic and Social Research Council

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

EPSRC

Engineering and Physical Sciences Research Council

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

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

Medical Research Council

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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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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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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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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

airto
making innovation happen

Contact: Professor Richard Brook OBE FREng
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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.

Association of Marine Scientific Industries

AMSI

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The Association of Marine Scientific Industries (AMSI) is a constituent association of the Society of Maritime Industries (SMI) representing companies in the marine science and technology sector, otherwise known as the oceanology sector.

The marine science sector has an increasingly important role to play both in the UK and globally, particularly in relation to the environment, security and defence, resource exploitation, and leisure. AMSI represents manufacturers, researchers, and system suppliers providing a co-ordinated voice and enabling members to project their views and capabilities to a wide audience.

Biochemical Society

THE BIOCHEMICAL SOCIETY
Founded 1911

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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

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

British Ecological Society

The British Ecological Society
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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

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.

BPS BRITISH PHARMACOLOGICAL SOCIETY

Today's science, tomorrow's medicines

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The British Pharmacological Society has been supporting pharmacology and pharmacologists for over 75 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

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

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

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

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

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

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

Chartered Institute of Patent Attorneys

Founded 1882 Royal Charter 1891

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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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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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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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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

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

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

GAMBICA Association Ltd

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

The Geological Society

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

Institute of Food Science & Technology

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

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

The Institute of Measurement and Control

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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 scientific charity devoted to increasing the practice, understanding and application of physics. It has a worldwide membership of more than 40,000 and is a leading communicator of physics-related science to all audiences, from specialists through to government and the general public. Its publishing company, IOP Publishing, is a world leader in scientific publishing and the electronic dissemination of physics.

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

IChemE is the hub for chemical, biochemical and process engineering professionals worldwide. We are the heart of the process community, promoting competence and a commitment to sustainable development, advancing the discipline for the benefit of society and supporting the professional development of over 32,000 members.

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Institution of Civil Engineers

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

IET The Institution of Engineering and Technology

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

Institution of Mechanical Engineers

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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 29 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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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

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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

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

Natural History Museum

The Science of Nature

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

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

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

The Nutrition Society

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

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

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

PHARMAQ Ltd

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PHARMAQ is the only global pharmaceutical company with a primary focus on aquaculture. 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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Physiology is the science of how humans and other animals function in an integrated way and is the basis for many biological and clinical sciences. Founded in 1876, The Physiological Society is a learned society with over 2,900 Members drawn from over 60 countries. The majority of Members are engaged in research, in universities or industry, into how the body works.

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

PLANTS PEOPLE POSSIBILITIES

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

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

The Royal Institution

The Royal Institution of Great Britain

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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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Website: www.royalsociety.org

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

Contact: Dr Stephen Benn
Parliamentary Affairs
The Royal Society of Chemistry
Burlington House, Piccadilly, London W1J 0BA
Tel: 020 7437 8656 Fax: 020 7734 1227
E-mail: benns@rsc.org or parliament@rsc.org
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

Contact: Mr Andrew Garratt
Press and Public Affairs Manager
The Royal Statistical Society
12 Errol Sreet, London EC1Y 8LX.
Tel: +44 20 7614 3920
Fax: +44 20 7614 3905
E-mail: a.garratt@rss.org.uk
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

Contact: Philip Wheat
Society for Applied Microbiology
Bedford Heights, Brickhill Drive
Bedford MK41 7PH
Tel: 01234 326661
Fax: 01234 326678
E-mail: pfwheat@sfam.org.uk
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,
Spencers Wood, Reading RG7 1AG.
Tel: 0118 988 1802 Fax: 0118 988 5656
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
Tel: 020 7685 2550

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

Contact: Gem Bektas,
Secretary General
Society of Cosmetic Scientists
Langham House East
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Tel: 01582 726661
Fax: 01582 405217
E-mail: ifscc.scs@btconnect.com
Website: www.scs.org.uk

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.

Universities Federation for Animal Welfare

Contact: Dr James Kirkwood
Chief Executive and Scientific Director
The Old School, Brewhouse Hill
Wheathampstead, Herts. AL4 8AN.
Tel: 01582 831818. Fax: 01582 831414.
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

Contact: Annabel Lloyd
Tel: 020 7222 7085
lloyda@pandsctte.demon.co.uk
parliamentaryandscientificcommittee@hotmail.org.uk
www.scienceinparliament.org.uk

Tuesday 17 May 17.30
Discussion Meeting
Boothroyd Room, Portcullis House
Strategic Metals: How can geoscience help increase resources? How will a supply shortage impact on the UK?
Speakers: Andrew Bloodworth, British Geological Survey; Hazel Prichard, Mineral Deposits Studies Group, The Geological Society; and Anthony Hartwell, Environmental Sustainability KTN

Tuesday 14 June 16.30
Boothroyd Room, Portcullis House
The Annual General Meeting
followed at 17.30 by Discussion Meeting
Nuclear Industry
Speakers to be confirmed

Tuesday 12th July 17.30
Discussion Meeting
Boothroyd Room, Portcullis House
What does the Future hold for Pharma in the UK?
Speakers to be confirmed

Tuesday 18 October 17.30
Discussion Meeting
Topic to be chosen in conjunction with the Royal Academy of Engineering

Tuesday 22 November 17.30
Discussion Meeting
Scientific Freedom

THE LIVERY COMMITTEE OF THE CITY OF LONDON CORPORATION, INCLUDING THE WORSHIPFUL COMPANY OF ENGINEERS

Monday 6 - Friday 10 June 10.00-18.00 daily
Livery Exhibition explaining the work of the Livery Companies, including their involvement with science
Upper Waiting Hall, House of Commons

THE ROYAL INSTITUTION

21 Albemarle Street
London W1S 4BS.

All events take place at the Royal Institution. Unless otherwise stated tickets cost £10 standard, £7 concessions, £5 Ri Members. For more information and to book tickets visit www.rigb.org

Saturday 4 June 11.00-16.00
Family Fun Day: **Forensic Science**
Get hands on with the science of crime busting.
Tickets: £10/£5 (under 18s).
Faraday Members free.
Two free under-18 tickets for Ri Members

Wednesday 8 June 19.00-20.30
Nurturing ideas that matter
From the Spitfire to the "knockout mouse", important technologies often begin by looking like crazy long-shots. Yet today's long shots are more expensive and more complex than ever before. Tim Harford examines the evidence that technological progress may actually be slowing down.

Thursday 23 June 19.00-20.30
The origin of our species
Chris Stringer sets out to answer some of the big questions in the debates about our evolution.

Thursday 30 June 19.00-20.30
Defeating ageing with regenerative medicine
90% of Westerners die of ageing. Is a 'cure' just around the corner? Aubrey de Grey claims regenerative medicine for ageing is coming.

Thursday 7 July 19.00-20.30
Aping mankind: neuromania, darwinitis and the misrepresentation of mankind
Raymond Tallis delivers a devastating critique on pseudo-Darwinian thought that is increasingly dominating discussion of what we humans are.

Saturday 30 July 11.00-16.00
Family Fun Day: **Waves**
What are some examples of different types of waves? Light, sound, water, and many more.
Tickets: £10/£5 (under 18s).
Faraday Members free.
Two free under 18 tickets for Ri Members

THE ROYAL SOCIETY

The Royal Society hosts a series of free events, both evening lectures and two-day discussion meetings, covering the whole breadth of science, engineering and technology.

All Royal Society lectures are available from the Royal Society website. The collection includes over 200 lectures with speakers including David Attenborough, Ottoline Leyser and James Lovelock. Details of all of these plus our forthcoming events programme can be found at royalsociety.org

THE ROYAL ACADEMY OF ENGINEERING

3 Carlton House Terrace
London SW1Y 5DG
www.raeng.org.uk/events or
events@raeng.org.uk
020 7766 0600

THE ROYAL SOCIETY OF CHEMISTRY

For details please contact Dr Stephen Benn
benns@rsc.org

ROYAL SOCIETY OF EDINBURGH

22-26 George Street
Edinburgh EH2 2PQ
Tel: 0131 240 5000
events@royalsoced.org.uk
www.royalsoced.org.uk

BRITISH SCIENCE ASSOCIATION

Wednesday 25 and Thursday 26 May
Science Communication Conference
At Kings Place, London.
Every year, the national two-day Science Communication Conference addresses the key issues facing science communicators in the UK and brings together people involved in public engagement. For more information go to: www.britishscienceassociation.org/sciencecommunicationconference

Tuesday 21 June to Thursday 14 July
The Big Bang Regional Fairs
The 2011-12 round of the National Science & Engineering Competition has now opened. Big Bang Fairs are taking place in 11 locations throughout the UK and some lucky students will be selected to represent their region in the Competition finals at The Big Bang in March 2012.
For more information, please visit www.thebigbangfair.co.uk/nearme/

ROYAL PHARMACEUTICAL SOCIETY

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

Thursday 16 June
Analytical methods to combat the counterfeiting of medicines
Joint Pharmaceutical Analysis Group
At GSK R&D, Stevenage

Thursday 7 July
Best practice for outsourcing of analytical support and use of contract laboratories
Joint Pharmaceutical Analysis Group
At the Royal Astronomical Society, London

THE LINNEAN SOCIETY OF LONDON

Burlington House
Piccadilly
London W1J 0BF
Tel: +44 (0)20 7434 4479 ext 11
www.linnean.org
Unless otherwise stated events are held at the Linnean Society of London

Thursday 16th June 18.00
Thinking art from within biology
Alexis Rago FLS

Thursday 7th July 18.00
Species on the EDGE
Craig Turner FLS

SCIENCE IN PARLIAMENT sip
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www.scienceinparliament.org.uk

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All enquiries, including those from members wishing to take the front or back covers, advertise in the journal or appear in the directory to Mrs Annabel Lloyd, Tel 020 7222 7085

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The Welding Institute

Welding with Chocolate

A novel and highly popular attraction delivered by The Welding Institute at the Big Bang UK Young Scientists' and Engineers' Fairs in Manchester in March 2010, and again in London from 10 to 12 March 2011.

Hot plate welding with a safe, low melting point engineering material creates hands-on fabrication fun!

The impressive load bearing capacity of a welded chocolate box girder!

Build it, break it, eat it! What could be better?