SCIENCE IN PARLIAMENT
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SUMMER 2014


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The Parliamentary and Scientific Committee

The Journal of the Parliamentary and Scientific Committee

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For Women in Science

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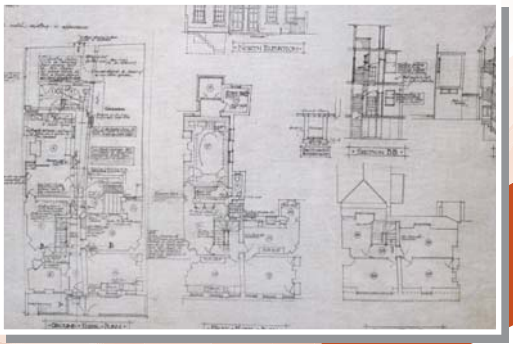

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Andrew Miller MP
Chairman, Parliamentary and Scientific Committee

We discuss from time to time the role which Government should play in deciding what research should be carried out using the funds which the tax payer provides.

The pendulum swings back and forth between "blue skies" and "applied". The Haldane Principal, first enunciated 100 years ago is regularly rolled out to illuminate the debate. Now we have the eight great technologies.

An important piece of directed research has been commemorated this year. The Government decided that a reliable method for sailors to know their longitude was essential for Britain's economic and military security. Latitude of course was easier and the modern sextant evolved from instruments that date back to antiquity.

In 1714, a prize was offered (not a research grant) by Act of Parliament, £20,000 for a solution which could measure longitude to within half-a-degree. That's about €6 million today!

It took John Harrison several decades to construct a timepiece accurate enough to record Greenwich Mean Time while out on the high seas. Naval charts were drawn up using the Greenwich Meridian as the base, and 100 years later the rest of the world (with one exception) fell into line. Not a bad return for the "investment" of £20k.

The concept has now been reinvented with the announcement of a Longitude Prize, but this time the public was asked to vote on what the topic should be. They were given six choices: Flight, Water, Paralysis, Food Security, Dementia and Antibiotics.

The winner was announced on 25th June – "Antibiotics".

This was the subject of one of our discussions during the summer of 2013. Not for the first time, the P&SC was ahead of the game!

Two of the others have been the subject of discussion meetings during the past few years, and a fourth is on our agenda for December this year. Our new website and our journal provide further information.

The distinguished panel of judges was led by Martin Rees who, as the Astronomer Royal, followed in the footsteps of Nevil Maskelyne who led the judges 250 years ago. Plus ça change!

He hopes that the other topics may be taken up by other sources of funding.

SCIENCE IN PARLIAMENT
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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.

CONTENTS

50 YEARS OF MATHEMATICS AND ITS APPLICATIONS

Rebecca Waters
Editorial Officer, *Mathematics Today*

Readers of *Science in Parliament* have seen on the front cover of the Spring issue that the Institute of Mathematics and its Applications (IMA) is 50 this year. The IMA is celebrating this milestone with a series of events in 2014. We were honoured to welcome our Royal Patron for this anniversary year, Her Royal Highness The Princess Royal, to The Royal Society on 14 May, where we held lectures celebrating the many important facets of mathematics that the IMA, and its members, represent.

... highlighting how the maths developed ...

The IMA was created to provide a home for professional mathematicians. The celebration reflected this with talks covering research mathematics, mathematics in teaching, mathematics in industry and maths for all. The importance of mathematics in all these areas was emphasised throughout, with all the talks highlighting how the maths developed in one area impacts on another seemingly unrelated area.

The day began with 'A Toy Model for a Magnetic Toy: from atomistic to continuum' by Professor Alain Goriely, University of Oxford, who used videos and physical demonstrations to show that the behaviour of 'ball-bearing magnets' can be very similar to elastic materials. One example was a circle of magnetic balls which could be compressed (like a bicycle tyre) and would then snap back to the original circular shape. There were two things to take away from Alain's talk. The first is that these magnets are great toys that can be assembled into some amazing shapes for use in maths outreach – see dotpedia.com for examples. The second is that current applied mathematics research on the topic, which investigates how the behaviour of the atomistic (discrete) magnets is similar to the behaviour of elastic (continuous) materials, and the well-known mathematics of elastic materials can be used to model the behaviour of the magnets. It is of course a lot more complicated than that and more details can be found in Alain's article [1].

IMA President, Professor Dame Celia Hoyles DBE, spoke about '50 Years of Maths in Education'. She began towards the beginning of her career. She attended the second International Congress on Mathematics Education (ICME) in 1972, where there was a Turtle Workshop by the MIT Logo group. Revolutionary at the time, this early programming language aimed to teach children about mathematics by getting them to write programs. Although the opportunities for this have significantly increased, programming is still alien to many people. It is important that children are taught programming and know that this is an important skill (alongside art) for the digital arts. Most people don't know you can't make a modern animation without mathematics! The IMA seeks to make this information available (without the need to understand the maths in detail) with its Mathematics Matters series of case studies [2].

'50 Years of Maths in Industry' by Iain Gray (Technology Strategy Board) continued the theme of mathematics hidden from the general public, and more importantly from the very businesses that stand to gain most from using industrial mathematics.

Iain Gray (TSB) emphasised the importance of maths in industry.

... teach children about mathematics ...

Iain gave a fictitious example of a day in the life of 'Isaac', an ordinary man who doesn't see the maths on which his daily life depends. Isaac used the mathematics in his morning coffee, online purchase, vacuum cleaner, Grand Prix viewing, glucose test for diabetes, without realising he had used any maths at all. Iain gave details for each example. I will give only the first – coffee. Coffee bean growers in Rwanda are being aided by an app that provides localised weather and farming recommendations [3].

Maths is hidden but essential to the UK economy. To learn more about the power of mathematics read the IMA's 50th anniversary book, *50 Visions of Mathematics*, which contains 50 maths images and 50 essays on everything from Arbers to Zebras. The book can be ordered on the OUP website [4].

One amazing piece of mathematics that we now all use is public key cryptography, which uses number theory – an area of core mathematics developed without any application in mind. The IMA Gold Medal Lecture, '(Almost) 50 Years of Public Key Cryptography', by Dr Clifford Cocks CB, began by explaining that public key cryptography is not yet 50 years old. The original research was done by Cliff Cocks and colleagues at GCHQ in the late 1960s and early 1970s. It was then secret, but is now everywhere – in chip and pin cards, mobile phone calls, remote car keys, and on the internet for secure transactions, which all use this extraordinarily powerful technique.

The President welcomed The Princess Royal, expressed warm thanks to her for agreeing to be our Patron in our anniversary year and for graciously agreeing to come to our event. She then introduced Professor Ian Stewart (University of Warwick) whose talk, 'Mathematics for the Billion' focused on the mathematics that is used by everyone. There are two ways maths is used by everyone. The first is the basic arithmetic we all use when we go shopping, for example. The second is far more interesting – it is the maths used by Iain Gray's 'Isaac'.

Professor Ian Stewart told us about the maths used by everyone.

HRH The Princess Royal presents IMA MathsCareers certificate to poster competition winner, Miss Laura Guyll.

... we now all use public key cryptography ...

Ian Stewart gave an example of mathematics that has been both research and school maths. Trigonometry was first research mathematics used in Babylonian and Greek times to calculate distances between planets. More recently trigonometry has been the school maths we are all familiar with for calculating the height of trees or mountains. The same mathematics is used to compress images (jpegs) and more recently for fingerprint compression by the FBI (using Daubechies wavelets).

After the talk Dame Celia thanked Professor Stewart and invited The Princess Royal to speak to the IMA guests. As Her Royal Highness mentioned, she is not the first member of The Royal Family to be involved with the IMA; HRH The Duke of Edinburgh was President of the IMA from 1976–1977.

Many of the IMA's activities were mentioned in glowing terms, including conferences, journals, books, promoting careers, employers' forums, MathsCareers, Mathematics Matters, Maths Teacher Scholars, CMath (which is incorporated by Royal Charter and provides a benchmark for professional mathematicians similar to CEng). The Princess Royal stressed the importance of maths teaching to ensure we have enough people in the future.

Her Royal Highness finished by saying that investing in the next generation certainly pays, before announcing her presentation of the certificate to the IMA MathsCareers 11–13 Competition Winner, Miss Laura Guyll, who she had no doubt is one of nature's natural mathematicians and will continue to be so.

The IMA then made two presentations to The Princess Royal in commemoration of her Patronage of the IMA in its 50th anniversary year. Dame Celia presented her with an Honorary Fellowship Certificate, and Chris Budd presented her with a copy of the IMA's 50th anniversary book, *50 Visions of Mathematics*.

... The Princess Royal stressed the importance of maths teaching ...

The day concluded with a comedy routine from stand-up mathematician Matt Parker (QMUL). My favourite part of the show was a trick with barcodes. Given the first 12 digits of a barcode, Matt calculated the final digit using the inbuilt error detection in the bar code [5].

The IMA's 50th anniversary programme continues with a Festival of Mathematics 3–4 July in Manchester, and concludes with a talk on 'Eight Great Reasons to do Maths' by the IMA Vice-President of Communications, Professor Chris Budd at the Royal Institution in October.

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THE SCIENCE OF MAKING COLOUR

Today artists are spoilt for choice by the vast array of synthetically manufactured paint colours.

However, journey back in time and you'll discover that the materials used to make paint pigments were often as creative as the great works of art to which they contributed. Some of the many examples include rich ultramarine blue, made from grinding the semi-precious stone lapis lazuli, the red, pink and orange produced by crushing cochineal insects, and verdigris, a green copper-based pigment.

The chemistry of creating colour also gave rise to a number of health risks, particularly if you were the sort of artist prone to putting the end of a brush in your mouth while concentrating. This ranged from the use of mercuric sulphide in vermilion red, chromates in orange and yellow, and lead carbonate in white.

This story illustrates the inextricable link between artistic and scientific endeavour. It is being celebrated at the National Gallery in the first exhibition of its kind in the UK. Called 'Making Colour', it provides an insight into how artists in the past used pigments to create visual illusions such as depth, reflection and texture, and how our brains and eyes respond to paintings when we view them.

... visual illusions such as depth, reflection and texture ...

The science behind 'Making Colour', and the overall conservation work at the National Gallery, has benefited from the support of the Engineering and Physical Sciences Research Council. The partnership between EPSRC and the National Gallery began in 2010. It highlights the contribution that science and scientists make to the world of art, and the intellectual value that emerges when scientific and artistic traditions come together.

Identifying the material used to make up a pigment provides information on aspects such as the age of a picture and the painting technique used. Being able to harness latest advances in imaging technology is of obvious benefit for conservators at the National Gallery.

However, making use of the latest digital imaging technology can be a tricky business when dealing with an object on the scale of a huge painting. The partnership with EPSRC has provided a solution to this, as Ashok Roy, the Director of Collections at the National Gallery, explains:

"With EPSRC's support we've been able to acquire a very advanced computer controlled micro-positioning easel, which is capable of safely holding a very large painting and moving it incrementally in minute steps. We are able to put in front of a picture a series of different imaging devices. We can use digital imaging to build up a very high resolution image of that object. We're going to be able to use different sensors in the future to scan pictures and learn more about their structure, the way they're made and indeed what needs to be done for their preservation. We will be able to acquire very high resolution images in various parts of the spectrum that would be unobtainable without this technology. It is a real advance in our imaging capabilities."

Claude Monet, 'Lavacourt under Snow', about 1878- 81
(copyright: The National Gallery, London)

This latest example of EPSRC support is shedding new light on old masters. It continues a long tradition of scientific endeavour at the National Gallery whose Scientific Department was founded in 1934. It is a world leader in the study of the materials and techniques of Western European paintings. Infrared imaging, X-ray imaging, electron microscopy and mass spectrometry are all used to discover more about the materials used by artists in the past and how they are likely to change over time.

This new state-of-the art aluminium easel is over six metres long and capable of holding a painting up to 2.8 metres high and wide. As well as its impressive size, the fact that it gives the ability to put any type of camera in front of a painting provides the National Gallery with tremendous flexibility. The same precisely pinpointed area of a painting can be analysed with the different techniques. In addition less space is needed because you do not need a separate room to accommodate each of the different imaging devices.

This flexibility also opens up the opportunity to try out new types of research using other techniques such as hyperspectral imaging, which collects and processes information across the electromagnetic spectrum. "We are able to capture the whole reflected spectrum, so the whole colour is accurate", says Joseph Padfield, a conservation scientist at the National Gallery. "You can take a picture of the painting and map where different materials have been used. This is not something you can now do easily. It is

Sassoferrato, 'The Virgin in Prayer', 1640-50
(copyright: The National Gallery, London).

an area of research that we are hoping to get into in the future."

Spanning the period from the Middle Ages up to the 19th century the exhibition has a wealth of great works of art to choose from. An example is Sassoferrato's *The Virgin in Prayer* (1640-50), where the gentle serenity of Mary's features, as she holds her hands together in worship, are enhanced by the soft drape of her cloak which is painted in a rich, spectacular, deep, royal blue of natural ultramarine, extracted from ground lapis lazuli. The observer feels they could almost reach out and touch the folds of the cloak, because they are so convincing. Moving forward to Claude Monet's *Lavacourt under Snow* makes use of cobalt blue developed by French chemist Louis Jacques Thénard. The picture shows a group of cottages in a French hamlet surrounded by snow. It is a picture that gives meaning to the expression 'blue with cold', as the colour

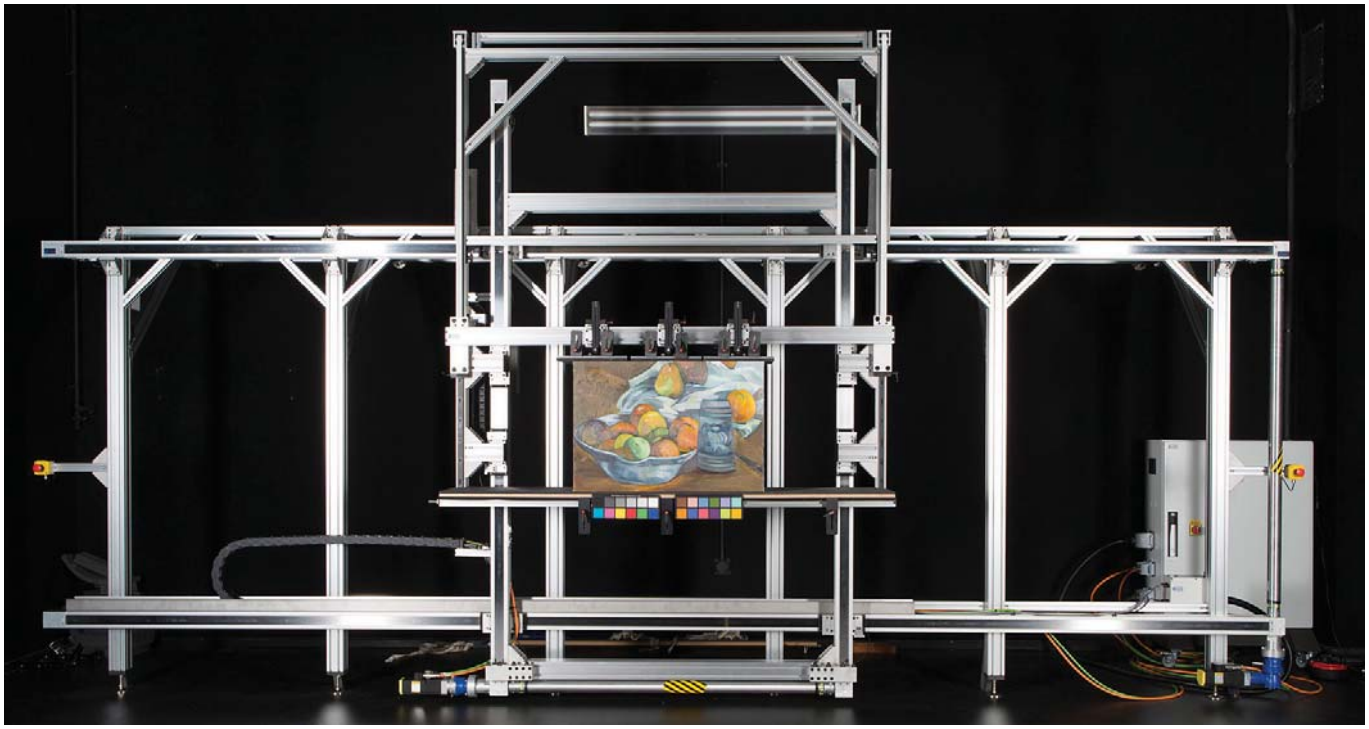
... gentle serenity of Mary's features ...

is reflected everywhere: the snow, the building brickwork, roofs and the surrounding sky and landscape. It was also painted when Monet was short of money, so a hard winter would have been especially difficult and bleak, and this composition conveys a strong sense of desolation. A severe case of what we would call the 'blues'!

Normally close examination of a Sassoferrato or a Monet is the preserve of a select few scientists working with a microscope sitting in front of a painting. Hyperspectral imaging will allow the accurate and reproducible measurements of the colour of paintings and open up the possibility of closer examination of such works of art to many more people.

The easel has also helped to inspire another part of the 'Making Colour' exhibition. This gives visitors a more detailed understanding of how we perceive hues and pigments. It includes an area where you can view a picture under different lighting conditions using tunable LEDs. This is part of an interactive computer-controlled experiment on how the brain and the eye respond to colour, and will contribute to future research at the National Gallery.

If you want to get a new perspective on an Old Master then this exhibition is the ideal opportunity to do so. 'Making Colour' is at the National Gallery until 7th September. You can also find out more about the scientific endeavour in this exhibition in an audio slide-show on Youtube. Put 'EPSRCVideo + The Science of Making Colour' into the YouTube search area.



The new state-of-the-art easel is literally shedding new light on the science behind pigments used in great paintings (copyright: The National Gallery, London).

Supporting Female Scientists in the UK & Ireland:

L'ORÉAL-UNESCO 2014 For Women In Science Fellowships Announced

Katriona Methven
Director of Scientific and Regulatory Affairs, L'Oréal UK & Ireland

The winners of the highly contested 2014 L'Oréal-UNESCO UK & Ireland For Women In Science Fellowships (FWIS) were announced on 19th June 2014 at a ceremony at the Royal Society.

Front cover photos:
1. Dr Eva-Maria Graefe
2. Dr Sneha Malde
3. Dr Clémence Blouet
4. Dr Tracy Briggs
5. 2014 winners together
6. 2014 Jury: from left: Dr Beth Taylor, Prof Pratibha Gai, Prof John O'Halloran, Prof Dame Janet Thornton, Prof John Pethica, Katriona Methven, Prof Anne Glover

With women currently making up just 13% of employees involved in STEM careers[1] and just 17% of professorial level academic researchers in the UK, the fellowships – now in their eighth year in the UK & Ireland – promote the importance of ensuring greater participation of women in science.

Although most agree there is no single explanation for this lack of diversity, starting a family and the absence of long-term contracts in early STEM careers are clearly significant barriers. Indeed, the House of Commons Science and Technology Committee report highlights that while efforts are often made to encourage young women into STEM careers or to study science, little focus is given to enabling them to stay and progress.

This is why the FWIS UK & Ireland fellowships have been designed to provide flexible financial help to women at the early stage of their research careers. Four fellowships of £15,000 were awarded to outstanding female postdoctoral scientists to continue research in their chosen fields. The four winners stated that they will use their fellowship money to purchase equipment, pay for travel to attend conferences, for field trips or international collaborations, and childcare.

Staggeringly, of the 289 women who applied for the fellowships this year, one in four said that they would use the fellowship money to fund childcare, highlighting the unique value of the programme in providing flexible funding to support women in science.

Left to right: Dr Clémence Blouet, Dr Eva-Maria Graefe, Dr Tracy Briggs and Dr Sneha Malde

I was delighted to be part of the jury which had the difficult job of selecting the four fellows. Expertly led by Professor Pratibha Gai who was awarded L'Oréal's prestigious International Laureate in 2013, my fellow judges included Royal Society Vice President Professor Sir John Pethica; Professor Anne Glover, Chief Scientific Adviser to the President of the European Commission; Dr Beth Taylor, Director of Natural Sciences for the UK National Commission for UNESCO; Dame Janet Thornton, Director of the European Bioinformatics Institute and Professor John O'Halloran, Head of School of Biological, Earth & Environmental Sciences at University College Cork.

Choosing between the eight women who were shortlisted

... outstanding female postdoctoral scientists ...

was an exceedingly difficult task, as all of the candidates were hugely impressive in their individual fields. However, it was inspiring to see the extraordinary work that is being carried out in diverse scientific disciplines all across the UK.

THE 2014 WINNERS ARE:

Dr Clémence Blouet, University of Cambridge, 'The consequences of high-fat intake on the hypothalamus and the mechanism behind obesity.'

Obesity and its associated conditions, such as type 2 diabetes and cardiovascular disease, are major health threats worldwide. Research has failed to develop safe therapeutics to treat obesity as we have been unable to characterise the mechanisms underlying eating and weight gain. The brain plays a huge role in the regulation of energy balance. Specialised brain cells in the hypothalamus process information about ingested food and fat stores and directly regulate food intake, energy expenditure or storage. Recent research indicates that a diet high in fat can cause these brain cells to change in type and number, through a process called adult neurogenesis. Clémence's research will improve our understanding of the consequences of a high-fat diet on the plasticity of these cells in the hypothalamus and how, this in turn, affects the body's energy balance. She hopes that this understanding will lead to the discovery of novel therapeutic targets to treat obesity.

Dr Tracy Briggs, University of Manchester, 'Understanding single-gene disorders that lead to systemic lupus'

Lupus is a potentially life-threatening disease that causes the body to attack its own tissue. In many people, it is likely to be the result of a combination of both environmental and genetic factors. However, in some cases, a change in a single gene can cause the condition. Studies of such single-gene causes of disease are helpful to pinpoint which genes play a role in systemic lupus and help to further our understanding of how the disease occurs. Tracy's research will determine the genetic basis of a familial form of lupus, which starts in childhood and predominantly affects the skin. By determining the chemical and genetic changes causing disease, Tracy hopes to determine the origins of lupus.

Dr Eva-Maria Graefe, Imperial College London, 'Engineering holes in quantum systems'

Progress in technology is often triggered by paradigm shifts in science that open up new and unexpected possibilities. Traditionally, loss, leakage, friction, and dissipation of energy from a quantum system were regarded as undesirable and to be avoided. Recent research however, focuses on the possibility of modifying systems via engineering these losses or holes and using them to our advantage. Eva-Maria's research concerns these leaky quantum systems, using a formalism known as non-Hermitian quantum mechanics. The systematic application of these ideas relies crucially on a detailed theoretical understanding of the mechanisms and effects of loss, on all scales. There is currently a lot of research interest in this field and many new experimental areas are opening up as a result. Eva-Maria hopes to provide new theoretical tools for the description and prediction of novel experimental applications, building on her own recent conceptual breakthroughs.

Dr Sneha Malde, University of Oxford, 'Searching for New Physics through measuring the differences between matter and anti-matter'

The universe began with a bang and energy came together to form equal quantities of matter and antimatter, but as the universe cooled and expanded, its composition changed and antimatter disappeared, leaving matter to form everything around us. The LHCb experiment at CERN's Large Hadron Collider was set up to explore what happened after the big bang that allowed matter to survive. Sneha's research at LHCb investigates why the universe is matter dominated. The Standard Model of the universe cannot be the full picture as it fails to answer this and Sneha hopes that New Physics – the term coined to describe the fundamental theories that go beyond the Standard model – will be discovered in the data collected by the LHC experiments. By fully understanding the differences between matter and anti-matter (commonly referred to as CP-violation) that are allowed within the Standard Model, Sneha anticipates the breakdown of the standard model and the manifestation of New Physics. For the first time, the data from the LHCb experiment allows a precise measurement of this difference, the CP-violation parameter "gamma". Sneha aims to expand a powerful method of measurement she has developed, to exploit data which have not yet been analysed. She anticipates a significant step forward in the search for New Physics.

Pratibha Gai, Professor of Chemistry and Physics, Founding Professor of Electron Microscopy and co-director of the York Nanocentre at the University of York commented on the winners: *"We had an absolutely outstanding shortlist this year, and these four women – Dr Clémence Blouet, Dr Tracy Briggs, Dr Eva-Maria Graefe and Dr Sneha Malde exemplify perfectly what the For Women In Science Fellowships stand for. They are deeply talented, committed and hard-working scientists, who have huge passion for their research areas. I am excited to see what they all achieve in the coming year, and am confident that the influence and dedication of the female scientific community in the UK is well represented by these remarkable women."*

This year L'Oréal joined the Government's 'Your Life' campaign, which encourages greater participation at all levels and particularly of young people in science, technology, maths and engineering. With women accounting for only 6% of the UK engineering workforce[2], from 2015 the For Women In Science programme will encourage applications from the engineering, mathematics and computer science fields and increase the number of fellowships to five worth £15,000 each. In addition, L'Oréal will dedicate a separate annual fund of £20,000 for the UK & Ireland Fellows community to support their work as STEM ambassadors, engaging the wider population – and particularly young people – in science.

These fellowships are designed to encourage, but also showcase, the amazing contribution female scientists are making. Considering this shortlist, I think we have achieved that.

The awards are run in partnership with the UK National Commission for UNESCO, the Irish National Commission for UNESCO, with the support of the Royal Society.

References

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2 Research from the Royal Academy of Engineering analysis of the Labour Force Survey, 2004-10 http://www.wes.org.uk/statistics

3D PRINTING – A REVOLUTION IN THE MAKING

The emergence of multifunctional 3D Printing has the potential to create high-value products and enable a new manufacturing revolution.

As a manufacturing technology, 3D Printing is based on the principle of adding material, hence it is also referred to as 'Additive Manufacturing'. A relatively recent approach to the manufacture of end-use components, it is based on creating parts and products directly from raw material in powder, liquid, sheet or filament form and digital 3D design data. This process works by depositing material, usually layer-by-layer, without the need for moulds, tools or dies.

By operating entirely without such tooling, Additive Manufacturing has two key advantages over other, more conventional, manufacturing techniques. Firstly, it enables the manufacture of products without many of the limitations that are normally placed on designs by conventional manufacturing processes involving tooling such as moulds. Secondly, Additive Manufacturing enables the cost-efficient production of bespoke low-medium volume products, which can be highly complex and tailored for a particular function or user.

In terms of established manufacturing thinking, the current focus often lies on large numbers of identical products originating from elaborate global supply chains. The key advantages of Additive Manufacturing allows this to be challenged: it is now possible to create efficiently complex and advanced geometries in a single, integrated, manufacturing step with the added possibility of each unit of output being different. This has led to considerable interest among manufacturing experts and sparked the imagination of the media and the wider public.

Prototype prosthetic arm and hand

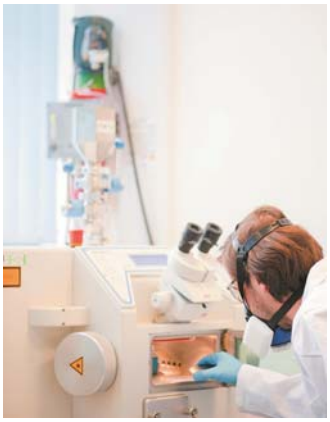
As illustrated by current commercial applications of Additive Manufacturing in the medical and aerospace industries, perhaps the most fundamental potential offered by Additive Manufacturing technology is the ability to produce designs that would not have been possible using traditional processes such as casting or machining. These include products with complex internal channels and pathways or with intricate lattices and honeycombs which can replicate some of the strongest materials that occur in nature, such as bone. In the aerospace and automotive industries, Additive Manufacturing could enable the weight of structures to be reduced by up to 40%, while improving strength and using significantly less raw material in production.

At the Additive Manufacturing and 3D Printing Research Group (3DPRG) at the University of Nottingham, researchers led by Professor Richard Hague are investigating ways of taking this to the next technological level: by depositing more than one material within a single build process, it will be possible to print entire working systems instead of individual parts and components. These could, for example, contain embedded electronics, chemical agents or even biological structures.

This special research focus is why the 3DPRG is recognised as the world's leading research group in the field and is helping to set the global research agenda.

Work at the University of Nottingham has shown that the step away from the single material case to multi-material Additive Manufacturing allows users to move beyond structural applications and create functional systems rather than passive individual components. The possibilities of creating added functionality and user value – through the embedding of 3D structures within structural materials such as engineering polymers or metals – appear immense. Such functional structures that may be built directly include electrical circuitry, optical tracks, sensors, conformal batteries, solar cells, LED screens, antennas and other interfaces.

The embedding of functional structures through the Additive Manufacturing process results in an ability to generate efficiently complex and tailored product solutions. As a fully digital manufacturing process, this aspect connects Additive Manufacturing to the ongoing debate about the consequences of decreases in marginal costs enabled by digital technology. Think, for example, of the impact that electronic media have had on the publishing industry. The possibility of integrating complex and customised functionality direct within products at (almost) no additional cost may produce staggering effects in manufacturing industry. This is likely to lead to manufacturers and designers increasing the levels of functionality of their products.



Operating a selective laser melting system

Especially where multifunctional Additive Manufacturing is used, this also promises to have important consequences for the underlying design approach. This is because low cost sensors and electronics, embedded directly within the component during multifunctional Additive Manufacturing, will be able to provide a wealth of data on a product's useful life. These data can then be used to support design optimisation techniques or customisation approaches, leading to refinements for the following generations of products.

Besides conducting a range of research projects, the 3DPRG has received funding from the Engineering and Physical Sciences Research Council (EPSRC) to host the Centre for Innovative Manufacturing in Additive Manufacturing. This is carrying out an ambitious programme of research worth in excess of £24m, designed to lay the foundations for the exploitation of multifunctional Additive Manufacturing technologies in the UK, enabling future commercial applications for the high value manufacturing industry. Highlights include:

• Development of novel design systems based on multiphysics optimisation

• Research towards structural materials supporting multifunctional Additive Manufacturing via ink jetting approaches

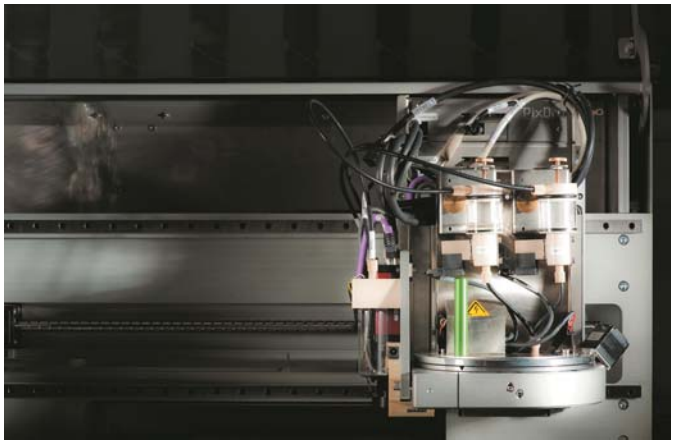
• Deposition of embedded conductive, optical or biological or otherwise functionalised structures from secondary materials

• Computational modelling of processes within multi-material additive deposition

• Micro-scale Additive Manufacturing based on two-photon polymerisation and optical tweezer technology

In terms of the technological approaches investigated, a special focus within the EPSRC Centre lies on the research of novel processes depositing materials via the jetting of droplets. Such processes are ideally suited to deposit a variety of materials at the same time. In a recent development, the group is proud to announce a pioneering project looking into the high temperature deposition of liquid metal via a materials jetting process.

The Centre was recently awarded an additional £2.7m from EPSRC to work with the University's School of Pharmacy on drug delivery through the Additive Manufacturing of pharmaceuticals. Their 3D printed tablets formed part of a landmark exhibition at London's Science Museum, ***'3D: printing the future'***. The printed tablets are structured to allow the release of pharmaceutical agents at varying speeds according to individual patient need. The University is a sponsor and adviser to the exhibition.


A multi-material jetting head in a PixDro materials printer

Student interns at Nottingham created another highlight of the exhibition – a demonstrator for a 3D printed prosthetic arm, illustrating how the technology could evolve to print customised prosthetics with embedded actuators, electronics and pick-ups for nerve endings (see image).


3D printing technology in action

Developing the next generation of researchers is a key strategic goal of the EPSRC Centre. It recently launched the £4.5m Centre for Doctoral Training (CDT) in Additive Manufacturing and 3D Printing. Further investment at the University of Nottingham Ningbo China gives activity a global perspective, building capacity within the world's biggest manufacturing economy.


Structurally optimised design, 3D printed in stainless steel

The commercial potential of Additive Manufacturing is immense.

In 2013, the size of the Additive Manufacturing industry was estimated at round £1.81 billion, with an annual growth rate of over 30%. This makes Additive Manufacturing a small but fast growing area in the manufacturing sector. What really captures the imagination of inventors, innovators and entrepreneurs however is the size of the business opportunity, and the scale of the potential market. As outlined in the Wohlers Report 2012, an annual industry publication, experts speculate that Additive Manufacturing has so far been adopted in only 1% to 8% of potential applications. At full technology diffusion and assuming that industry revenue corresponds to the potential market, this would equate to an industry size from at least £14 billion to over £110 billion in annual turnover.

Additive Manufacturing may also yield environmental benefits. The technology will enable many new supply chain configurations – possibly heavily decentralised – in which the creation of considerable product value is compressed into a single manufacturing process step. Due to excellent product performance, energy efficiency and the minimisation of logistics, it has the potential to reduce the environmental burden of manufacturing activity.

Identified as a key part of one of the government's 'eight great technologies' to drive UK growth, Additive Manufacturing has the potential to bring manufacturing back to high-wage economies around the world. University of Nottingham researchers are ensuring that UK companies will be at the forefront of that revolution.

CELEBRATING 100 YEARS OF PLANT HEALTH AND AGRI-FOOD SOLUTIONS

Dr Philip Newton
Director of Science, Food and Environment Research Agency

June 2014 marked the centenary of what is known today as The Food and Environment Research Agency (Fera). Over the last 100 years Fera has been the leading voice for scientific evidence, advice and solutions across plant health and the agri-food production and supply chain. Only recently, Fera science was critical in developing early responses to detecting ash dieback and identifying horsemeat and associated chemical residues in food. As the pressures on natural resources grow in the future, Fera's role will be ever more critical.

I joined Fera as the Director of Science in April 2014, and am responsible for growing the quality of our scientific outputs and reputation, and translating research into solutions, both nationally and internationally. I need to ensure that Fera's scientific capability maintains its leading edge, and sustains the integrity and quality of all its scientific activity, so as to enable us to solve tomorrow's challenges in plant health and agri-food.

... Fera's scientific capability maintains its leading edge ...

In doing this, each year Fera publishes over 150 scientific papers, analyses over 50,000 plant and food samples, and provides expert advice and input to governments, numerous national and international committees and industry. But as we look to the future, it is fascinating to look where we have come from – and to celebrate Fera's success over a century of evolving to meet the needs of our customers.

Fera's roots can be traced back to 1914. At this time, there was a growing problem of new pests and diseases brought into Britain following international expeditions. This led to the setting up of the Institute for Plant Pathology at the Royal Botanic Gardens, Kew. In 1916, during World War I, the need to improve food storage was brought into focus. Wastage of imported perishable foods was becoming so severe that

Gumley and Chestnut cottages at Kew Gardens – the original home of the Institute for Plant Pathology

research into food preservation was urgently needed and the Food Investigation Board was formed.

The Kew Institute's work proved invaluable, and in 1918 it was re-organised into the Plant Pathology Laboratory, and shortly after was moved to Harpenden, Hertfordshire, where it remained for over 70 years. 1988 saw the now named Harpenden Laboratory merge with the Pest Infestation Control Laboratory – which had arisen largely from the need to protect Britain's World War II grain and flour stocks from pests and disease, and from the growth of ecotoxicology — forming the nucleus of what would become the UK's Central Science Laboratory.

The Cold War led the Government to set up the Strategic Food Stockpile, designed to feed Britain following a nuclear strike. A secret network of giant warehouses held thousands of tonnes of food ready to enter the nation's food chain. Ensuring this food wouldn't spoil became a fundamental responsibility for the Food Science Laboratory and the Pest Infestation Laboratory. Their work was so successful that, even in 1995, well over 200,000 tonnes of food were still in storage.

... Strategic Food Stockpile, designed to feed Britain ...

By 1994, both plant and food roots had come together as the Central Science Laboratory (CSL), along with a world-leading honeybee protection laboratory, the National Bee Unit, which remains central to tackling today's bee-health problems.

CSL has played a vital role in solving critical challenges over the years. In 2001, staff helped to control the foot and mouth outbreak. In 2003 CSL faced another challenge, but it had prepared for this one since the 1980s. Potato ring rot was discovered in seed potatoes, and as the devastating disease favours cooler climates, it could have spread across the UK. Decisive action based on CSL's scientific evidence and advice eradicated the disease, and with continual monitoring, outbreaks are, thankfully, rare. In 2003/04 CSL became the sole laboratory for detecting nitrofurans – banned because of concerns about the safety of their chemical residues – in imported seafood and honey.

Fera scientists using the very latest portable plant health diagnostic equipment at ash dieback sites

In 2009, CSL became Fera, and this included welcoming a number of other organisations including the Plant Health & Seeds Inspectorate, the Plant Varieties Rights Office & Seeds Division and the UK Government Decontamination Service, each of which has a long history. Fera has since provided solutions to some high-profile problems. These include controlling the fungus-like pathogens *Phytophthora ramorum* and *Phytophthora kernoviae*, which saw the first wide scale use of field-based diagnostics, and rapidly developing an early-detection technology for ash dieback. Fera was also on hand to tackle a wide range of food fraud and food safety cases.

... provided solutions to some high-profile problems ...

Responding to crises catches the eye, but more importantly the identification of emerging threats, their early detection, and advice on intervention is the routine business of Fera and results in the avoidance of economic costs as much as successfully tackling a crisis. We are now developing protein-based approaches to determine the animal species in processed foods (in which DNA techniques don't work well), and using advanced analytical technologies to work out how to 'fingerprint' food biologically and chemically. We are also collaborating with the Met Office and industry to improve crop-disease risk forecasting and early intervention advice to farmers. Our broader ambitions include innovation in agricultural technologies to improve the sustainability of food production and consumption.

Fera is evolving, and the next year will see us move from Defra ownership to a joint ownership between Defra and a non-Government partner. Whatever the details, Fera will discover new ways of using science to solve our customers' problems, by providing scientific evidence, advice and solutions across the complexity of the agri-food chain. These problems will become more challenging as drivers such as environmental change, and a rising population with higher living standards, increase the pressure on natural resources, and demand that nations achieve sustainable approaches. Fera's scientists understand the complexity of these challenges, and the evolving regulatory context in which they sit, and will be a critical force providing those elusive, but essential, sustainable solutions.

FARMING NEEDS SCIENCE: SMART SOLUTIONS FOR AN INNOVATIVE INDUSTRY

Meurig Raymond
NFU President

Farmers and growers are innovators and experimenters to the core, even if they do not always realise it. The history of modern agriculture shows how science has transformed farming from a small-scale, largely subsistence activity 300 years ago into an industry that contributes £9.2 billion Gross Value Added to the UK economy (Defra Agricultural Accounts, 2013).

Step-changes in productivity over the past century enabled a rapidly growing population to be fed. Key advances that drove this revolution included mechanisation, rotations, synthetic fertilisers, crop protection and genetic improvement of both crops and livestock. For all its image of rolling countryside, mud and flocks of sheep, in many ways farming is a high-tech industry, reliant on tools and practices grounded in scientific research.

The UK has a world-leading tradition in life sciences. However, we are now paying the price for a period of significant underinvestment in agricultural research, and our farm productivity is suffering. In particular, it is in making the link between research and commercial application where the UK is falling behind.

Addressing this situation is an important goal of the Government's Agri-Tech Strategy, launched in July 2013. This recognises the potential of both the industry and the agricultural research base to grow and deliver economic benefit for the UK. I am hopeful that the added emphasis the Strategy places on applied research and knowledge exchange, as well as the injection of 'catalyst' funding into the sector will make a genuine and long-term difference. The Centres for Innovation should provide a clear link between science and practice. To deliver this there must be genuine collaboration between research centres; knowledge exchange that fosters a culture of equality of expertise between scientists and farmers; and a skills and training infrastructure that is fit for purpose.

... Key advances that drove this revolution ...

We appreciate that there remains a challenge for the Department for Business, Innovation and Skills in delivering this Strategy for the farming sector. Agriculture is not the same as aerospace, automotive or pharmaceutical industries. The vast majority of farm businesses are not carrying out any R&D themselves. They are very much the end users, usually with no direct link or input to the underpinning science. Also, it is easier for economic impact to be envisaged and quantified for agricultural technologies and 'kit' like GPS and sensors on tractors, robotic milking parlours, hydroponics or even decision-making software. While such tools are certainly valuable to farmers, they also need innovation in managing the whole system including soils, water, nutrient flows, animal welfare etc. The route from science to commercial and production gain is far less clear, is subject to a wide range of influencing factors and can take a long time. I would urge the Leadership Council to ensure that practices as well as products are given sufficient weight and can be captured by their delivery mechanisms.

In 2013, the National Farmers' Union (NFU), Agriculture and Horticulture Development Board (AHDB), Agricultural Industries Confederation (AIC) and Royal Agricultural Society of England (RASE) published a report "Feeding the Future: Innovation Requirements for Primary Food Production in the UK to 2030" (www.feedingthefuture.info). It is designed to tell research funders such as BBSRC what the industry's research priorities are:

1. Use of modern technologies to improve the precision and efficiency of key agricultural management practices.

2. Applying modern genetic and breeding approaches to improve the quality, sustainability, resilience and yield-led profitability of crops and farm animals.

... genuine collaboration between research centres ...

3. Use of systems-based approaches to better understand and manage interactions between soil, water and crop/animal processes.

4. Developing integrated approaches to the effective management of crop weeds, pests and diseases within farming systems.

5. Developing integrated approaches to the management of animal disease within farming systems.

6. Develop evidence-based approaches to valuing ecosystem service delivery by land users, and incorporate these approaches into effective decision-support systems at the enterprise or grouped enterprise level.

7. Extending the training, professional development and communication channels of researchers, practitioners and advisors to promote delivery of the targets above.

8. Improving the use of social and economic science to promote the development, uptake and use of sustainable, resilient and profitable agricultural practice that can deliver affordable, safe and high-quality products.

In the NFU's evidence to the 2012 Science & Technology Committee Inquiry "Bridging the "valley of death": improving the commercialisation of research" we stated that, in England, the privatisation of our national knowledge transfer capabilities and replacement with short-term, and often environmentally-focused projects, has further fragmented delivery channels for research and commercialisation opportunities in agriculture. The translation of science into practice is arguably one of the biggest challenges for agriculture in making a functioning connection between research and the industry. Several reports have gone on to link this with our lower level of relative productivity compared to our competitors.

... science to commercial and production gain is far less clear ...

There is now a significant opportunity to look at how public/private partnership and a boost in knowledge exchange could work better in this vital area. Who are the advisers going on to farms already? How can existing initiatives be better harnessed and coordinated to provide a translation role? How equipped are advisers and consultants with the latest science and research? Critically, what motivates and prevents farm businesses from adopting innovative practices and technologies?

The European Innovation Partnership (EIP) concept could be hugely beneficial for my farmer and grower members in addressing these questions. The new EIP on Agricultural Productivity and Sustainability supports closer links between researchers and farmers through the new rural development programme budget. Therefore Defra must ensure that the necessary administration is in place now for the UK to benefit in the future. The EIP will be delivered at a national level via Operational Groups, which should include farmers, researchers, businesses etc. and support activities such as sharing information and knowledge transfer, provision of advice, or testing out new ideas through projects which adapt existing techniques/practices to new geographical/environmental contexts. Importantly, the European Commission insists that the EIP must be a bottom-up instrument driven by businesses and not researchers. The link to new science is made through the Horizon 2020 programme, the new research funding framework across the EU that runs from 2014 to 2020. Again, there is a particular emphasis on involving SMEs at the earliest stage.

... delivery channels for research and commercialisation opportunities in agriculture ...

The NFU is a founding stakeholder of the All Party Parliamentary Group on Science and Technology in Agriculture www.appg-agscience.org.uk. For those parliamentarians with an interest in science and in farming, the group's meetings are always engaging, enlightening and thought-provoking. The group highlights not only the research and innovation that underpins modern farming, but also the regulatory, commercial and cultural barriers to progress. It regularly has ministers and Government science advisers speaking at its meetings, and hears from leading scientists and companies from around the world. It is currently running a series of meetings about building public support for UK agri-science. I am very aware that food and the environment can be highly emotive subjects, and those of us working in that field need to be very aware of the impact of our communications.

... food and the environment can be highly emotive subjects ...

To make a real difference we have to go wider than just academic activity, innovative technologies, upskilling and optimising farm management. The whole regulatory context in which we work must support and not hinder progressive, efficient and innovative businesses. There remain some serious barriers to the British farming industry making full use of innovative technologies. The anti-technology, backward looking culture that seems to pervade so many EU institutions continues to amaze and frustrate me, given the huge challenges of global food security. Food and environment are always going to be highly emotive topics, but I think it is the responsibility of politicians to press strongly for policies and legislation to be firmly based on sound scientific evidence. Without this our ability to respond to national and global needs, to fulfil our environmental obligations and to boost our productivity and profitability for the good of economy and society will be severely constrained.

PRECISION FARMING AND ANIMAL WELFARE

Marian Stamp Dawkins

Department of Zoology, University of Oxford

Globally, agriculture is under unprecedented pressure to meet the twin demands of feeding the rising human population and mitigating the effects of climate change by becoming more efficient and more 'sustainably intensive'. As a recent FAO report[1] put it: "Agriculture will need to produce more food from the same or less land, using less water, energy and other inputs and reducing waste and adverse environmental impacts including greenhouse gas emissions". These pressures are particularly great on livestock production which now uses 70% of available agricultural land and 8% of global water as well as emitting 20% of global greenhouse gases. Yet demand for meat and dairy products continues to rise. Meat production across the world has tripled over the last 4 decades and is projected to increase by 73% by 2050. As of now nearly 60 billion chickens, 1.4 billion pigs and 300 million cattle are killed for meat each year. If this increasing demand is to be met by more efficient production, this will mean that more animals will be reared with less space, less food, less waste and less water. And what does this mean for the welfare of the animals themselves? Even where 'sustainable' is specifically defined to include animal welfare[2] the power of the word 'intensification' is so great that to many people, the idea of livestock farming becoming even more efficient and even more intensive looks like a licence to accelerate and exaggerate the very conditions that they hold responsible for welfare problems such as lameness in cattle and chickens in the first place. Where, if anywhere, does animal welfare fit in to the brave new world of efficiency-driven, climate-friendly farming?

Research at the University of Oxford on the welfare of broiler (meat) chickens aims to show that, by working closely with commercial poultry producers, more efficient farming may actually lead to improvements in animal welfare. This is because some of the greatest improvements in efficiency come from reducing mortality and waste and keeping animals in conditions that make them less likely to be injured or to succumb to disease. These are often exactly the same conditions that improve their welfare. For example, improving the quality of air through good ventilation and the quality of litter under their feet so that it is dry and doesn't give off a lot of ammonia leads to lower mortality, lower levels of foot and leg damage, which in turn means healthier, more comfortable birds[3] and a better quality end product that is safer for humans to eat.

... brave new world of efficiency-driven farming? ...

Of course, animal welfare and efficient agriculture do not always coincide perfectly and there will be improvements in animal welfare that do not necessarily stack up commercially just as there will be efficiency gains that would be unacceptable to the public on welfare grounds, such as crowding the animals into a smaller space. But there is a large area of overlap that has yet to be fully explored. The development of new technologies – sometimes referred to as 'precision farming' – is now showing us that it may be much larger than we previously suspected. What is important for animal welfare is that the economic gains of high standards of animal welfare are built into efficient farming at every step of the way.

... better quality end product that is safer for humans to eat ...

A collaboration between Stephen Roberts and Thomas Nickson in the Department of Engineering Science, and Russell Cain and myself in the Department of Zoology at Oxford has led to the successful development of smartphone software to help farmers manage their flocks more effectively and with higher welfare. The cameras on the smartphones monitor the movements of chicken flocks and the images are analysed on the spot by the phones' computers. The cameras do not track the movements of individual birds (that would be quite overwhelming in a house of 30,000 or more chickens) but each phone simply delivers a 4-number description of flock mobility every 15 minutes. Remarkably, these four numbers, which describe the average movement of a flock and unusual features of the way it moves, allow us to detect flocks in which there is, or will be, a welfare issue. For example, the software can detect whether a flock is made up largely of healthy birds that can all walk around easily or whether the flock contains a proportion of lame birds mixed in with the healthy walkers. It can predict which flocks will have the highest and lowest mortalities and the highest and lowest levels of damaged legs. The software can even predict which flocks will develop damaged legs and feet later on when the chicks are as young as 3 days old when they as yet show no external sign of damage.

... monitor the movements of chicken flocks ...

This ability to pick up health and welfare problems at a very early stage is potentially of great value to farmers as it enables them to intervene and take pre-emptive action before a situation becomes serious. It is also

potentially of great importance in actually reducing the total amount of antibiotics and other medication used in agriculture by enabling famers to target their treatments where they are really needed. At the same time, it is important to stress that no smartphone with a camera can replace a good stockman, but it does provide an extra eye for when he or she cannot be present and is also a way of telling them that things are not going quite as they should be. To respect the privacy of the farm staff, our smartphones do not store visual images – just numbers – so no-one need feel they are being spied on. It's the behaviour of the chickens that interests us.

... intervene and take pre-emptive action ...

Our current research is aimed at exploring further this important interface between health, welfare, behaviour and disease resistance. We are seeing whether our smartphone devices can detect which flocks are carrying specific diseases. Working with Martin Maiden, Frances Colles and Adrian Smith, we are looking at how the statistics of flock movement vary with flocks known to have different levels and genotypes of *Campylobacter, Salmonella, Clostridium* and Coccidia. Precision farming that sets 'efficiency' as its only goal and ignores the implications that this might have for human and animal disease, will be good for no-one. The agriculture of the future, if it is to deliver what is required of it, needs to be set a wide range of goals that includes the health and well-being of both humans and non-humans.

None of these goals will be achieved, however, if farmers cannot also make a living from what they do. So precision agriculture that has animal health and welfare at its heart needs also to take into account the commercial realities of farming in a world of scarcity of feed resources, increasing demand, pressure on land and other constraints. For this reason, we are developing our smartphone system in conjunction with major poultry producers, not only so that they can see the advantages of precision farming with high welfare but also so that we understand what works best for them and can adjust our system to what they need. We currently have commercial trials in the UK, France and the US, all successfully using the system and in each place, the support we have received from the producers themselves has been crucial for the success of our trials. We compare our camera data with what the producers are finding from their own production measurements so that we can give them information that helps them to manage their flocks more efficiently as well as with higher welfare.

... health and well-being of both humans and non-humans ...

Making links between animal welfare and efficient, commercial production does not detract from ethical arguments that animal welfare should be supported because it is of ethical value in its own right, but bolsters and consolidates them. Just as ecologists increasingly put a monetary value on the 'services' or 'natural capital' that a healthy environment provides to make the case for conserving habitats and preventing the loss of biodiversity, so the case for animal welfare based on the benefits it brings to humans, including financial benefits, will be stronger than just hoping that it will somehow come about through consumer pressure alone. Making animal welfare a priority in the efficient farming of the future is much more likely to be achieved if it can be firmly linked to human food security, animal and human health and financial competitiveness. We hope that our inexpensive and easy to use phone app, developed in conjunction with key stakeholders in the farming and food industry, will go some way to doing just that.

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THE BIG BANG FAIR BREAKS RECORDS IN 2014

Led by EngineeringUK, The Big Bang UK Young Scientists & Engineers Fair is the largest celebration of science, technology, engineering and maths for young people in the UK. Everything we do is aimed at showing young people (primarily aged 7-19) the many exciting and rewarding opportunities there are out there for them with the right experience and qualifications.

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The Big Bang Fair takes place in March every year. We work with around 200 partner organisations across business and industry, government and academia to give a flavour of the real scale of engineering and science in the UK.

The Fair hosts the finals of the prestigious National Science + Engineering Competition and is the flagship event of National Science & Engineering Week.

The Big Bang UK Young Scientists & Engineers Fair welcomed record numbers to Birmingham's NEC on 13-16 March 2014. Over 75,000 visitors, including more than 70,000 young people, teachers and parents, attended the Fair to see science, technology, engineering and maths (STEM) brought to life.

Over 200 organisations from across government, business and industry, education, professional bodies and charities came together to inspire the UK's future scientists and engineers.

Opening the Fair, Education Minister, Elizabeth Truss MP, said: "The range of high profile employers present at the Fair – including GCHQ, Siemens and Rolls Royce – show the careers these subjects can open up. Maths commands the highest earnings in the jobs market and roles in tech and science are paid 20% more than other jobs."

Visitors took part in hundreds of shows and activities designed to show young people where their science and maths subjects can take them, from bouncing across the surface of the moon to exploring the insides of the human body and witnessing a robot solve a Rubik's cube at record-breaking speed. Hundreds of scientists and engineers from businesses and universities were

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©The Big Bang Fair.

on hand to share their experience and advice about the exciting career opportunities open to young people.

Paul Jackson, Chief Executive of EngineeringUK, which leads the Fair, said: "A huge thank you to everyone who has supported the Fair. The Big Bang Fair is so much more than a great day out – it's having a real impact. Early evaluation findings for the Fair show that over half the key age-group of 11-14 year-olds learnt a lot, two thirds of young attendees took the opportunity to speak to someone about careers, and more than seven out of ten knew where to go next for more information. The desirability of a career in engineering among 11-14 year olds who visited the Fair is 55% higher than the national average.

"At its core, The Big Bang Fair is all about the STEM community working together encouraging the next generation of scientists and engineers and these early results show the extent to which we are doing just that."

The Finals of the National Science + Engineering Competition took place at the Fair, culminating in an Award Ceremony on the Friday. Rebecca Simpson, from Dame Alice Owen's School in Hertfordshire, was awarded UK Young Engineer of the Year for creating an arcade game to help young people to revise STEM subjects. Twin sisters, Ameeta and Aneeta Kumar, from the Abbey School in Reading, became the UK Young Scientists of the Year after impressing judges with their project to develop an early diagnostic tool for cancer.

Business Minister Vince Cable MP, Education Minister Elizabeth Truss MP, Shadow Minister for Higher Education Liam Byrne MP and Labour MP for Birmingham Ladywood and the Shadow Education Minister Steve McCabe MP were among a number of parliamentarians who attended the Fair.

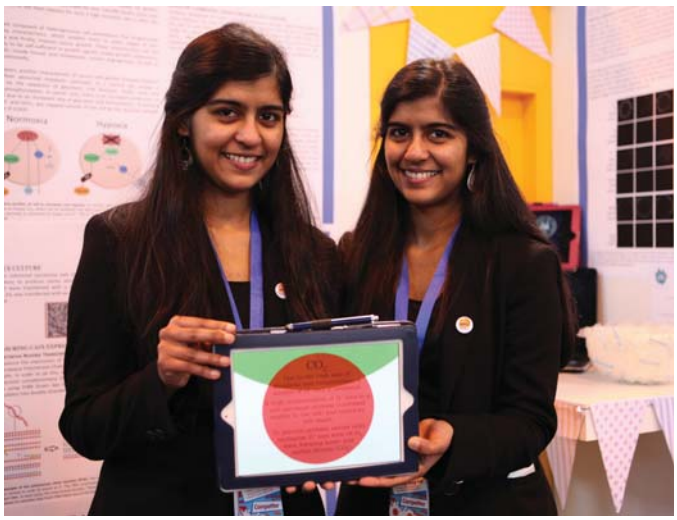
Visiting the Fair for the third time, The Rt Hon Vince Cable MP said: "The Fair is enormously important for the country. We desperately need more highly motivated young people with maths, physics and other sciences because we're short of them and short of engineers and scientists."

Big Bang Near Me Fairs are taking place across the UK and The Big Bang Fair will return to the NEC in Birmingham in March 2015. There are a number of ways to get involved.

For information about supporting the Fair contact Andrew Grazebrook on agrazebrook@engineering uk.com

The call for activities is now open and can be found at www.thebigbangfair.co.uk/Activities

www.thebigbangfair.co.uk
www.engineeringuk.com



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A TASTE OF THINGS TO COME?

Professor Dame Julia Slingo
Met Office Chief Scientist

As the Intergovernmental Panel on Climate Change (IPCC) publishes its Fifth Assessment Report on climate change science, the impacts on human and natural systems, and the options for adaptation and mitigation, UK scientific expertise in weather and climate is more important than ever before. From water resources to food security, rising sea levels and more extreme weather, the IPCC Report showed that climate change impacts are already widespread.

This winter highlighted how vulnerable we are to extreme weather. We know the weather was unusual and we understand how it was related to weather patterns elsewhere in the world. The big question is did climate change contribute to the severity and impacts of the storms and should we expect more of the same in the future?

Sea levels are rising as the Earth warms due to increased greenhouse gases in the atmosphere, adding to the risk of coastal inundation from storm surges. A warmer atmosphere holds more water, so a storm

... how vulnerable we are to extreme weather ...

today gives more rainfall than the same storm 50 years ago.

Severe storms have always affected the UK and are well documented in historical records. Throughout history, societies have adjusted to climate variability and extremes with varying degrees of success. What is different now is our exposure and vulnerability to changes in the climate and weather we experience. There are many more of us on the planet, and we rely more than ever on critical infrastructures to protect our lives and livelihoods and to deliver reliable supplies of water, food and energy. We live in an interdependent world, so climate change, whether it's in the UK or elsewhere, touches all our lives.

... We live in an interdependent world ...

RESPONDING TO THE CHALLENGE OF CLIMATE CHANGE

Since its establishment by Margaret Thatcher in 1990, the Met Office Hadley Centre for climate prediction and research has provided Government with the scientific evidence to inform climate change policies. Our science has been critical in demonstrating that our climate is changing and that this is largely due to human activities. Of course, it is not just about science – it is really important that we are able to communicate and help integrate this knowledge into decision-making, whether that be in the context of regional and national infrastructure or on the world-stage at the United Nations Conference of the Parties.

The Met Office Hadley Centre's work has been fundamental to setting UK policies on mitigation in terms of controlling emissions. As evidence grows around the impacts of climate change on our lives, we must become better prepared and more resilient. Climate science must evolve to respond to this shift in demand.

THE EVOLVING LANDSCAPE OF CLIMATE SCIENCE

For too long the climate change debate has focused on global mean temperatures as a simple metric to guide international negotiations on reductions in carbon emissions. We frequently hear that a world that is 2°C warmer than in the mid-19th century is dangerous – but dangerous to whom, when and where? For some, the warming of 0.8°C that has already occurred is dangerous,

... Climate science must evolve ...

as many of the small island states faced with rising sea levels would attest.

This fixation on global mean temperatures has not helped the communication of the seriousness of climate change. People do not generally relate to small rises in global mean temperature. They relate to what

happens to their region or them personally; add to that a growing appreciation that some of the most profound impacts of climate change will be felt through the intensity and frequency of extreme weather, like we experienced this winter.

Understanding regional implications of a changing climate is what matters to individuals, governments, businesses and the natural world. That means delivering a level of local detail that hasn't existed in scenarios of climate change so far. It means being able to quantify the changing

... intensity and frequency of extreme weather ...

risks of extreme weather, from floods, drought, storms and heatwaves.

Filling that gap has driven the Met Office Hadley Centre programme in the last five years – to get the same level of detail in climate predictions as in our weather forecasts. Just as we could give early warnings of severe weather this winter to Network Rail, enabling them to take mitigating action, we also need to be able to say how often we'll be confronted with severe weather events in future and what that means for investments in our transport infrastructure, coastal protection and flood defences. That level of granularity is essential; only then can society understand future risks, invest in the right places and take adaptation decisions that use financial resources wisely.

... as yet no definitive answer ...

OPENNESS AND TRANSPARENCY: COMMUNICATING UNCERTAINTY IN CLIMATE SCIENCE

The IPCC Fifth Assessment Report was another milestone in understanding climate change and its consequences. The scale of the endeavor is unmatched in any other branch of science. In Working Group I alone, which considered the physical science basis, 250 scientists reviewed 9,000 papers and addressed over 50,000 comments.

This sort of consensus on climate science cannot happen often. In the meantime, science advances at pace – climate models improve, we gather more observations, and our understanding of the Earth system develops. We must have confidence in the integrity of new science as it emerges; the rigour and robustness of the peer review process is crucial in this regard. Last year we published 324 peer-reviewed articles co-authored with scientists from 196 institutions across 31 countries, emphasising the collaborative nature and international reach of weather and climate science.

... severe weather events in future ...

It is understandable that, with so much at stake, many are entering the debate on the science of climate change. This is to be welcomed. Scientists are sceptical and continually question our understanding and the evidence behind it.

A good example is the debate on climate sensitivity – how much the planet will warm if carbon dioxide concentrations are doubled. Some claim climate model estimates are wrong – and too high – because 'observations' suggest a lower sensitivity. The truth is that climate sensitivity cannot be observed directly, but only deduced from observations through making assumptions about, for example, how the oceans take up heat and how much aerosols – small particles that typically reflect sunlight – have cooled the planet. Simple models are used to make these deductions, but there are uncertainties in the assumptions that underlie these models because of the complex processes they seek to emulate.

... integrity of new science ...

Conversely, climate sensitivity produced by full climate models is an emergent property of the complex, non-linear dynamics and thermodynamics of the full climate system – atmosphere, ocean, land and ice. There is uncertainty here too because our understanding of the climate system is incomplete and the granularity of our models – often referred to as resolution – has been limited by supercomputing power. We must have an open debate on the fundamentals and uncertainties of climate science, rather than the 'black and white' debate that often ensues.

WHERE NEXT?

In the last decade the world has experienced extremes of weather and climate that exceed those in living memory, and increasingly affect us as individuals either directly or indirectly. Impacts of these events around the world have been profound. The UK has not been exempt from this. Challenging weather – from cold winters and drought to the wettest summer and wettest winter on record – has asked more of our science than ever before.

Whilst there is as yet no definitive answer on whether climate change contributed to the severity of these events, the impacts on all of us – individuals, businesses and policymakers – brought our vulnerability into sharp focus. More than ever, weather and climate have considerable direct and indirect impacts on us – our livelihoods, property, well-being and prosperity.

... Simple models are used to make these deductions ...

There is increasing advantage in the UK being the best at global environmental science and I accept the responsibility that the Met Office has, with its partners, to maintain our leadership on the international stage. We will drive our models to greater detail so that we can give more definitive answers on the changing risks of high impact weather and extreme seasons. Through our understanding of customer needs for weather services, we will seek to understand the nature of the risks that society will be exposed to as our climate changes. More and more, our climate research must place customer needs at its heart – making climate science work for society.

CARBON CAPTURE AND STORAGE: a role for the geosphere in mitigating climate change

Nic Bilham
Director of Policy and Communications, the Geological Society

The rocks beneath our feet contain abundant evidence of past changes in our climate. This geological record does not make comfortable reading. But the geosphere is not just a repository of information about the past. Long-term underground sequestration of CO_2 could make a significant contribution towards the reductions in global carbon emissions which are necessary if we are to avoid the likelihood of dangerous anthropogenic climate change. Indeed, it is hard to see how these reductions can be achieved without rapid and widespread deployment of carbon capture and storage (CCS).

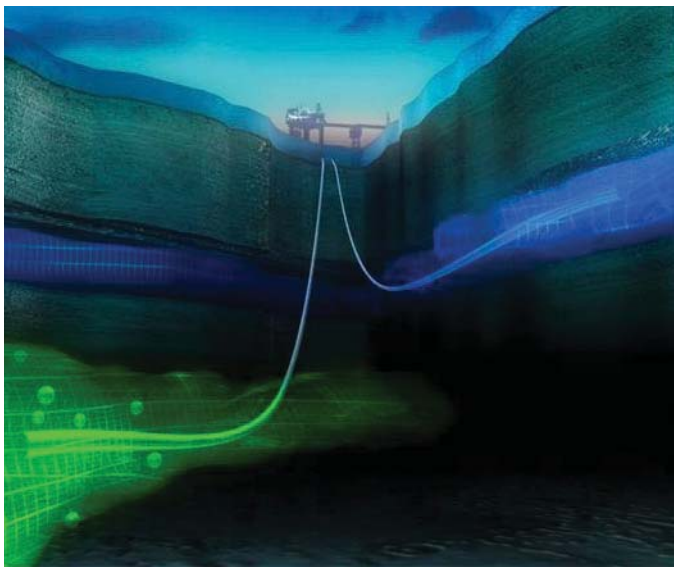
The present day is not the first time in Earth's history that large amounts of carbon have been injected into our atmosphere at rates comparable to those now resulting from human activity. This has happened half a dozen times over the last 500 million years, most recently 55 million years ago, when a rapid release of carbon – possibly from destabilisation of methane hydrates on the sea floor – triggered a period of abrupt warming known as the Palaeocene-Eocene Thermal Maximum. At that time, temperatures rose by about 6° C globally and by 10-20° C at the poles. Sea levels rose, the oceans became more acidic and less oxygenated, and widespread extinction of species resulted. It took the Earth system in the order of 100,000 years to recover. It is increasingly evident that the outcome was broadly similar on each occasion that such rapid carbon injections have occurred.

... widespread extinction of species resulted ...

The more recent geological record can also tell us a great deal about the complex feedbacks and lags which operate in the Earth system, and about what our world was like when the atmospheric CO_2 level was last at 400 parts per million for a sustained period – that is, the annual average level reached again during 2014. Temperatures were 2-3° C higher than today, and sea level rose by up to 20m in places. Sea level takes a few hundred years to reach equilibrium in response to atmospheric CO_2 and temperature, which may explain why present day sea levels have not yet increased to such an extent. (See the Geological Society's 2010 Climate Change Statement and 2013 addendum at http://www.geolsoc.org.uk/climaterecord for further information.)

This geological evidence, entirely independent of present day atmospheric measurements and climate modelling, should help to dispel any lingering doubt about the urgency of drastically reducing our CO_2 emissions.

The House of Commons Energy and Climate Change (ECC) Committee's May 2014 report on CCS highlights the difficulty of achieving the required emissions reductions without rapid and widespread implementation of CCS. We will continue to depend on fossil fuels for decades to come, not least to complement the intermittency of most renewable energy sources and the lack of flexibility of nuclear plant (which cannot be fired up and shut down rapidly). Consequently, UK Government places considerable reliance on CCS in its plans to decarbonise our electricity system. Furthermore, as the ECC Committee points out, CCS is the only large-scale mitigation option currently available to make significant reductions in emissions from industrial sectors such as cement, iron and steel, chemicals and refining. Such change will be necessary if we are to bring carbon emissions down to the required levels – decarbonising the electricity system will not be enough.



'Image courtesy of Statoil ASA'

Despite Government's stated

commitment to CCS, progress in delivering this, including the competition to award funds to support full-chain commercial-scale demonstration projects, has been very slow. The ECC's report concludes that 'this delay has called into question the credibility of Government CCS policy and has resulted in a lost decade for this vital fledgling industry'.

CCS is still sometimes referred to as an unproven technology. This is quite misleading. Although no full-chain commercial-scale CCS project (from capturing CO_2 produced from the burning of fossil fuels or other industrial applications, to transporting it and injecting it into a suitable geological formation where it will be held securely in the long-term) is yet operational, several such projects are in advanced stages of development worldwide, many smaller demonstration projects are already operational, and each element of the chain is well tested. CCS is not a distant prospect – it is already happening.

... huge potential to reduce future carbon emissions ...

In April 2014, the Geological Society hosted the third in a series of conferences on CCS held jointly with the American Association of Petroleum Geologists. Speakers and delegates from a range of geoscience specialisms and from across academia and industry were unanimous in concluding that geological storage of carbon in depleted oil and gas reservoirs and other 'conventional' geological settings is a low-risk technology in which we can have a high level of confidence, with huge potential to reduce future carbon emissions.

The fact that a structural or stratigraphic 'trap', where a porous rock is overlain by an impermeable 'cap rock', has kept relatively buoyant oil or gas in place for millions of years (until we drilled into it to extract the hydrocarbons) is a good indication that CO_2 can be held securely in such a formation. This is borne out by field demonstrations, for example in the Sleipner field in the North Sea, where 11 million tonnes of CO_2 has been injected since 1996. Subsequent monitoring shows this has so far been contained in the reservoir.

Sleipner gas field. Image credit: Bair175, Wikimedia Commons

Sleipner is by no means unusual in terms of its storage potential – there is significant potential economic advantage to the UK in developing a CCS industry, and our North Sea pore space, infrastructure and know-how is a considerable asset.

As with many technologies, the fact that CCS can be shown to work does not mean that there is no need for further research – nor should the continuation of that research be taken as grounds for lack of confidence in the technology. Research into improved capture technologies and the storage potential of various 'unconventional' geological settings, should proceed in tandem with implementation in well-understood and low-risk sites, to reap the dividends of 'learning through doing', in order to bring down costs, improve efficiency and underpin public trust and confidence.

While depleted hydrocarbons reservoirs and closed saline aquifers (which are geologically similar, but do not host oil or gas) offer significant storage opportunities, this potential could be much greater still if promising research into novel CO_2 trapping mechanisms in a range of 'unconventional' geological settings bears fruit. Examples are migration-assisted trapping in open saline aquifers, and mineral trapping in mafic rocks (those with high magnesium and iron content, such as basalt, which are very widespread). (See the Geological Society's submission to the ECC Committee's recent inquiry at http://www.geolsoc.org.uk/CCS-inquiry13 for further details.)

The science and engineering associated with CCS are not significant barriers to its implementation at large scale. The principal constraints are political and economic. If the potential of CCS is to be realised, an urgent priority is to develop storage capacity – to identify and characterise potential storage sites, and to model and test the injection of CO_2 there – at a far greater rate than at present. Generic technologies and geological research may be transferable between nations, but development of storage capacity is not. If we are to implement CCS in the UK, we cannot depend on such work being done elsewhere.

Under current market conditions and policy frameworks, the prospects of large-scale CCS becoming commercially viable are dubious.

... urgent priority is to develop storage capacity ...

But this does not weigh the cost of implementing CCS against the cost of not doing so, while still meeting our future energy and other resource needs. The question for policy-makers to address should be how – not whether – to create the political and economic conditions to stimulate rapid and widespread deployment of CCS.

Further reading:

House of Commons Energy and Climate Change Committee report on CCS, May 2014: http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenergy/742/742.pdf

Geological Society submission to ECC Committee CCS inquiry, September 2013: http://www.geolsoc.org.uk/CCS-inquiry13

Geological Society Climate Change Statement, November 2010 and Addendum, December 2013: http://www.geolsoc.org.uk/climaterecord

Sleipner demonstration project: http://www.bgs.ac.uk/science/CO_2/home.html

FACTS ABOUT FRACKS: RESEARCHING FRACKING IN EUROPE

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INTRODUCTION

If the biggest talking point of UK energy in the last two years can be summed up in a single word, it's probably "fracking". The process of creating permeability in rocks by injecting fluids into them at high pressure, hydraulic fracturing (to give fracking its proper name) has been employed in oil and gas production for many years. However, the technique has come to particular attention during the recent shale gas boom in North America.

Shales (Figure 1) are sedimentary rocks that have been formed by mud accumulating over millions of years and then slowly buried and compressed. If the muds contained a lot of organic matter (the remains of plants and animals) this can be turned into oil or gas during burial. However, as shales are so fine-grained, these hydrocarbons cannot easily escape from the rock. To extract the oil or gas economically artificial permeability must be created, which is where fracking comes in.

... environmental impacts of fracking fluids and shale gas ...

As the first fossil fuel of the internet age, shale gas has attracted plenty of controversy. Many aspects of its discovery and exploitation have provoked public concerns, so it is crucial that scientific research into these topics is carried out. The ReFINE (Researching Fracking In Europe) project, an independent research consortium led by Durham Energy Institute at Durham University, focuses on the risks associated with shale gas and oil exploration and exploitation. These range from whether fracking can cause earthquakes or subsidence, to what the environmental impacts of fracking fluids and shale gas emissions might be.

... recent shale gas boom ...

The first three peer-reviewed studies by the ReFINE team have examined the vertical distance that hydraulic fractures can propagate, the likelihood and magnitude of earthquakes caused by fracking, and the long-term integrity of shale gas wells.

HOW FAR DO THE FRACTURES GO?

Our research into hydraulic fracture propagation (http://refine.org.uk/media/488 6/hydraulicfractures.pdf) shows that natural hydraulic fractures can extend upwards more than 1 km (see Figure 2). However, the maximum vertical distance recorded for a *stimulated* (man-made) hydraulic fracture is 588 m (Figure 2), and our calculations indicate that there is a <1% chance of a stimulated fracture extending vertically more than 350 metres.

Figure 1

Since gas-bearing shales and drinking water aquifers are usually separated by more than 1 kilometre of rock (Figure 2), it is very unlikely that fracking itself

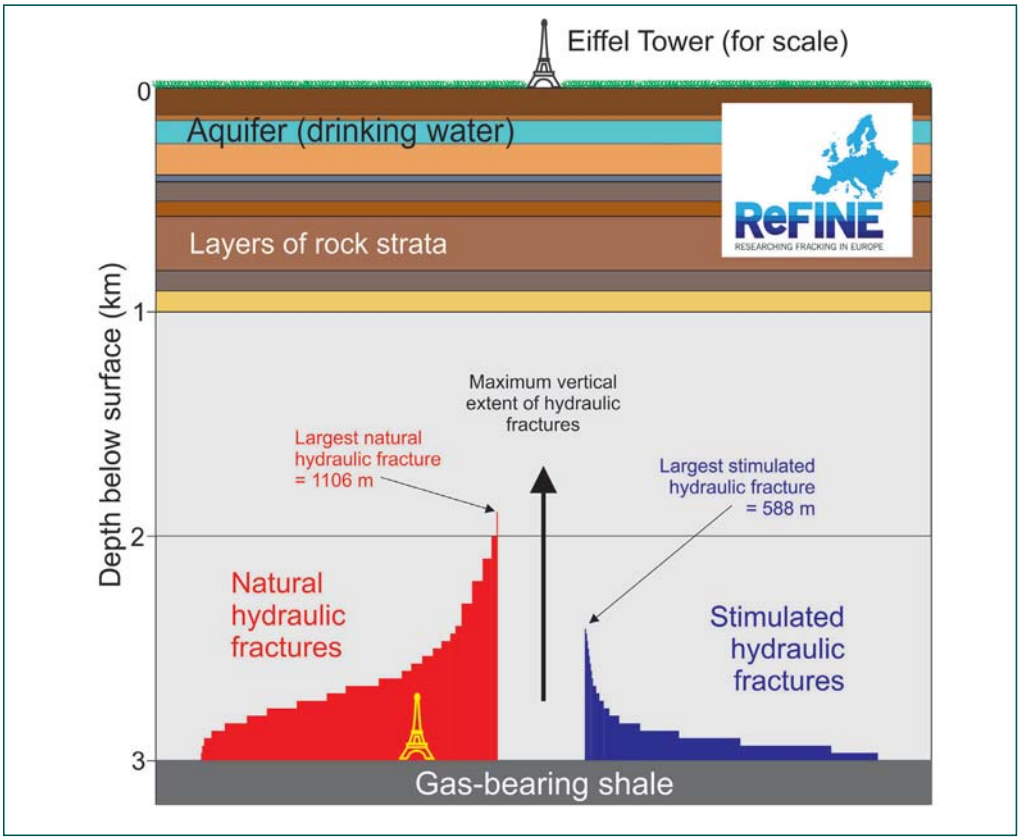


Figure 2

could create a pathway for water contamination. Nonetheless, it is crucial to understand the structural geology of areas in which shale gas fracking is proposed. It would also be wise to impose a minimum separation distance between shale gas intervals targeted for fracking, and the groundwater aquifers above them.

CAUSING EARTHQUAKES

Earth tremors and quakes are referred to collectively as seismicity, and occur when a geological fault moves suddenly. Seismic activity in a region reflects the structure of the Earth's crust there, and the stresses being applied to it. If human activities cause a dormant fault to move this is described as 'induced seismicity'.

One of the commonly raised concerns about fracking is the possibility that it could cause earthquakes that would be felt at the surface. Members of ReFINE carried out a global review of published data on induced seismicity (http://refine.org.uk/media/4883/inducedseismicity.pdf). This showed that although fracking has caused earthquakes, they are much smaller in magnitude than those generated by other human activities, such as mining, reservoir impoundment, and conventional oil and gas extraction.

The likelihood of hydraulic fracturing causing felt seismicity is very small, though it is possible that fault reactivation during frackng might cause induced seismicity larger than that recorded to date. Again, a fuller understanding of shale geology can further mitigate against this risk. DECC has also proposed a traffic light monitoring scheme. If shale gas sites record seismicity of magnitude 0.0 or less, fracking can continue (green). If seismicity between 0.0 and 0.5 in magnitude is recorded, fracking can only proceed with caution and increased monitoring (amber). If a magnitude of 0.5 is exceeded, fracking is immediately suspended (red).

WELL LEAKAGE

The long-term integrity of shale gas wells is something we examined in our most recent study (https://www.dur.ac.uk/resources/refine/Publishedversion.pdf). To reach shale gas target horizons, wells have to be drilled down through groundwater aquifers. To prevent hydrocarbons leaking out from the well, barriers such as steel casings and cement are added. If one of these barriers fail, this is termed a *well barrier failure*, but hydrocarbons might not escape as a consequence. However, if all the barriers fail, this *well integrity failure* could create a pathway for pollution and contamination.

Data from the USA indicate that a small percentage of shale gas wells leak, so it is very important that there is assessment of wells, both during their lifetime and after abandonment. Results of such monitoring should be made publicly available, and the appropriate financial and monitoring processes should be put in place, particularly after well abandonment, so that legacy issues associated with the drilling of wells for shale gas and oil are minimized.

CONCLUSIONS

Research by the ReFINE consortium is funded by the Natural Environment Research Council, Shell, Total, and Chevron. The project has an Independent Science Board, led by Professor John Loughhead of the UK Energy Research Centre, to ensure that research is accurate, relevant to the public interest, and free from industry bias.

Current ReFINE studies are examining the risk of subsidence in shale gas sites, methane leakage, and the quantity of radioactive materials occurring in fluids that flow back to the surface after fracking. When it comes to determining what the true risks of fracking are, such scientific research carried out by independent academic experts is crucial. From there, informed decisions can be made on the basis of scientific evidence.

... Results of such monitoring should be made publicly available ...

For more information on the research being carried out by ReFINE, and for resources such as videos and research briefs, visit www.refine.org.uk/research.aspx

SEPARATING FACTS FROM FANTASY IN THE SHALE GAS DEBATE

Huw Clarke
Senior Geoscientist, Cuadrilla Resources

It's been fascinating, and occasionally infuriating, to watch the debate around hydraulic fracturing develop in the UK during the last 18 months.

Cuadrilla has often found itself at the forefront of this debate. Last summer, for example, our exploratory site at Balcombe was surrounded by protesters, many of whom seemed to believe we were about to start fracking for gas within shale rock. In fact, we drilled a 2,700ft exploratory oil well through limestone.

Subsequently, our **actual** plans to undertake exploratory hydraulic fracturing for shale gas, 250 miles away in Lancashire, are attracting considerable interest, as we do our best to separate facts from fantasy.

... focusing our efforts on community engagement ...

Unfortunately, the residents of Lancashire and Sussex, along with people across the UK, have been subjected to a vociferous spread of misinformation from anti-fracking activists.

One of the most famous examples concerns the misleading Gasland documentary, which has been shown many times on TV. One section features Mike Markham from Colorado setting light to his tap water. The State of Colorado's investigation concluded that Mr Markham, in sinking his water bore-hole, had inadvertently drilled his very own coal bed methane well.

... separate facts from fantasy ...

More recently, we have seen outrageous claims that hydraulic fracturing can cause cancer or pollute drinking water, despite the utter lack of evidence to substantiate a single verified case from the hundreds of thousands of fracked wells around the world.

This is not to say there are no concerns with shale gas, rather that we should form opinions from peer-reviewed facts, instead of relying on sensational "most viewed" You-Tube clips or ill-informed scaremongering.

Looking ahead, the primary focus for Cuadrilla is continuing exploration work within the Bowland Basin and specifically our 1,200km^2 licence area in north-west England.

In February, we announced our intention to apply for planning permission to drill, hydraulically fracture and test the flow of gas from up to four exploration wells on two sites – one at Preston New Road and the other at Roseacre Wood. Since then we have been focusing our efforts on community engagement and consultation as well as preparing an Environmental Impact Assessment for both sites.

Separate applications will also be made to install two seismic arrays that would be used to monitor the hydraulic fracturing process. Seismic activity above the level of 0.5 magnitude (m), which can only be detected at surface by extremely sensitive equipment, will mean fracturing jobs will be halted; immediate flow back of the fracture water will commence alleviating the stress on the rock. This traffic light system in place for seismicity provides confidence that any seismic events created by our engineering works will be

far below the threshold of even superficial structural damage and further more greatly decrease the likelihood of detection from human perception.

The Bowland Basin is one of a number of lower-carboniferous (320 million years old) extensional basins that lie onshore within the UK. Compared with similar basins such as the Gainsborough Trough or Edale Gulf, the Bowland Basin has undergone deeper burial and greater inversion meaning greater thermal maturity pushing the rocks further into the gas window. Cuadrilla was drawn to the Lancashire region by a combination of large open acreage, a small unconventional producing gas field (Elswick) and the rather more substantial East Irish Sea gas field. The gas in Elswick and that in the East Irish Basin have long thought to be sourced by the deeper carboniferous Bowland Shales. The Elswick 1 well, drilled in 1990, is of great importance to the hydraulic fracturing

... water aquifer contamination ...

discussion. It is one of a number of onshore gas wells within the UK that have undergone hydraulic fracturing treatments and have shown to be a productive safe gas well with no adverse effects. Opponents of shale gas often state that hydraulic fracturing is a poorly understood new technology, it is important to note that the first commercial fracturing treatment was carried out in 1947.

At community engagement meetings, by far the most frequent question I am asked is with regard to groundwater pollution. This covers a wide range of misinformation with the most common being that hydro-fractures will grow from the depth of the gas reservoir all the way up through the crust into the water aquifer. I will address this assertion head-on as it needs to be put to bed.

... great importance to the hydraulic fracturing discussion ...

Geo-mechanical theories disproving this concern are robust. They include the energies required to make such a gigantic fracture height, the rocks layers that act as fracture growth barriers containing vertical height growth, and the fracture evolution direction, which is controlled by maximum stress direction. These are peer reviewed accepted theories but anti-scientific anti-fracking blogs often claim otherwise. We hope that with micro-seismic imaging showing fracture evolution during fracturing operations we will physically demonstrate the true reality.

As an industry we do not deny that water aquifer contamination can occur as a result of drilling oil and gas wells, but these cases are few and very far between. But it is lack of well bore integrity that leads to water contamination by thermogenic gas, not the process of fracturing. Well bore integrity is critical to all oil and gas wells (hydraulic fractured or not); poor isolation of the gas zone can result in gas channelling to a water aquifer. Cuadrilla spends a vast amount of time on ensuring well integrity to mitigate any water contamination. As a control we drill three to four shallow monitor wells around the perimeter of the drill pad prior to drilling for shale gas, monitoring background levels to ensure methane in ground water remain unaffected by our operation.

Other concerns include toxic chemicals mixed in with the fracture fluid, the use of large quantities of water, flow back water, land subsidence, negative property prices, air pollution, increased traffic volume, noise and light pollution from the drilling itself. One concern, raised at a recent public meeting regarded the risk of damaging the geopathic stress of the earth, left me perplexed. As a scientist it is not easy to accept that the feng shui of the ground should be a determining factor! These concerns amount to a great deal of anxiety attached to shale gas extraction. A benefit from the US experience is most of those anxieties that are valid have been addressed and solutions found which we in the UK have already adopted.

Cuadrilla's approach to public concern is one of openness and transparency. Our public information evenings in Lancashire countryside work well to allay residents' concerns, empowering local people with real information regarding Cuadrilla's operations. Time spent listening to concerns and explaining our operations is time well spent.

The benefits from shale gas are obvious: employment, taxes, lower gas prices for a greener natural gas compared with what we currently import and most importantly, security of supply. The challenge lies not in the extraction of the gas or the environmental management as solutions are already in place, but rather persuading the communities in which we work that the industry can be trusted.

... benefits from shale gas are obvious ...

From the opinion polls we've conducted in Lancashire, we've found that most people have open minds when it comes to shale gas exploration. It's crucial that we continue providing local communities with as much information as possible concerning our plans, so they can make decisions on facts instead of rumours.

STRENGTHENING LINKS WITH JAPAN ON EDUCATION AND RESEARCH

Beth Hogben
Science and Innovation Network
British Embassy, Tokyo

Japan and UK as partners

Japan is vital to the UK economy. More cars were built in Sunderland last year than in the whole of Italy, thanks to Japan. Over 140,000 British jobs are due to Japanese investment. More than half of all UK Internet traffic goes through Japanese servers in the UK. More Japanese investment comes to the UK than any other European country.

And the Japanese market, which was closed a generation ago, is now open for business. JAL, the flag carrier, bought Airbus over Boeing last year for the first time – half the content of all the 31 planes is built in the UK. UK expertise is helping with Fukushima clean-up. And the 2020 Olympics is a major opportunity for British firms who helped make London 2012 a great success, in areas like cyber security and design.

It is not only a commercial relationship. We share a commitment to rules based economic governance and international security. We work together to protect an internet free of government diktat, to protect intellectual property, and the rule of law in commercial disputes. We also share a commitment to harnessing science and research to tackle global challenges like infectious diseases, dementia, resource security and climate change.

Universities open up to international collaboration

Japan's universities are also opening up to international links. A programme of reform aims to produce outstanding talent, research excellence and innovation at a global level. This will bring further opportunities for relationships to be forged between UK and Japan that will lead to even more knowledge exchange and research collaboration. The UK has a strong reputation in Japan for its world class universities and as an international hub for research, innovation and personnel exchange.

Like the UK, Japan recognises that scientific research and innovation are key to economic success. Science, technology and innovation form a key pillar of Japan's growth strategy and the Prime Minister himself chairs the Government's Council for Science, Technology and Innovation Policy.

The quality of scientific and technological research and development in Japan is high and our two nations have a similar outlook on the societal value of science with many areas of complementary strengths. The Nobel prizes won in 2012 by Prof Shinya Yamanaka and Prof John Gurdon for their work on induced pluripotent stem cells is a good example but our researchers are working together in many other areas. Projects supported by the UK's Science and Innovation Network team in Japan are helping develop a broad range of collaboration: from **cutting edge research** in new materials, synthetic biology; **technology opportunities** such as big data for healthcare or optical imaging for neuroscience; **security and sustainability** research on manufacturing disaster resilience and cybersecurity.

Aside from researcher links, strong institutional level relationships also exist. The strong and enduring historical links that University College London has with Japan, were celebrated last year on the 150th anniversary of the Choshu Five's arrival in Britain. These 5

young Japanese noblemen endured a perilous 135-day sea journey to come to Victorian-era London and study at UCL. On their return to Japan, they went on to form the core of a new Japanese government, leading the nation's transformation to one of the world's foremost technological powers.

Japan-UK Universities conference on education and research

On Thursday 1 May 2014, to mark the visit of Prime Minister Shinzo Abe to the UK, the Japanese Embassy in London held a Japan-UK Universities Conference for Collaboration in Research and Education co-hosted by UCL, supported by British Council, JSPS London, MEXT in Japan and the Science and Innovation Network. Attended by senior representatives from 14 Japanese universities and 16 UK universities, this conference was an unprecedented landmark event, with discussions on a wide range of issues surrounding research and education. It was also a valuable opportunity to deepen and develop collaboration and cooperation between universities of the two countries.

As well as various presentations and panel discussions, there was a roundtable discussion attended by Prime Minister Abe. Participants discussed measures to promote exchange of students and young researchers between Japanese and UK universities, consideration of a framework for multilateral (rather than bilateral) collaboration, and cooperation between Japanese and UK universities in facing global challenges such as ageing societies. The British Council's research and education network for knowledge economy initiatives, known as RENKEI for short (the Japanese word for collaboration), has been helping to develop and extend these links.

Attended by Ministers Ed Davey and David Willetts, the conference also provided a venue for presenting UK-Japan agreements on climate change and energy, and in particular nuclear cooperation, including the announcement of new joint fund for nuclear safety research and an agreement between TEPCO FDEC and NDA & Sellafield Ltd.

The conference was a valuable opportunity to deepen and develop collaboration and cooperation between universities of the two countries. Participants agreed the Joint Announcement at the Conference which pledges to hold regular follow-up meetings regarding both research and education in order to continue and develop these areas.

Further information: http://www.uk.emb-japan.go.jp/en/event/2014/05/uni.html

PRESIDENTIAL SCIENCE AND INNOVATION POLICIES: WHERE ARE WE NOW?

Bradley Keelor
Science and Innovation Network
British Embassy, Washington

The words "hope" and "change" were pervasive in Barack Obama's 2008 Presidential campaign, and they are part of the narrative in today's America. Although not typically a high-profile campaign issue, science enjoyed a relatively strong stature in 2008. Of the science issues that he discussed during the campaign, three have taken a place at the head of the class, and in some cases, with significant capital investments.

CLIMATE CHANGE

Climate change was the first scientific issue that the Administration addressed, with the announcement of three-high level appointments even before Obama's 2009 inauguration. These had backgrounds in climate research and signalled a shift from the Bush administration, whom many viewed as indifferent to such issues. The trio of John Holdren, Science Advisor to the President; Jane Lubchenco, Administrator of the National Oceanic and Atmospheric Administration (NOAA); and Nancy Sutley, Chair of the White House Council on Environmental Quality, gave greater visibility to climate research and policy.

In 2009, the Administration strongly supported the Congressional initiative to begin a National Climate Service (NCS) within NOAA, similar to the National Weather Service, which would provide climate data free of charge and to issue weather forecasts. Contrary to the Administration's expectation, the effort failed due to Congressional refusal to approve the budget for NCS for FY 2012.

The NCS's setback was not terminal. In 2013, the Administration set its direction of travel on climate policy with the Climate Action Plan. The CAP is a high-level policy document which contains one research-relevant section. This lays out action items for the US government that ensure the United States is prepared for the impacts of climate change. Notably, the CAP does not call directly for increased spending, but does recommend significant coordination among federal agencies in areas like resilience and green buildings.

OPEN DATA

Open data was the second scientific issue that the Obama Administration focused on with the appointment in early 2009 of Aneesh Chopra and Vivek Kundra, Chief Technology Officer and Chief Information Officer. This marked the first time either position existed on a national level. Kundra was tasked with

launching, publicising, and maintaining data.gov – an ambitious attempt to create a repository of data generated with federal funding, which the public could then use to create new applications and technologies. Within a year, over 250,000 data sets had been uploaded. Despite initial operational hiccups, the utilisation of the dataset has gained national acceptance. Recently, the government has utilised the data to run apps challenges, including the particularly successful International Space Apps Challenge, which is sponsored by NASA and has nearly 100 teams participating on six continents in the 2014 event.

As the age of big data dawns, the Administration is taking every step to ensure that the United States is not left behind. It created the National Information Technology Research and Development (NITRD) as the coordinating office for interagency big data group, in which over 20 federal agencies participate. NITRD coordinates over $4 billion in research funding.

ADVANCED MANUFACTURING

Advanced Manufacturing was the third top priority issue. Building on the momentum the Bush Administration and Congress initiated with the America COMPETES Act in 2007 and again in 2010, the President announced the Advanced Manufacturing Partnership in June 2011. In the three years since, the initiative has developed into a network of manufacturing centres coordinated by the National Institute of Standards and Technology (NIST). Congress has not funded the National Network for Manufacturing Innovation (NNMI), but consortia of businesses and universities have been rolled out, each with its own research portfolio. The most recent round includes the 60-member Lightweight and Modern Metals hub, headquartered in Michigan, and the Digital Manufacturing and Design Innovation Institute, headquartered in Chicago. Several new centres will be announced in the coming months.

The AMP's major accomplishment to date has been the coordination of several government-funded manufacturing initiatives, including the 25-agency National Nanotechnology Initiative, the National Robotics Initiative, and the Materials Genome Initiative.

TRANSLATING WORDS TO ACTIONS

Many of the Administration's science-based proposals have struggled to get off the ground, chiefly because of a lack of funding and Congressional reluctance to fund something it did not create – this has been the case with all three initiatives named here. Over the past several years, Congressional appetite for large, sweeping initiatives has lessened, especially at the Committee level, and several Congressional science champions from both parties have retired. With midterm Congressional elections in 2014 and the 2016 Presidential election looming, little time remains to create and implement broad policies in science or other issue areas. Areas like open data and advanced manufacturing will continue to deliver results for the President's priorities. We in the UK's Science and Innovation Network will continue to champion and promote UK's science and innovation agenda in Washington and across the whole of the United States.

TELLUS

Meeting of the All-Party Parliamentary Group for Earth and Environmental Sciences on Tuesday 13 May

VALUING AND REALISING OUR NATURAL CAPITAL ASSETS – TELLUS ALL ABOUT IT

Andy Howard
British Geological Survey

Co-authors from Geological Survey of Northern Ireland:

Mike Young

Marie Cowan

The 2011 White Paper *'The Natural Choice: Securing the Value of Nature'* commits us to be the first generation to leave the natural environment in a better state than it inherited. The Tellus projects – a series of multi-partner environmental survey and research projects carried out in the UK and Ireland – have delivered innovative data and research that have successfully shaped policy and stimulated new investments in mineral, energy and infrastructure resources. On 13 May, at a meeting of the All-Party Parliamentary Group for Earth and Environmental Sciences, chaired by Martin Caton MP, Andy Howard, Mike Young and Marie Cowan explained how the Tellus Projects are transcending their original goals to contribute to the measuring and realising the value of our natural capital assets, and to deliver the world-leading research needed to inform decisions and measure success in meeting the White Paper objectives.

In the early 2000s the geological surveys of Britain, Northern Ireland, the Republic of Ireland, and Finland joined forces to design a Resource and Environmental Survey for Ireland (RESI). RESI's purpose was not only to provide new data to stimulate exploration investment and licensing in minerals and energy resources but also to inform research, regulation and management of other natural capital

assets including soil, groundwater and landscape amenity. Re-branded as '*Tellus*', the first of these was completed in Northern Ireland between 2005-8, with funding from the Department of Enterprise, Trade and Investment. Building on a highly positive, post project cost benefit analysis of the impacts of Tellus, €5M funding was secured from the EU INTERREG IV programme for a second project – *Tellus Border* – which ran from 2010 to late 2013 and surveyed the six border counties of the Republic of Ireland.

Presenters at the Tellus South West project launch, Eden Project Cornwall, October 2013

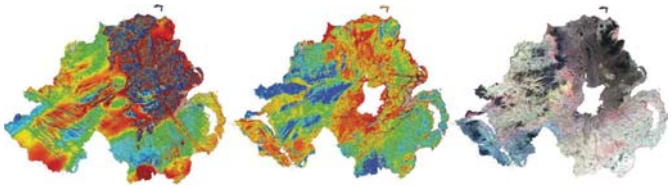
What does a Tellus survey involve? Firstly, an *airborne geophysical survey* flies a specially equipped light aircraft at low altitude over the landscape, in some places only 60m above ground. On-board sensors measure trace amounts of magnetism, radioactivity and electrical conductivity to build a 3 dimensional map of the properties of the soils, rocks, minerals and fluids below ground. At the same time, ground-based geochemical survey teams collect soil, stream sediment and water samples for analysis of over 50 key elements from the periodic table, representing a combination of the most essential minerals, nutrients and contaminants present in the environment. The results are combined into datasets and maps that are delivered online, providing a stock take of the extent and quality of minerals, soil and water resources, a *health check* of both natural and man-made chemical and radiological contaminants in the environment, and an objective *data resource* for multidisciplinary scientific research.

From an original cost of £5.8M, the outcome and impact of Tellus Northern Ireland has been considerable. The maps and data have led to investment commitments of over £32 million in new minerals exploration activity, with licensed blocks increasing from 15% to 70% of Northern Ireland's land area. The data are now routinely used to inform implementation of soil, water and waste directives, and deliver new maps on diverse themes such as radon hazard, soil moisture and carbon stocks, residual Chernobyl fallout, soil erosion and landfill contamination. Data on subsurface properties of aquifers, notably on previously unresolved barriers to groundwater flow, have informed new strategies for managing Belfast's groundwater supplies. Commercialisation of the Tellus data to provide information products and expert services to the agricultural industry on nutrient balances in soil, water and feed is proceeding with the release of the Tellus Border data. Furthermore, 20 new Tellus data-based research degrees and 16 short term grants have delivered on topics such as cancer epidemiology, critical metal resource potential, wetland ecosystem status and trace element toxicology.

... world-leading research needed to inform decisions ...

... samples for analysis of over 50 key elements ...

Following the lead of the Tellus projects in Ireland, the Tellus South West project in Devon and Cornwall is the first regional scale project of this type in Great Britain. The region presents a unique combination of future mineral and geothermal resource opportunities counter-balanced by environmental constraints on development, some of which relate to the region's industrial and mining legacy and others to a changing natural environment. Funded by the Natural Environment Research Council, the project is a collaboration between 3 of the NERC's research centres, the British Geological Survey (BGS), the Centre for Ecology and Hydrology (CEH), and the British Antarctic Survey (BAS). The University of Exeter Camborne School of Mines connects us with local businesses and the research community. Tellus South West has augmented the original Tellus specification with surveys of the status of the landscape, flood plains and natural habitats. Sampling of organic films on the beds of streams, for example, is looking for tell-tale evidence of the impacts of industrial activity on the smallest organisms in the food chain. At the other end of the scale, an *airborne lidar survey* flown by an aircraft from the BAS fleet has used high precision laser range-finding technology to make a 3 dimensional map of the ground surface, built assets and vegetation canopy, accurate to within a few centimetres. Combining these datasets provides us with a powerful set of tools to value resources and measure environmental change at a range of scales and timespans. We can model and predict how much rainfall is absorbed into the soil, how much runs off into streams and rivers, how nutrients and man-made contaminants are mobilised and transported by this water, how much of this water is taken up by vegetation, and which areas may be at risk of flooding and landslides.



Magnetic (left), conductivity (centre) and radiometric (right) airborne geophysical survey maps, Northern Ireland. Coastline © Crown Copyright DMOU205

... value resources and measure environmental change ...

The most important outcome of these projects is the 'Tellus Effect', the ability of these projects to encourage knowledge exchange and collaboration between specialists in businesses, research and government with a common

interest in the data. Launches of the Tellus Border data in October 2013 and the Tellus South West data in May 2014 brought together data users from the minerals, energy, agricultural and water industries, from local government and environmental regulators, from heritage and conservation bodies, and from researchers in geoscience, ecology, hydrology, agricultural science and environmental health. Most importantly, the data from both projects are available free of charge both to view and download from easily accessible web portals. This catalyses the further sharing of environmental data among these groups, and the development of new partnerships to deliver value and innovation from new cross-disciplinary combinations of research capability. Momentum is building from one Tellus project to the next, with new surveys and new partners contributing to more diversity of data and joined-up research. With a bid for INTERREG V funding, we hope to expand Tellus into the marine environment, joining the Irish Sea, western Wales and eastern Ireland, and partners are currently being sought for other

Airborne geophysical surveys require low altitude flying to acquire high resolution data on the subsurface. Image courtesy Tellus Border project, supported by the EU INTERREG IVA Cross-Border programme.

projects in the so-called Energy Coast of north west England and in the major regeneration areas of the central belt of Scotland.

So what of Natural Capital, and the White Paper commitment? The Tellus Effect helps to pull together the partnerships of businesses, decision makers and researchers that need to work in concert to value, manage and sustain our natural capital. The projects provide an 'instrument panel' of indicators and 'big data' to observe and learn lessons from past and present human impacts on our environment, and measure our future progress towards a 'better state' for future generations. Working together, we hope that these projects, and others like them, can help us understand the business of the environment, and ensure that economic growth and a sustainable natural environment are mutually compatible objectives.

Authors:
Andy Howard (British Geological Survey)
Mike Young (Geological Survey of Northern Ireland)
Marie Cowan (Geological Survey of Northern Ireland)

Tellus Partners:
Geological Survey of Northern Ireland http://www.bgs.ac.uk/gsni/
Geological Survey of Ireland http://www.gsi.ie/
Natural Environment Research Council http://www.nerc.ac.uk/
British Geological Survey http://www.bgs.ac.uk/
British Antarctic Survey http://www.bas.ac.uk/
Centre for Ecology and Hydrology http://www.ceh.ac.uk/
University of Exeter Camborne School of Mines http://emps.exeter.ac.uk/csm/

Tellus websites:
Tellus http://www.bgs.ac.uk/gsni/Tellus/
Tellus Border http://www.tellusborder.eu/
Tellus South West http://www.tellusgb.ac.uk/

WHY EXPLORE THE SOLAR SYSTEM?

Tom Gunner
Parliamentary Space Committee

In September last year, the P&SC teamed up with the Parliamentary Space Committee in a special session chaired by Andrew Miller and Phillip Lee, to hear from Britain's leading planetary scientists what we have learnt recently about our own Solar System, what more there is to find out, and why it matters.

Space still has a mixed rep in and around Parliament. Probably the most common question asked on the subject, is "I didn't know we did space!" rapidly followed by, "why do we do space? Isn't that a cold war superpower thing? Can we really afford to do that kind of thing?"

... rely on gas pumped through National Grid's national network ...

There are many responses to these questions. The response to the first question, is yes, we do space. And we do it very well. Britain's space sector now supports 83,000 jobs, and adds £9.1 billion to the economy. When you think about it, it's perhaps not surprising. In your average day, you will quietly depend on a host of space-enabled services. The shower you take, if it is gas powered, could rely on gas pumped through National Grid's national network of 170,000 miles of pipeline, managed by a network of nearly 500 switch points. The instructions to these points are transmitted up into orbit and back, because satellites offer some of the most secure form of communications available.

Whether you pick up a brolly or suncream will depend on the information satellites provide the Met Office. All data for five day forecasts, and 90% of the data for shorter term forecasts, come from satellites. And then of course as you move about, most people now depend on navigation services powered by satellites. And no, satellites are not responsible for driving you into ditches. That's the software. For many in remote areas, satellites are the only realistic chance of getting online, to fill in DEFRA's online farm payment forms, perhaps. But perhaps

most of all, the space industry is a real wealth creator for the UK, exporting high technology goods and services across the world. Last year, the PM and the premier of China witnessed the signing of £1.2 billion of UK export deals to China. 10% of these came in the form of a single satellite contract, supplying the data from three earth observation satellites.

But there is also space science, and here the answer to the second question, "can we really afford to do that kind of thing?", is very different. Quite simply, we do space science for the same reasons we do science. Space is in many areas the best place to do science, and in some fields, the only place. Space is the biggest lab in the universe, free from Earth's gravity and atmosphere. As Phillip Lee highlighted in a recent debate, the International Space Station is a unique lab for the world's scientists to conduct

... The Mars rover is being .. tested here in the UK, by Astrium ...

experiments in microgravity, looking into the impact of ageing on human skin cells, or the impact of zero gravity on bone density (our bones lose 1% of their density for every month in space). And there is also the other reason for discovering more about our Solar System – curiosity. Because we can. As Fabio Favata of the European Space Agency argued, curiosity was the primary driver in mankind's interest in the Cosmos. Curiosity gave birth to the ancient science of astronomy. Astronomy provided the key to long-distance navigation. Astronomy therefore enabled the British Empire! And today, a new constellation of man-made stars position us anywhere on the Earth's surface to less than a metre.

In September last year, the Parliamentary and Scientific Committee joined with the Parliamentary Space Committee to find out more about some of the most exciting research being conducted today by Britain's leading planetary scientists, alongside the European Planetary Science Congress, held last year in London for the first time. According to Dr Lewis Dartnell of Leicester University, Mars, our closest and most accessible planetary neighbour, could once have been teeming with life. We now know that billions of years ago, Mars was a more inviting place for life to set hold – it was wetter, warmer and had a thicker atmosphere. Organic molecules would have rained down on its surface, in the same way that brought life to Earth – perhaps, even from Mars, according to one new theory. Europe's response is its Mars rover, the most sophisticated robot ever to be sent to Mars. The Mars rover is being designed and tested here in the UK, by Astrium, in Stevenage. Capable of withstanding cosmic radiation which would fry a human, this lab on wheels has a six wheel drive and twin robotic cameras, allowing it to see in 3D. But it is its drill that most excites planetary scientists, allowing it to drill into the Martian soil and search for signs of life. There is no better way to inspire young people into STEM subjects than the search for life. If one day we find the signs of past life on Mars, we will have our new post-Apollo generation of scientists and engineers. And the advanced technology needed to develop this miniaturised box of tricks has been spun off and down to Earth, powering mobile solar powered radios, for instance, in Africa.

Further afield, Michele Dougherty, professor of space physics at Imperial, has been enquiring into the properties of

... Why does such an old moon have such an unrippled surface? ...

Enceladus, one of Saturn's oldest moons and one of the brightest objects in our solar system. Why does such an old moon have such an unrippled surface? Could it be the source of Saturn's E-ring, the largest ring in the Solar System, made up mostly of water compounds? The surface of Enceladus is also mainly ice. The European spacecraft Cassini has undertaken two flybys of Enceladus to take a closer look. What they found was that the magnetic fields emanating from Enceladus suggested an atmosphere, and at its poles, vast water vapour plumes were belching out from vast cracks on its surface. So there is a sub-surface heat source, which is a surprising feature of such an old moon. For life to form, you need water, organic material, a heat source and stable conditions over time. Enceladus, tantalisingly, has three of these conditions. In 2022, Europe's next explorer, the Jupiter Icy Moons Explorer, or JUICE for short, will be launched, reaching Jupiter by 2030, and will spend 2½ years exploring the Jupiter system, focusing on three moons, Ganymede, Europa and Callisto. Ganymede is the largest moon in the solar system, and scientists believe it has a large, deep ocean beneath its surface. In a generation, we should know far more about the solar system's second biggest planet, and perhaps solve some of these mysteries.

... Asteroids and comets offer us a unique glimpse ...

Why bother looking at comets and asteroids? Professor John Zarnecki of the OU gave us three reasons. Firstly, science. The solar system was formed when a cloud of dust congealed to form our planetary system. Asteroids and comets offer us a unique glimpse into the founding blocks of our solar system. It is almost certain that a major asteroid strike 65 million years ago wiped out the dinosaurs. In the case of a killer asteroid hitting the Earth again, the question is not if, but when. The problem is, we don't know if it will happen tomorrow or in a million years! The spectacular and damaging airburst of an asteroid above Chelyabinsk on 15th February this year, on the same day, in fact, as a near miss, in cosmic terms, of a far bigger comet, reminded us that the date may be closer to tomorrow than a million years! Fortunately, Britain's space industry could provide the answer. A team of engineers and scientists at Astrium in Stevenage are working on a suitably Hollywood named project, NEO shield, to look into the technologies to avert the next strike, whenever it may happen. Three ideas are currently being looked at: blasting it into tiny fragments, deflecting it, and slowing it to a halt using gravity.

There have been five close-up views by spacecraft of comets. Some of Man's earliest recorded art are from China, 3,000 years ago, of comets. The first spacecraft to conduct a flyby of a comet was part designed and

built in Bristol in 1986. The hard bit is to land on a comet. Europe's spacecraft Rosetta hopes to rendezvous with and actually put a lander on the surface of a comet. Put the 10th November 2014 in your diary! About 10:30am. The lander will carry a whole suite of clever stuff, to study its chemical and isotopic composition, all in a piece of kit not much bigger than a shoebox, so compact in fact that the technology has been spun off to detect tuberculosis in sub-Saharan Africa, and monitor air quality in submarines. But now the race is on. Several space agencies are mounting missions to asteroids to bring back significant amounts of material. In the UK, Astrium is developing special technologies to land the lander and carry the samples safely back to Earth without contaminating them.

There are also at least two private consortia developing technologies to mine asteroids, backed with big money from serious investors, including Larry Page of Google and Walt Schmidt. If only Britain had somehow managed to net the passing comet in February, we might have been able to pay off the national debt!

... carry the samples safely back to Earth ...

It is easy to dismiss space science as an area of luxury Britain can ill afford. But in our world leadership in space science and industry, we still walk tall as a nation, and our eyes are set firmly on the horizon.

MARS – did life ever evolve there and what will future exploration reveal?

Dr Lewis Dartnell
Department of Physics and Astronomy, University of Leicester

Last autumn saw the prestigious conference, EuroPlanet, come to London, hosted by UCL. Attended by nearly one thousand scientists from around the world, this was the biggest such conference yet, and included sessions in planetary science on everything from Mars missions to distant solar systems. But, most importantly, this was the first EuroPlanet ever to hold a session in a legislative body: hosted jointly by the Parliamentary and Scientific Committee and the Parliamentary Space Committee. I was one of three scientists invited to present an overview of the research we are involved in, and its wider significance, to the packed audience.

I am an astrobiologist; I investigate the possibility of life beyond the Earth. I'm not talking about green bug-eyed aliens and UFOs, but the possibility of hardy microorganisms surviving in the watery environments found on other planets and moons in our solar system. As you might imagine, astrobiology is a deeply 'interdisciplinary' field of science – it sits as the overlap between geology and planetary science, biochemistry and microbiology, and physics and astronomy.

My own piece of the puzzle involves studying what effect the bombardment of cosmic radiation might have on the survival of bacteria, or 'biosignatures' of their past existence, in the martian surface, and what are the best ways to look for them. One especially exciting forthcoming mission is the ExoMars probe, due to launch in 2018 to look for signs of past life. The UK is playing a leading role in many of the systems and instruments for this Mars rover. The UK Space Agency is funding my fellowship

to work on a Raman spectrometer – a laser-based technique which reveals both the minerals of a rock as well as organic molecules indicative of life that might be there. Raman spectrometry is a classic example of a technology that has been tried and tested in civil applications, proving itself time and time again before being adopted for space missions. It is now used for analysing the pigments used in oil paintings to spot fakes, drugs testing, and security scans for traces of explosives at airports. ExoMars will be the first mission to try Raman spectrometry beyond the Earth; scrutinising martian soil and rocks.

... everything from Mars missions to distant solar systems...

The transfer of knowledge and equipment also flows in the opposite direction: space hardware – technology literally out-of-this-world – being repurposed to solve real-world problems back down on solid ground. Instruments designed to be launched to explore other planets need to be simultaneously miniaturised and compact, lightweight, and have very low power demands. These are exactly the attributes required for portable devices – to be used by health workers in rural Africa testing for compounds indicative of different diseases, for example.

This isn't the only down-to-Earth benefit of astrobiology and space exploration. I devote a lot of my time to delivering public lectures and outreach events at schools (I also hold a Science in Society fellowship from the Science & Technology Facilities Council, STFC) and I have found that few things inspire young minds like hearing about our on-going exploits in exploring other worlds and searching for life. Encouraging more students to continue with STEM subjects (Science, Technology, Engineering and Mathematics) through A-levels and undergraduate degrees is utterly critical if the UK is to continue as a world-leader in fundamental discovery and innovation, and for us to financially thrive as an information economy.

Dr. Lewis Dartnell is a research fellow at University of Leicester, and author of 'Life in the Universe: A Beginner's Guide'

HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE

The members of the Committee (appointed 12 June 2014) are Lord Dixon-Smith, Baroness Hilton of Eggardon, Lord Hennessy of Nympsfield, Lord O'Neill of Clackmannan, Baroness Manningham-Buller, Lord Patel, Lord Peston, Lord Rees of Ludlow, Viscount Ridley, the Earl of Selborne (Chairman), Baroness Sharp of Guildford, Lord Wade of Chorlton, Lord Willis of Knaresborough and Lord Winston.

Lord Krebs' term as Chairman concluded at the end of the 2013-14 session. He has been succeeded by the Earl of Selborne. Baroness Perry of Southwark rotated off the Committee at the end of the 2013-14 session. New Members of the Committee are Lord Hennessy of Nympsfield and Viscount Ridley.

Behaviour Change

In May and June 2014, the Committee took oral evidence from witnesses to follow up on its 2011 report into behaviour change and assess what progress has been made in this area. This focused on the two behaviour change case studies that the Committee had investigated in its original inquiry: modal shift in transport and obesity.

International STEM students

In January 2014, the Committee launched a follow up inquiry to its 2012 report on higher education in science, technology, engineering and mathematics (STEM) subjects. The inquiry focused specifically on the effect on international STEM students of immigration policy. More than forty written submissions were received, seven oral evidence sessions were held in February and March, and a report published on 11 April 2014. A Government response is expected shortly.

Waste and the bioeconomy

The Committee launched an inquiry into waste and the bioeconomy in July 2013. The Call for Evidence closed on 27 September. Evidence was collected on the technology used to exploit bio-waste and waste gases in order to generate high-value products. The inquiry aimed to assess the potential for this technology to enable bio-waste and waste gas to replace current feedstocks, and the potential contribution this could make to a bioeconomy. The Committee published its report on 6 March 2014. A Government response was received in early June.

Scientific infrastructure

The Committee launched an inquiry into scientific infrastructure in May 2013. The call for evidence closed on 22 June. Oral evidence was taken across June and July on the large and medium-sized scientific infrastructure currently available in the UK with a particular focus on: future needs and strategic planning, funding and governance arrangements, international partnerships and partnerships with industry. The Committee published its report on 21 November 2013. A Government response was received in February 2014 and a debate held on 13 May 2014.

Regenerative medicine

The Committee launched an inquiry into regenerative medicine before the 2012 summer recess. A group from the Committee visited the California Institute for Regenerative Medicine. Oral evidence was taken from October to March 2013. The Committee reported on 1 July 2013 and a Government response was received on 1 October. A debate was held in the Chamber on 13 March 2014.

Nuclear follow-up

In July 2013, the Committee undertook an

evidence session with Professor David Mackay, Chief Scientific Advisor at the Department of Energy & Climate Change, to follow up on its November 2011 report, Nuclear research and development capabilities. A further follow-up evidence session was held with the Minister for Energy, Rt Hon Michael Fallon MP, on 10 December 2013.

Science spend

In May 2013, ahead of the Comprehensive Spending Review, the Committee held a one-off evidence session on the topic of science spend. A letter was sent to the Chancellor of the Exchequer on 4 June 2013 calling for an increase in the science budget. In a separate but related development, on 4 December 2013, the Committee wrote to the Rt Hon David Willetts MP, Minister for Universities and Science, to seek clarity on claims in the media suggesting that the ring-fenced science budget may be used to shore up the Department's budget in other areas.

FURTHER INFORMATION

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

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

RECENT POST PUBLICATIONS

There have been no recent POST Publications

CURRENT WORK

Biological Sciences – Minimum Age of Responsibility, Childhood Allergy, Population Health Management, GM Crops, Biobanks, Parity of Esteem between Physical and Mental Health

Environment and Energy – Short Lived Climate Pollutants, Ancient Woodlands, Reducing Diffuse Water Pollution from Agriculture, REDD+, Smart Metering of Energy and Water, Energy Storage, Phosphate Resources, Environmental Citizen Science, GM Insects, Integrated Management of Floodplains, Biodiversity Auditing

Physical sciences and IT – Unmanned Aerial Vehicles, Big Data Overview, Big Data in Business

Social Sciences – Big Data, Crime and Security, Big and Open Data in Transport, End of Life Care, Alternative Currencies

CONFERENCES AND SEMINARS

Urban Green Infrastructure

On 6th May, POST hosted a breakfast briefing on urban green infrastructure for parliamentarians on the evidence for the effectiveness of urban green infrastructure in supporting different aspects of human wellbeing and challenges to its implementation and maintenance, with representatives from academia, planning, policy and local authorities. It was chaired by Chi Onwurah MP and presentations were made by: Professor Richard Mitchell, Professor of Public Health at Glasgow University and Co-Director of Centre for Research on Environment Society and Health (CRESH), Professor Jim Harris, Chair of Environmental Technology, Cranfield University, Professor Rosie Hails, Centre for Ecology and Hydrology, Chair of the Natural Capital Initiative and Member of the Natural Capital Committee, Diane Smith, Interim Chief Executive, Town & Country Planning Association, Dr Shepley Orr, Department of Civil & Environmental Engineering, UCL, Dr Ian Mudway, Analytical & Environmental Sciences Division, King's College London, Dr Mathew White, European Centre for Environment and Human Health, Exeter University, Peter Massini, Urban Greening Team Leader, Greater London Authority and Tom Butterworth, Natural England's Senior Adviser for Local Government. A summary of the discussion at the event is available on the POST website.

STAFF, FELLOWS AND INTERNS AT POST

Fellows

Adriana De Palma, Natural History Museum, Biotechnology and Biological Sciences Research Council
Oscar Branson, University of Cambridge, Natural Environment Research Council
Mark Richardson, University of Reading, Natural Environment Research Council
Rosalind Davies, University of Birmingham, Engineering and Physical Sciences Research Council
Daniel Rathbone, Imperial College London, Engineering and Physical Sciences Research Council
Maria Thorpe, University of Manchester, Engineering and Physical Sciences Research Council
Elizabeth Duxbury, University of East Anglia, BBSRC
Helen Brewer, Rothamstead Research Centre, BBSRC
Clare Wenham, University of Aberystwyth, Nuffield Council on Bioethics
Louise Moyle, King's College London, Nuffield Foundation Flowers Memorial Fellowship
Rachel Stocker, University of Durham, British Psychological Society
Paul Gilbert, University of Sussex, Economic and Social Research Council
Stephen Hanley, University of Leeds, Economic and Social Research Council
Rosanna Greenop, University of Southampton, Natural Environment Research Council
Kimberley Pyle, Cardiff University, Natural Environment Research Council
Lucy Anderson, University of Leeds, Natural Environment Research Council
Ian Keyte, University of Birmingham, Royal Society of Chemistry

Visiting Researcher

Dr Anusha Panjwani, Pirbright Institute

Staff

Nadine Walters, Publication and Events Secretary, is leaving POST in July 2014.

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 members of the Science and Technology Committee are:

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

Andrew Miller was elected by the House of Commons to be the Chair of the Committee on 9 June 2010. The remaining Members were appointed to the Committee on 12 July 2010. Caroline Dinenage, Gareth Johnson, Sarah Newton and Hywel Williams were appointed to the Committee on 27 February 2012 in the place of Gavin Barwell, Gregg McClymont, Stephen McPartland and David Morris. Jim Dowd was appointed to the Committee on 11 June 2012 in the place of Jonathan Reynolds. David Morris was re-appointed to the Committee on 3 December 2012 in place of Gareth Johnson. David Tredinnick was appointed to the Committee on 4 February in place of Caroline Dinenage. David Heath was appointed to the Committee on 25 November 2013 in place of Roger Williams.

CURRENT INQUIRIES

Climate: public understanding and its policy implications

On 28 February 2013 the Committee announced an inquiry: Climate: public understanding and its policy implications.

On Monday 9 September 2013, the Committee took evidence from James Randerson, The Guardian, Catherine Brahic, New Scientist; Fiona Harvey, The Guardian, Lewis Smith, Freelance Correspondent and Richard Black, Former BBC Environment Correspondent.

On Wednesday 11 September the Committee took evidence from Tony Grayling, Environment Agency, Phil Rothwell, Environment Agency, Paul Crick, Kent County Council and Katie Stead, Kirklees Council; John Hirst, Met Office and Professor Julia Slingo OBE, Met Office.

On Wednesday 9 October the Committee took evidence from Rt Hon the Lord Deben, Chairman, and David Kennedy, Chief Executive, Committee on Climate Change; Rt Hon David Willetts MP, Minister of State for Universities and Science, Department for Business, Innovation and Skills; Rt Hon Gregory Barker MP, Minister of State for Climate Change, Department of Energy and Climate Change, Professor David MacKay, Chief Scientific Advisor, and David Warrilow, Head of Science, Department of Energy and Climate Change.

On Wednesday 6 November the Committee took evidence from Professor Sir Mark Walport, Chief Scientific Adviser to HM Government and Head of the Government Office for Science.

The evidence received is on the Committee's website. A Report was agreed and was published on 2 April 2014. The Government's response was published on 23 June 2014.

Government Horizon Scanning

On Wednesday 23 October the Committee took evidence from Alun Huw Williams, Principal, SAMI Consulting, Doug McKay, Vice President, International Organisations, Shell International, and Natalie Day, Head of Policy, Oxford Martin School, University of Oxford; Dr Martyn Thomas, Royal Academy of Engineering, Jonathan Cowie, former Head, Science Policy, Institute of Biology, and Professor Ann Buchanan, Academy of Social Sciences.

On Wednesday 27 November the Committee took evidence from Fiona Lickorish, Head, Institute for Environment, Health, Risks and Futures, Cranfield University, Jessica Bland, Technology Futures Analyst, Nesta, and Marcus Morrell, Senior Futures Analyst, Arup; Professor Burkhard Schafer, Professor of Computational Legal Theory, Edinburgh School of Law, Professor Paul Newman, Mobile Robotics Group, University of Oxford, Nick Reed, Intelligent Transport Systems UK, and Dr Graeme Smith, Business Manager, Connected Services, Control and Electronics, Ricardo UK Ltd.

On Wednesday 4 December the Committee took evidence from Sir Mark Walport, Government Chief Scientific Adviser, and Jon Day, Chair, Horizon Scanning Oversight Group, Cabinet Office.

The evidence received is on the Committee's website. A Report was published on 4 May 2014.

Women in STEM careers

On Wednesday 16 October the Committee took evidence from Dr Bryn Jones, Visiting Fellow, School of Physics, University of Bristol, Jenny Marsden, Principal Physicist, Hull and East Yorkshire NHS Trust, and Dr Nicola Patron, Head, Synthetic Biology, Sainsbury Laboratory.

On Wednesday 30 October the Committee took evidence from Dr June McCombie, former Chair of IOP Project, Juno Panel, Institute of Physics, Sarah Dickinson, Manager, Athena SWAN Charter, Equality Challenge Unit, Professor Dame Julia Higgins, Chair of Diversity Programme, Royal Society, and Dr Pia Ostergaard, Senior Fellowship Advisor, Daphne Jackson Trust; Professor Uta Frith, Emeritus Professor of Cognitive Development, University College London, representing Russell Group, Professor Jane Powell, Deputy Warden, Goldsmith's, University of London, representing 1994 Group, and Clem Herman, Senior Lecturer, Computing and Communications, Open University.

On Monday 4 November the Committee took evidence from Dr Lesley Thompson, Engineering and Physical Sciences Research Council (representing the Research Councils UK), and David Sweeney, Director, Research, Innovation and Skills, Higher Education Funding Council for England.

On Monday 18 November the Committee took evidence from Rt Hon David Willetts MP, Minister of State for Universities and Science, Department for Business, Innovation and Skills.

The evidence received is on the Committee's website. A Report was agreed and was published on 6 February 2014. The Government response was published on 7 May 2014.

Antimicrobial resistance

On Wednesday 18 December the Committee took evidence from Dr Pat Goodwin, Society of Biology, Professor Laura Piddock, British Society for Antimicrobial Chemotherapy, Professor John Threlfall, Society for Applied Microbiology, and Professor Sharon Peacock, Cambridge Infectious Diseases Initiative, University of Cambridge.

On Wednesday 8 January 2014 the Committee took evidence from Professor Anthony Kessel, Public Health England, Dr Michael Moore, Royal College of General Practitioners, Professor Alison Holmes, Imperial College London and Dr Susan Hopkins, Royal College of Physicians; John Hardcastle, Novolytics, Dr David McIntosh, Novartis, Professor George Lewith, University of Southampton Medical School and Doris-Ann Williams, British In Vitro Diagnostics Association.

On Wednesday 29 January 2014 the Committee took evidence from Phil Sketchley, National Office of Animal Health, John FitzGerald, Responsible Use of Medicines in Agriculture Alliance, Catherine McLaughlin, National Farmers' Union and Cóilín Nunan, Alliance to Save our Antibiotics.

On Wednesday 26 February 2014 the Committee took evidence from Professor Jeremy Farrar, Wellcome Trust, Professor Sir John Savill, Research Councils UK, Kush Naker, Universities Allied for Essential Medicines UK and Professor Sir Anthony Coates, Antibiotic Discovery UK; Dr Louise Leong, Association of the British Pharmaceutical Industry, James Anderson, GlaxoSmithKline, Dr David Williams, Discuva and Michael McIntyre, European Herbal and Traditional Medicine Practitioners Association.

On Wednesday 12 March 2014 the Committee took evidence from Professor Dame Sally Davies, Chief Medical Officer, Sally Wellsteed, Department of Health, and Nigel Gibbens, Chief Veterinary Officer; George Eustice MP, Department for Environment, Food and Rural Affairs, Jane Ellison MP, Department of Health, Professor Dame Sally Davies, Chief Medical Officer and Professor Peter Borriello, Veterinary Medicines Directorate.

The evidence received is on the Committee's website. A report is being prepared.

Blood, tissue and organ screening

On Wednesday 5 February the Committee took evidence from Mark Ward and Joseph Peaty, TaintedBlood, Liz Carroll, Haemophilia Society, Dr Matthew Buckland, UK Primary Immunodeficiency Network and Christine Lord; Professor Marc Turner, Advisory Committee on the Safety of Blood, Tissues and Organs Prion Group, Dr Roland Salmon, Advisory Committee on Dangerous Pathogens and Dr Sheila MacLennan, UK Blood Services Joint Professional Advisory Committee.

On Wednesday 5 March 2014 the Committee took evidence from Dr Steven Burton, ProMetic Biosciences Ltd, Dr Kelly Board, DuPont Chemicals and Fluoroproducts, Dr Alex Raeber, Prionics AG, Nigel Talboys, Terumo BCT and Professor John Collinge, MRC Prion Unit.

On Wednesday 26 March 2014 the Committee took evidence from Professor Richard Knight, National CJD Research and Surveillance Unit, Professor Sheila Bird, Medical Research Council Biostatistics Unit, Dr Paula Bolton-Maggs, Serious Hazards of Transfusion (SHOT) Haemovigilance Scheme and Dr Simon Mead, Association of British Neurologists.

On Monday 28 April 2014 the Committee took evidence from Dr Richard Baker, British Transplantation Society, Dr Mike Knapton, British Heart Foundation, Ed Owen, Cystic Fibrosis Trust and Keith Rigg, Transplant 2013.

On Wednesday 30 April 2014 the Committee took evidence from Professor James Neuberger, NHS Blood and Transplant, Dr Lorna Williamson, NHS Blood and Transplant, Dr Paul Cosford, Public Health England, and Dr Katy Sinka, Public Health England; Jane Ellison MP, Parliamentary Under-Secretary of State for Public Health and Professor Dame Sally Davies, Chief Medical Officer, Department of Health.

The evidence received is on the Committee's website. A report is being prepared.

National health-screening programmes

On Wednesday 7 May 2014 the Committee took evidence from Professor Jane Wardle, Academy of Medical Sciences, Jessica Kirby, Cancer Research UK and Dr Sian Taylor-Phillips, Warwick Medical School.

On Wednesday 11 June 2014 the Committee took evidence from Robert Meadowcroft, Muscular Dystrophy Campaign, Professor Michael Baum, Advocates for Honesty and Transparency in Breast Screening and Steve Hannigan, Children living with inherited metabolic diseases (Climb); Síle Lane, Sense About Science, Dr Margaret McCartney and Dr John Middleton, UK Faculty of Public Health.

Practical science in schools

The Committee held a one-off session to discuss proposals from Ofqual to change the practical assessment of science at A level.

On Monday 12 May 2014 the Committee took evidence from Professor Julia Buckingham, SCORE, Dr Sarah Main, Campaign for Science and Engineering, Professor Ian Haines, UK Deans of Science and Malcolm Trobe, Association of School and College Leaders; Dennis Opposs, Ofqual, Glenys Stacey, Ofqual and Janet Holloway, Ofqual; and Elizabeth Truss MP, Parliamentary Under-Secretary of State for Education and Childcare.

Proposed takeover of AstraZeneca

The Committee held a one-off session to discuss the implications of Pfizer's proposed takeover of AstraZeneca on the UK science base.

On Wednesday 14 May the Committee took evidence from Dr Mikael Dolsten, Pfizer, Dr Rod MacKenzie, Pfizer and Ian C. Read, Pfizer; Pascal Soriot, AstraZeneca plc, Dr Mene Pangalos, AstraZeneca plc and Dr Jane Osbourn, AstraZeneca plc; and Rt Hon David Willetts MP, Minister of State for Universities and Science.

REPORTS

Government horizon scanning

On 4 May 2014, the Committee published its Ninth Report of Session 2013-14, *Government horizon scanning*, HC 703.

GOVERNMENT RESPONSES

Government Response to the Committee's report 'Women in scientific careers', the Committee's Sixth Report of Session 2013–14

On 7 May 2014 the Committee published the Government Response to the Committee's report on Women in scientific careers.

Government Response to the Committee's report 'Communicating climate science', the Committee's Eighth Report of Session 2013–14

On 23 June 2014 the Committee published the Government Response to the Committee's report on Communicating climate science.

FURTHER INFORMATION

Further information about the Science and Technology Committee can be obtained from the Clerk of the Committee, Stephen McGinness, or from the Senior Committee Assistant, Darren Hackett, on 020 7219 2792/2793; 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 recommended to obtain a copy of the guidance note first. This can be found at www.parliament.uk/commons/selcom/witguide.htm. The Committee has a website, www.parliament.uk/science, where recent publications, terms of reference for inquiries and press notices are available.

HOUSE OF COMMONS LIBRARY SCIENCE AND ENVIRONMENT SECTION

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

Opposite are summaries of some recent briefings.

For further information contact:
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RECENT PUBLICATIONS

Planning for Nationally Significant Infrastructure Projects

SN06881

The Planning Act 2008 introduced a new development consent process for Nationally Significant Infrastructure Projects. NSIPs are usually large scale developments (relating to energy, transport, water, or waste) which require "development consent". An extension of the regime in 2013 allows certain business and commercial projects to opt into this process.

A Development Consent Order (DCO) removes the need to obtain several separate consents, including planning permission, and is therefore a much quicker process. Applications for DCOs are decided in accordance with National Policy Statements (NPSs), which after a process of consultation and Parliamentary scrutiny are formally "designated" by Government. There are currently 12 designated or proposed NPSs, which fall under the categories of hazardous waste, water supply, energy, transport networks, aviation and ports.

In November 2013 the Government concluded that there was no need for a wholesale change to the DCO regime, which could damage developer confidence, but that some minor changes were needed to provide more clarity about the process and to speed it up. These changes will be introduced through the Infrastructure Bill introduced in June 2014.

Shale Gas and Fracking

SN06073

Drilling for shale gas is at the exploratory phase in the UK. The rapid development of shale gas resources in North America has transformed the world gas market.

The consensus is that shale gas will not be a 'game changer' in the UK as in the US. There is, for example, less land available to drill and landowners do not own the rights to hydrocarbons beneath their land. However, in June 2013 Centrica acquired a 25% stake in Cuadrilla's exploration licence in Lancashire and the Government and British Geological Survey published raised estimates of the shale gas resource in Northern England. The Government is

also consulting on tax incentives for shale gas exploration, and has announced community financial benefits. Existing onshore petroleum exploration and development licences, which are not specific to shale gas, are therefore now likely to be explored for their shale potential.

The Royal Society and Royal Academy of Engineering reviewed the risks of hydraulic fracturing, or 'fracking', concluding that the health, safety and environmental risks can be managed effectively in the UK and calling for more research on the carbon footprint of shale gas extraction. A report published by DECC in September 2013, in which shale gas emissions were said to be similar to those of conventional gas and lower than those of coal and LNG, led the Secretary of State to describe shale gas as a 'bridge' to a low-carbon future.

The Queen's Speech in 2014 confirmed Government plans to streamline the underground access regime and make it easier for companies to drill for shale gas.

Broadband – Update 2014

SN06643

The Government's ambition is to provide everyone in the UK with access to broadband with a download speed of at least 2 Megabytes per second (Mbps) and to provide 90% of the UK with 'superfast broadband' (at least 24Mbps).

The Government allocated £530 million to do this with a strategy for Britain's superfast broadband future (December 2010) which incentivises the deployment of broadband through a variety of technologies. It also set up Broadband Delivery UK (BDUK) to manage the roll-out of broadband in rural areas.

On 5 July 2013 the NAO report on the Government's broadband programme noted that Departmental forecasts predict the programme will complete its rollout 22 months later than originally planned.

Marine Conservation Zones in England

SN06129

Marine Conservation Zones (MCZ) are being introduced under the Marine and Coastal Access Act 2009 to protect important marine wildlife, habitats, geology and geomorphology. They will sit alongside other protected areas such as those designated under European law. Controls on damaging activities may be required in some MCZ. As a result their designation may be controversial in some cases.

127 MCZ were identified by regional stakeholder groups in 2011. An independent Science Advisory Panel concluded that the 127 sites would contribute to an ecologically coherent network of marine protected areas, but that the network would need to be strengthened. In July 2013 the Government said that it would not take forward all of the 127 MCZ at this stage due to concerns about the evidence.

On 21 November 2013, the Government designated 27 MCZ covering 8,000 sq km offshore and around 2,000 sq km of inshore waters. Measures to protect these sites will be developed after conservation bodies publish "site-specific conservation advice". This process would involve dialogue with stakeholders. The Government plans to designate two more phases of MCZs over the next three years. A consultation on the next phase will be launched in early 2015.

Carbon Price Floor

SN05927

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.

To address this, 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. At the time of the announcement the trading price was around £15 per tonne, but by January 2013 it had fallen to under £4.

The Treasury published carbon prices three years in advance from April 2013, together with indicative prices up to 2017. These were due to rise every year until 2020, with all revenue raised retained by the Treasury. However in the Budget 2014 the Government announced that prices would be capped at £18 per tonne from 2016 to 2020 to limit the competitive disadvantage faced by business and reduce energy bills for consumers.

Nuclear power

SN06228

On 21 October 2013 the Secretary of State for Energy, Edward Davey, announced that a deal had been reached between EDF Energy and the Government to build the first new nuclear power station in the UK since Sizewell B was commissioned in 1995. It will be funded by the private sector but will receive a guaranteed price for the electricity it generates.

As part of the deal, under a Memorandum of Understanding on civil nuclear cooperation between the UK and Chinese Governments, EDF will be allowed to sell minority stakeholdings in Hinkley Point C to the Chinese companies, CGN and CNNC.

It is now highly likely that nuclear power will continue to make an important contribution to the UK's electricity needs within a mixed economy of gas, coal and renewables.

ACTIVITIES

In addition to its usual work providing bespoke briefings for MPs, and publishing briefing papers such as those highlighted above, the Section has contributed topical pieces to the Library's blog (See for example the blog on halal slaughter http://commonslibraryblog.com/2014/05/16/is-better-labelling-the-answer-to-concerns-about-slaughter-methods/#more-927) and collaborated with the Parliamentary Office of Science and Technology to ensure that updated briefing was available for an event on Food Banks and Food Poverty (SN06657).

The section has kept up its outreach activities participating in a trip to Warwick University to help run a workshop to inform academics

about engaging with Parliament. Following a successful visit by House staff to Lancaster University's Environment Centre (LEC) earlier this year, LEC Director, Kevin Jones, visited Westminster in May to showcase LEC's work to specialists across Parliament (read more at http://commonslibraryblog.com/2014/05/21/establishing-academic-connections/).

On 4th June Her Majesty the Queen opened the 2014-15 Session of Parliament and set out the Government's legislative programme giving rise to new areas of work for the Section. The Queen's Speech included plans to introduce an Infrastructure Bill which would reform planning law, open up access to shale and geothermal sites and maximise North Sea resources (see blog post on fracking in the Queen's Speech: http://commonslibrary blog.com/2014/06/05/fracking-in-the-queens-speech/#more-997), and provide for a scheme to set a zero carbon standard for new housing. The Infrastructure Bill has now been published and has had its second reading in the Lords. Secondary legislation was promised to implement electricity market reform and to reduce the use of plastic bags. There were also announcements on Garden Cities, and governance of the National Parks in England.

Listed opposite (grouped by subject area) is a selection of Debates on matters of scientific interest which took place in the House of Commons, House of Lords or Westminster Hall between 1st May and 24th June 2014.

A full digest of debates and PQs on scientific issues during the 2013/14 and to date in the 2014/15 sessions of Parliament can be found at http://www.scienceinparliament.org.uk/publications/uk-digests/

SELECTED DEBATES

HEALTH

Cervical Cancer Screening	1.5.14	HoC 1025	Steve Rotheram
Melbourne Declaration on Diabetes	18.6.14	HoC 94WH	Adrian Saunders
National Health Service	17.6.14	HoL GC47	Lord Crisp
Organ Donation Register	17.6.14	HoC 1WH	Andrew Griffiths
Patient Safety	24.6.14	HoC 191	Statement by Rt Hon Jeremy Hunt

INFRASTRUCTURE

Draft National Policy Statement for National Networks	8.5.14	HoL 1623	Lord Berkeley
Infrastructure Bill Second Reading	18.6.14	HoL 837	Baroness Kramer
Scientific Infrastructure (S&T Report)	13.5.14	HoL GC453	Lord Krebs
Self-Build and Custom-Build	7.5.14	HoC 246	Richard Bacon

EDUCATION

Education Institutions: Autonomy and Accountability	24.6.14	HoL GC104	Baroness Perry of Southwark
Student Visas	24.6.14	HoC 206	Statement by James Brokenshire

MISCELLANEOUS

All-party Parliamentary Groups	13.5.14	HoC 709	Kevin Barron
Migratory Birds (Malta)	7.5.14	HoC 122WH	Sir John Randall
Sulphur Regulations	18.6.14	HoC 120WH	Karl Turner

Science Directory

Research Councils UK

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

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

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

Biotechnology and Biological Sciences Research Council (BBSRC)

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

Economic and Social Research Council

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The ESRC is the UK's largest organisation for funding research on economic and social issues and is committed to supporting the very best research with wide-ranging impact. Social science contributes to greater knowledge and understanding of the many challenges our society faces today and by ensuring that ESRC-funded research makes the biggest possible impact, our research shapes public policies and makes business, voluntary bodies and other organisations more effective, as well as shaping wider society. We also develop and train the UK's future social scientists.

EPSRC

Pioneering research and skills

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

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

Medical Research Council

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

Natural Environment Research Council

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NERC is the UK's leading public funder of environmental science. We invest £330 million each year in cutting-edge research, postgraduate training and innovation in universities and research centres.

Our scientists study the physical, chemical and biological processes on which our planet and life itself depends – from pole to pole, from the deep Earth and oceans to the atmosphere and space.

We partner with business, government, the public and the wider research community to shape the environmental research and innovation agenda. Our science provides knowledge, skills and technology that deliver sustainable economic growth and public wellbeing.

Science & Technology Facilities Council

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

Alzheimer's Research UK
Defeating Dementia

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Alzheimer's Research UK is the UK's leading dementia research charity. Currently, we support 130 projects worth over £21.5m. As research specialists, we fund pioneering research at leading universities across the UK and the globe with the aim of defeating dementia. Our expertise helps bring together leading dementia scientists to share ideas and understanding.

We work with people with dementia to reflect their concerns and firmly believe that science holds the key to defeating dementia.

Association of the British Pharmaceutical Industry

abpi
Bringing medicines to life

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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 – The Association for Independent Research and Technology Organisations – is the foremost membership body for organisations operating in the UK's intermediate research and technology sector. AIRTO's members deliver vital innovation and knowledge transfer services which include applied and collaborative R&D, frequently in conjunction with universities, consultancy, technology validation and testing, incubation of commercialisation opportunities and early stage financing. AIRTO members have a combined turnover of over £4bn from clients both at home and outside the UK, and employ over 40,000 scientists, technologists and engineers.

AMPS

AMPS
The Association of Management and Professional Staffs.

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Website: www.amps-tradeunion.com

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

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

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

Biochemical Society
Advancing Molecular Bioscience

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The Biochemical Society exists for the advancement of the molecular and cellular biosciences, both as an academic discipline and to promote its impact on areas of science including biotechnology, agriculture, and medicine. We achieve our mission though our publications and journals, scientific meetings, educational activities, policy work, awards and grants to scientists and students. The Biochemical Society is the largest discipline-based learned society in the biosciences with 6800 members.

The British Ecological Society

British Ecological Society

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

The British Ecological Society's mission is to advance ecology and make it count. The Society has nearly 6,000 members worldwide. The BES publishes five internationally renowned scientific journals and organises the largest scientific meeting for ecologists in Europe. Through its grants, the BES also supports ecologists in developing countries and the provision of fieldwork in schools. The BES informs and advises Parliament and Government on ecological issues and welcomes requests for assistance from parliamentarians.

British In Vitro Diagnostics Association (BIVDA)

BIVDA

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

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

The British Psychological Society

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

The British Society for Antimicrobial Chemotherapy

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www.e-opat.com | www.nas-pps.com
|www.appg-on-antibiotics.com
www.bsacsurv.org

The BSAC is an inter-professional organisation with over forty years of experience and achievement in antibiotic education, research and leadership. The Society has an active international membership and:

- Is dedicated to saving lives through the effective use and development of antibiotics, now and in the future.
- Communicates effectively about antibiotics and antibiotic usage via workshops, professional guidelines and its own high impact international journal, the Journal of Antimicrobial Chemotherapy.
- Is home to the UK-led global initiative Antibiotic Action
- Serves as secretariat to the All Party Parliamentary Group on Antibiotics

British Society for immunology

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

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

Brunel University

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Brunel is a world-class university based in London. Our distinctive mission combines teaching and research excellence with the practical and entrepreneurial approach of our namesake, Isambard Kingdom Brunel.

Brunel works closely with business to bring social and economic benefit by undertaking groundbreaking research to find solutions to major problems and producing graduates with the knowledge and skills sought by employers.

Cavendish Laboratory

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

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

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

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

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

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

Chartered Institute of Patent Attorneys

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

Clifton Scientific Trust

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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; also the Ukraine)

Clifton Scientific Trust Ltd is registered charity 1086933

The Council for the Mathematical Sciences

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

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

Eli Lilly and Company Ltd

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

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

EngineeringUK

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

The Food & Environment Research Agency

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

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

GAMBICA Association Ltd

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

The Geological Society

The Geological Society
serving science & profession

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The Geological Society is the national learned and professional body for Earth sciences, with 11,000 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.

Glass and Glazing Federation

GGF
Glass and Glazing Federation

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The GGF is the main representative organisation for companies involved in all aspects of the manufacture of flat glass and products and services for all types of glazing, in commercial and domestic sectors.

Members include companies that manufacture and install energy efficient windows, in homes and commercial buildings, the performance glass used in every type of building from houses to high-rise tower blocks and the components that are used to manufacture every type of glazing.

Institute of Food Science + Technology ifst

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

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

Institute of Marine Engineering, Science and Technology (IMarEST)

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

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 leading scientific society. We are a charitable organisation with a worldwide membership of more than 50,000, working together to advance physics education, research and application.

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

In September 2013, we launched our first fundraising campaign. Our campaign, Opportunity Physics, offers you the chance to support the work that we do.

Visit us at www.iop.org, follow us @physicsnews

Institute of Physics and Engineering in Medicine

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

IChemE

ADVANCING CHEMICAL ENGINEERING WORLDWIDE

The Institution of Chemical Engineers

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

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Kuala Lumpur | London | Melbourne | Rugby | Singapore | Wellington

Institution of Civil Engineers

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

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

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

Institution of Engineering Designers

support inspire achieve

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

IET

The Institution of Engineering and Technology

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

Institution of Mechanical Engineers

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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

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

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

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

The Linnean Society of London

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

A Forum for Natural History

L'ORÉAL UK AND IRELAND

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L'Oréal employs more than 3,500 scientists world-wide and dedicates over €600 million each year to research and innovation in the field of healthy skin and hair. The company supports women in science research through the L'Oréal UNESCO For Women in Science Programme and engages young people with science through the L'Oréal Young Scientist Centre at the Royal Institution. L'Oréal also collaborates with a vast number of institutions in the UK and globally.

Marine Biological Association

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Since 1884 the Marine Biological Association has been delivering its mission *'to promote scientific research into all aspects of life in the sea, including the environment on which it depends, and to disseminate to the public the knowledge gained.'* The MBA represents its members in providing a clear independent voice to government on behalf of the marine biological community. It also has an extensive research programme and a long history as an expert provider of advice for the benefit of policy makers and wider society.

Met Office

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

National Physical Laboratory

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

Natural History Museum

The Science of Nature

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

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

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

NEF: The Innovation Institute

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The Innovation Institute aims to drive innovation and growth in science, technology and engineering to achieve growth, prosperity and wellbeing in the UK. Our partners, clients and stakeholders include:

- Businesses
- Education providers
- Government bodies

New Engineering Foundation, our charitable arm, focusses on SciTech skills development. NEF work in vocational training and further education is supported by a Panel drawn from key industries.

Our Institute of Innovation and Knowledge Exchange is a professional body and a "do tank", led by the Innovation Council to support the role of innovation in society.

Nesta

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

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

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

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

www.nesta.org.uk

THE UNIVERSITY OF NORTHAMPTON

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The University of Northampton is a Top 50 UK University*. We are committed to science education through initial teacher training, a STEM Ambassador network which works within the community and teaching and research to doctoral level. We are only UK University with Ashoka U 'Changemaker Campus' status recognising our commitment to social innovation and entrepreneurship.

(*Guardian University Guide 2015)

The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

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With 43,000 students and campuses in Nottingham, China and Malaysia, The University of Nottingham is 'the nearest Britain has to a truly global university.' With more than 90 per cent of all research of international quality according to the most recent Research Assessment Exercise, the University is ranked in the World's Top 75 universities by the QS World University Rankings.

PHARMAQ Ltd

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PHARMAQ is the only global pharmaceutical company with a primary focus on aquaculture. Our mission is to provide environmentally sound, safe and efficacious health products to the global aquaculture industry through targeted research and the commitment of dedicated people. We have a product portfolio that includes over 20 fish vaccines along with specialist feed additives, anaesthetics, antibiotics, sea lice treatments and biocide disinfectants. Through our sister company, PHARMAQ Analytiq, we also offer a range of diagnostics services that can be used to help safeguard fish welfare and improve productivity.

The Physiological Society

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Physiology is the science of how molecules, cells and organs work in the body. Representing over 3000 life scientists, The Physiological Society supports scientific research through its grants schemes, conferences and its three open access journals.

The Society also supports the teaching of physiology in schools and universities, and works to promote an understanding of physiology amongst policy-makers and the general public.

Prospect

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Prospect is an independent, thriving and forward-looking trade union with 117,000 members across the private and public sectors and a diverse range of occupations. We represent scientists, technologists and other professions in the civil service, research councils and private sector.

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

ROYAL ACADEMY OF ENGINEERING

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As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering. We have four strategic challenges: drive faster and more balanced economic growth; foster better education and skills; lead the profession; and promote engineering at the heart of society.

Royal Botanic Gardens, Kew

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

- understand and conserve biodiversity
- accelerate discovery and global access to plant and fungal diversity information
- map and prioritise species and habitats most at risk
- promote sustainable local use of plants and fungi
- collect and store seed from 25% of plant species through the Millennium Seed Bank Partnership
- restore and repair habitats
- inspire interest in plant and fungal science and conservation

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

The Royal Institution Science Lives Here

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The Royal Institution (Ri) has been at the forefront of public engagement with science for over 200 years and our purpose is to encourage people to think further about the wonders of science. We run public events and the famous CHRISTMAS LECTURES®, a national programme of Masterclasses for young people in mathematics, engineering and computer science, educational activities at the L'Oréal Young Scientist Centre and policy discussions with science students. And through the Ri Channel we share the stories behind cutting-edge science with people around the world.

The Royal Society

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

ROYAL SOCIETY OF CHEMISTRY

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The Royal Society of Chemistry is the world's leading chemistry community, advancing excellence in the chemical sciences. With 48,000 members and a knowledge business that spans the globe, we are the UK's professional body for chemical scientists; a not-for-profit organisation with 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

Society for Applied Microbiology

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SfAM is a UK organization, serving microbiologists internationally. It works 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. With Wiley-Blackwell, SfAM publishes five internationally acclaimed journals. Value for money and a modern, innovative and progressive outlook are its core principles. A friendly society, SfAM values integrity, honesty, and respect, and seeks to promote excellence and professionalism and to inspire young microbiologists.

SOCIETY FOR GENERAL MICROBIOLOGY

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The Society for General Microbiology is the largest learned microbiological society in Europe with a worldwide membership based in universities, industry, hospitals, research institutes and schools. The Society publishes key academic journals, organises international scientific conferences and provides an international forum for communication among microbiologists. The Society promotes the understanding of microbiology to a diverse range of stakeholders, including policy-makers, students, teachers, journalists and the wider public, through a comprehensive framework of communication activities and resources.

Society of Biology

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The Society of Biology is a single unified voice, representing a diverse membership of individuals, learned societies and other organisations. We are committed to ensuring that we provide Government and other policy makers – including funders of biological education and research – with a distinct point of access to authoritative, independent, and evidence-based opinion, representative of the widest range of bioscience disciplines. Our vision is of a world that understands the true value of biology and how it can contribute to improving life for all.

SCI

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

Society of Cosmetic Scientists

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

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

Society of Maritime Industries

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

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STEMNET is an independent charity which enables young people to meet inspiring role models, understand real world applications of STEM and experience practical activities that bring learning and career opportunities to life. We do this through three core programmes:

- STEM Ambassadors - We run the UK network of STEM Ambassadors: over 27,000 inspiring volunteers
- STEM Clubs Programme - We provide free, expert advice and support to all schools which have set up or plan to develop a STEM Club
- Schools' STEM Advisory Network (SSAN) - We deliver free impartial advice to teachers and use our business links and partnerships to enhance the STEM curriculum in secondary schools in the UK

Universities Federation for Animal Welfare

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Registered in England Charity No: 207996

UFAW, the international animal welfare science society, is an independent scientific and educational 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 quarterly scientific journal Animal Welfare and other high-quality publications on animal care and welfare
- providing advice to government departments and other concerned bodies.

The Welding Institute

Contact: Chris Eady
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The Welding Institute is the leading institution providing engineering solutions and knowledge transfer in all aspects of manufacturing, fabrication and whole-life integrity management.

Industrial membership provides access to innovative problem-solving from one of the world's foremost independent research and technology organisations.

Non-Corporate services include membership and registration, education, training and certification for internationally recognised professional development and personnel competence assurance.

TWI provides Members and stakeholders with authoritative and impartial expert advice, knowhow and safety assurance through engineering, materials and joining technologies.

SCIENCE DIARY

THE PARLIAMENTARY AND SCIENTIFIC COMMITTEE

Tel: 020 7222 7085
annabel.lloyd@parliament.uk
www.scienceinparliament.org.uk

Tuesday 15 July 17.30
A Levels
Speakers: Dr Sarah Main, Director, Campaign for Science and Engineering
Professor Ian Haines, Executive Secretary, UK Deans of Science
Dr Michelle Meadows, Director of Research and Evaluation, Ofqual

Tuesday 21 October 17.30
National Infrastructure

Tuesday 18 November 17.30
Energy Storage

Tuesday 9 December 17.30
Dementia

THE ROYAL SOCIETY

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

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

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

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THE ROYAL INSTITUTION

Details of future events can be found at www.rigb.org

Booking is essential. For more information and to book visit www.rigb.org

There is a charge for tickets. Members go free.

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

For details of events organised by POST visit

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

THE INSTITUTION OF MECHANICAL ENGINEERS

The Institution of Mechanical Engineers plays a leading role in the international engineering community in providing advice to governments, industry and global society. Each year it organises some 300 technical conferences, seminars, lectures, debates and workshops around the UK and internationally, on key updates, developments or new techniques across 18 engineering and manufacturing sectors.

For details visit: www.imeche.org/events

THE LINNEAN SOCIETY OF LONDON

For details visit: www.linnean.org

The Linnean Society, in Piccadilly, has a diverse programme of evening lectures and day meetings covering the natural world, encompassing science, history and art. Most meetings are open to the public and many are free. Please subscribe to our free email-based newsletter - Linnean-News or visit our website www.linnean.org where you will find full programme details and registration forms.

More information on P&SC members' events can be found at: www.scienceinparliament.org.uk/members-news

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www.nottingham.ac.uk

Andrew Miller MP, Stephen Metcalfe MP and Dr Julian Huppert MP
invite you to attend on behalf of the science and engineering community

Parliamentary Links Day 2014

Science and Public Trust

Tuesday 24 June 2014 10:00 - 13:00
The Attlee Suite Portcullis House
House of Commons London SW1A 0AA

RSVP events@societyofbiology.org