The Journal of the Parliamentary and Scientific Committee

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SPRING 2017

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Stephen Metcalfe MP, Chairman, Parliamentary and Scientific Committee

Welcome to this edition of Science in Parliament. Following the sad death of our Editorial Administrator, Annabel Lloyd last year publication was temporarily suspended. I am pleased to say our usual quarterly editions are resuming.

We are at a momentous time in the history of our country as the UK focuses on obtaining the best possible deal in the Brexit negotiations. We must continue to attract the most skilled workers and researchers from across Europe, including young people who choose to come to the UK to study.

Last year's Nobel Prize awards gave us mixed emotions. Four winners were born and educated in the UK, but all had carried out the research for which they were recognized in the US. Yet another demonstration that science has always been "global", and that the best scientists will migrate to where they can best flourish. This is something we need to remember as the Brexit discussions get under way.

One UK invention / discovery which has not yet had the recognition it deserves is DNA testing / fingerprinting. One reason must be that it is eligible for recognition in more than one Nobel categories. It started as pure blue skies research investigating the genes for haemoglobin (Physiology/ Medicine) It then became a vital tool in catching murderers / rapists, whether domestic or genocidal (Peace). It has since been applied to investigating mutations following nuclear incidents (Chernobyl et al) and hence increased incidence of cancers (Physiology /Medicine). Finally, the way in which the analysis is now conducted relies on advances in Chemistry and Physics.

Alfred Nobel could never have envisaged that the categories he devised 120 years ago might no longer be appropriate in 2017. But then who could?

Stephen Metcalfe

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The Journal of the Parliamentary and Scientific Committee.
The Parliamentary and Scientific Committee is an All-Party 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.

Science in Parliament has two main objectives:

1. to inform the scientific and industrial communities of activities within Parliament of a scientific nature and of the progress of relevant legislation;
2. to keep Members of Parliament abreast of scientific affairs.

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PLASTICS MEETING

Meeting of the Parliamentary and Scientific Committee on Monday 18 July

WHAT ARE WE GOING TO DO ABOUT PLASTICS?

Kim Christiansen, Regional Director of PlasticsEurope and Dr Penelope Lindeque spoke on: 'What are we going to do about plastics?'
Below is a summary. Speakers' slides can be found at http://www.scienceinparliament.org.uk/activities/programme/

The European plastics industry is an **important source of growth**, turning over €350 annually as well as employing 1.45 billion. Plastics meet the need of a wide variety of markets, with packaging and building & construction being the most significant. There are a variety of different plastic polymers available to help meet the needs of these different markets.

Due to their lightweight characteristics and their ability to achieve more with less, plastics **achieve significant resource savings.** Plastics offer solutions for future challenges, such as enabling energy efficiency and achieving the goal of a circular economy (extracting maximum value from limited resource). Despite the misconception of plastics as users of primary resources, plastics only use 1.5% of the mineral oil and consumption in Western Europe (7-8% when considering production) and therefore, plastic packaging **saves more resources than they consume.**

In terms of end of life management, there are three main treatments: landfill (30.8%) recycling (27.7%) and energy recovery (39.5%). Energy recovery is when the plastic waste is used to generate energy through incineration. Since 2006 we have seen a **38% reduction in landfilling in Europe,** leading to a 64% increase in recycling and 46% increase in energy recovery. Austria, Germany and Luxembourg include some of the European countries with zero plastics to landfill rates. The UK's performance in plastic waste management can be improved as it is still reliant on landfill (~32%) and further increasing the recycling rate above ~40% is challenging. **A zero plastics to landfill objective** makes economic and environmental sense as eliminating landfilling will increase resource efficiency and make sure we use all the benefits provided by plastics.

Kim Christiansen believes that the story of plastics should be a successful one if a competitive and resource efficient Europe remains at the heart of the thinking and a life cycle approach is followed. To enable this, he calls for support innovation in waste management technologies and sustainable solutions to enable enhanced plastics circularity and coherence between legislations dealing with waste, products and chemicals.

Dr Penelope Lindeque addresses the growing threat plastics pose on our marine life, stating that it is estimated that there are at least **5.25 trillion plastic particles** currently floating at sea. Microplastic fragments which are described as small beads or fibres of plastic (<5mm in diameter) are a particular problem. Microbeads are found in everyday cosmetic products such as facial scrubs and toothpaste.

Dr Lindeque's research looks at the problems microplastic pollutants pose to small marine organisms, focusing on zooplankton and copepods. One study found that zooplankton have the ability to **ingest microplatic beads**. Another study found that microplastics interfere with copepod feeding which has repercussion for reproductive outputs and survival.

Dr Lindeque states that it is not clear how many plastic particles are in the sea. Current studies have found less than expected, possibly due to unrepresentative sampling. **Current sampling is biased** towards the surface of the sea, however most marine life is based in costal areas and calls for **further studies in costal areas** to determine the true impact of microplastic interactions on marine life.

Plymouth Marine Laboratory are studying six selected sites off the Devon coast to determine whether zooplankton in these waters are ingesting microplastics. Zooplankton are a key link the marine food web, and by ingesting plastic, it could have an impact on fish productivity and subsequently food provision. This shows that plastic pollution **could impact the UK economy and human wellbeing.** Dr Lindeque recommends increased education in plastic waste, banning unnecessary micro beads in consumer products, and the need for **further studies to draw evidence together** on the impact of plastics on marine life and society. Dr Lindeque notes the challenge of making any policy changes in plastics unless there is a clear link to human toxicity.

THE PROBLEM OF MICROPLASTICS IN OUR MARINE ENVIRONMENT

Dr Pennie Lindeque
(Plymouth Marine Laboratory)

Plastic debris is a widespread pollutant of the marine environment. Step on to any beach around the world and you will almost certainly find plastic litter. Not only is this plastic an eyesore, but it also poses a distinct threat to marine life and in turn human wellbeing. However, research is now suggesting that it is microscopic sized plastic, the plastic we don't readily spot, that we should be really concerned about (Figure 1).

Figure 1: Small plastic litter visible amongst the strand line on an otherwise pristine beach, Cockleridge, Devon. © Dr. Penelope Lindeque

PLASTIC IN OUR SOCIETY AND IN OUR SEAS

Large-scale production of plastics began in the 1950s, since which there has been an exponential growth of plastic production, with over 300 million metric tons currently manufactured globally each year. Plastic can be of vast benefit to society, providing a durable and low-cost material with widespread application. However, plastic is increasingly used to manufacture single-use, throwaway products, such as food packaging and drinks bottles, or to replace natural materials traditionally used in fishing gear, fabrics, or personal care products. Unfortunately, society has been slow to comprehend the pervasiveness and durability of plastic litter and waste management strategies have been equally slow to emerge. Through beach littering, road runoff, sewage, and illegal dumping, it is estimated that up to 10% of manufactured plastic ends up in the marine environment where it may take centuries to degrade. As a result plastic litter is increasingly emerging as a threat to marine life, ecosystems and potentially human health.

MICROPLASTICS

The effect that larger plastic debris has on wildlife is well documented. However, in recent years it has become apparent that microscopic plastic litter – termed "microplastics" – may pose an equal threat to marine life. Microplastics describe particulates and fibres, <5 mm in diameter, of various shapes, size, colour and polymer. Microplastics originate from two sources:

i) primary microplastics are manufactured to be of a microscopic size, and include small plastic resin pellets (nurdles or mermaid's tears) used to manufacture plastic goods, and extremely small plastic beads used as exfoliates in shower gels, toothpastes and industrial abrasives; and

ii) secondary microplastics which are derived from the degradation of larger plastic litter through exposure to ultraviolet radiation from the sun, abrasion or by the action of washing synthetic nylon or polyester clothing which can release thousands of plastic fibres into wastewater.

Microplastic debris has been identified in the water column and sediments of marine and freshwater ecosystems across the globe, including freshwater and glacial lakes, rivers, polar icecaps and deep sea sediments. Recent estimates suggest there are currently over 5 trillion bits of plastic floating within our oceans, the majority of which are microscopic in size, however this is likely to be a gross underestimate. According to recent studies there's much less microplastic observed in the sea surface compared to estimates of plastic production, release and expected rates of fragmentation. So where is this missing microplastic? Hypotheses put forward to explain this shortfall include accelerated fragmentation to nanoparticles, biodegradation, ingestion by organisms, sinking due to biofouling and settling in marine aggregates. In addition, sampling of microplastics with a traditionally used 335 micron

net may be unrepresentative. We have recently made a comparison of microplastic abundance sampled with different size nets which clearly indicates that the smaller the net size used for sampling the more mircoplastics are found. In Plymouth Sound, for example, >16,000 anthropogenic fibres per cubic metre have been recorded following heavy rainfall and an ebbing tide using a 100 micron net.

Sampling is currently biased towards the collection of larger plastics from surface waters of the subtropical gyres in the open ocean where plastics are known to accumulate. However, sources of plastics are largely centred on urbanized areas and it is here in these highly biologically productive coastal environments that interactions between microplastics and small marine organisms are most likely to occur, suggesting that these coastal areas should be given greater attention (Figure 2; Clark, Cole, Lindeque et al., 2016).

SMALL PLASTIC, BIG RISK?

Owing to their small size and abundance, microplastics are readily consumed by marine organisms. Microplastic debris has been identified in the stomachs of over 200 different species, including seabirds, turtles, fish, shellfish and barnacles. Evidence indicates that microplastics can be directly ingested, or transferred to other organisms through the consumption of prey, animal carcasses, faeces or biotic material containing plastic. Ingestion of microplastic debris can result in gut blockages and anecdotal evidence indicates they can lead to mortality in whales, fish, turtles and seabirds.

There is growing evidence that plastic debris can act like a magnet to other pollutants, including pesticides and industrial contaminants, present within the water; if eaten, there

Figure 3: Polystyrene microplastics ingested during laboratory experiments and visible in the intestinal tract of the marine copepod, Calanus helgolandicus. © Dr Matthew Cole

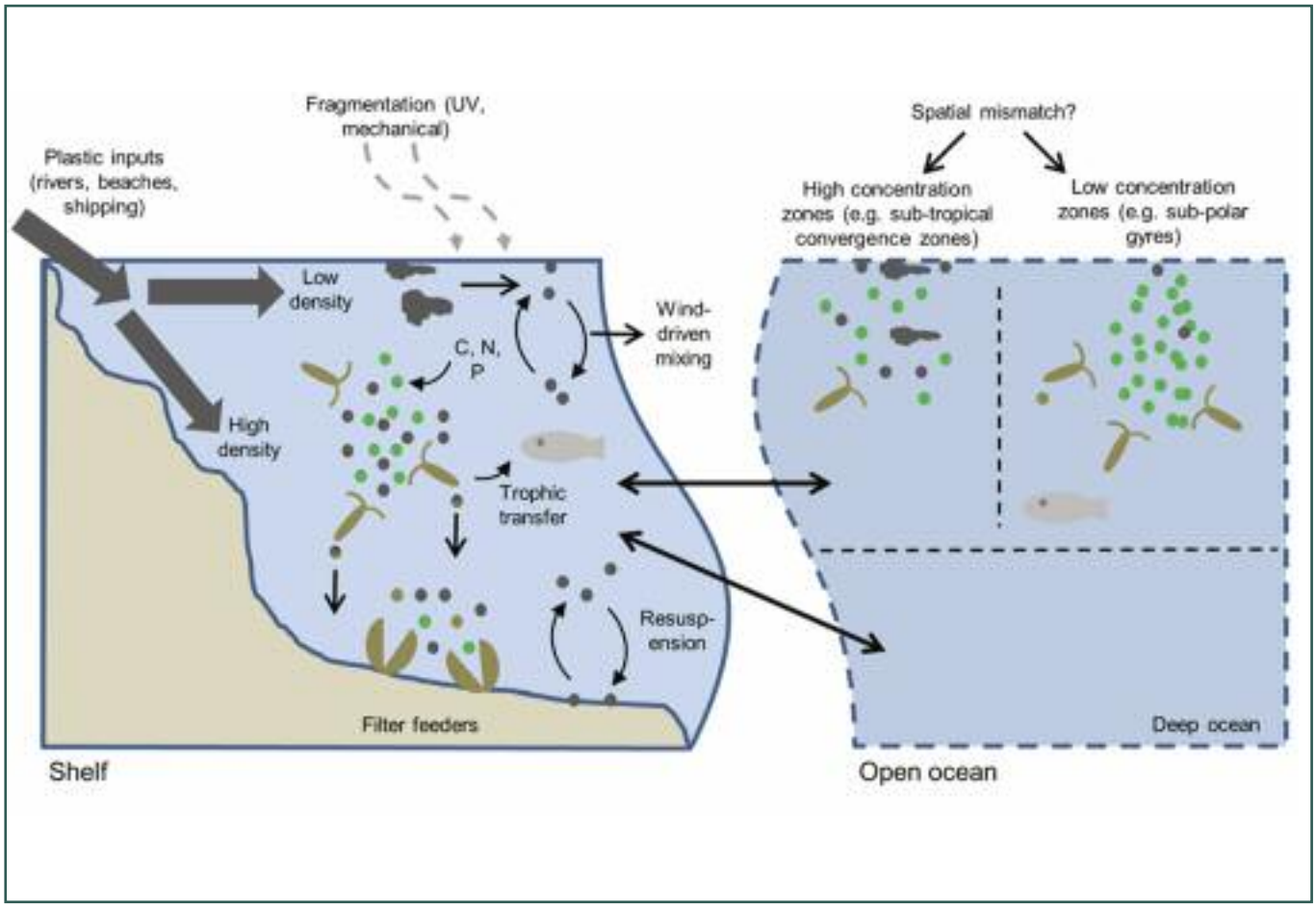

Figure 2: Schematic showing hypothesised regions and modes of interaction between microplastics (dark grey), small planktonic prey items (green) and other marine organisms (brown and light grey). Open ocean: known areas of high plastic accumulation (e.g. sub-tropical convergence zones) have low primary productivity meaning less energy is available to fuel the growth of consumers. Consequently, biological interactions with these organisms are expected to be less frequent. Shelf seas: areas with generally high levels of biological productivity that are often close to sources of plastic input, where we predict biological interactions will be more frequent (From Clark, Cole, Lindeque et al., 2016).

is concern such plastics might release these toxic compounds to the animal.

Our investigations into the risks microplastics pose to marine life have centred on zooplankton, small marine animals ubiquitous throughout our seas, which provide an essential link between primary producers (small marine plants such as algae) and higher trophic levels such as commercially important fish species and whales. Research conducted at Plymouth Marine Laboratory with the University of Exeter has demonstrated that a range of zooplankton, common to the Northeast Atlantic, including copepods (Figure 3), the larvae of bivalves (mussels, oysters etc.) and juvenile decapods (crabs, lobsters etc.), all have the capacity to ingest microplastics (Cole, Lindeque et al., 2013). Tiny plastics can also get trapped on the appendages of these animals, potentially affecting their movement and ability to detect predators and prey.

To better understand the consequence of microplastic ingestion in zooplankton we conducted in-depth experiments on copepods, a dominant group of zooplankton. Compared with microplastic free controls, copepods exposed to polystyrene microplastics ingested fewer algae and also showed a shift in preference to smaller algae prey, resulting in a 40% reduction in energy consumed (Cole, Lindeque et al., 2015). Over time, microplastic exposed copepods showed reduced reproductive outputs and survival. Similar adverse health effects have been observed in fish, polychaete worms, mussels and oysters.

The problem of microplastic ingestion by zooplankton however, doesn't end there. Recent studies have also shown that microplastics egested within copepod faecal pellets result in the pellets having less structural integrity (Cole, Lindeque et al., 2016). Additionally, if the egested microplastics were low density (e.g. polystyrene) then the faecal pellets sank more slowly. It is postulated this will increase the chances of them being eaten by other marine animals, resulting in the movement of the plastics through the food chain. The problem is two-fold; first moving the plastics through the food chain further disperses their potential to have negative effects, and secondly, this may reduce the organic matter reaching the seabed and increase the amount of particulate matter in the water column, with possible repercussions for wider marine ecological processes, and even the oceans climate control capacity.

Beyond the laboratory, and in the marine environment itself, it is currently unclear to what extent zooplankton will be affected by microplastic pollution. To address this knowledge gap at the Plymouth Marine Laboratory we have been undertaking an annual sampling programme based around the Western Channel Observatory http://www.westernchannelobservatory.org.uk/ (English Channel) to determine the extent of ingestion by zooplankton, including fish larvae, in the natural environment (Figure 4). Results from the laboratory and field based studies are being used in conjunction with mathematical models to determine the impact of microplastics on zooplankton and marine ecosystems; including the potential to affect the food chain.

Figure 4: Whiting Merlangius merlangus (12 mm) post-larval stage caught at Station L5, Western English Channel (http://www.westernchannelobservatory.org.uk/) with a blue fibre (310µm x 30µm) dissected from the intestinal tract. © Madeleine Steer

ACTION IS URGENTLY NEEDED

With rates of manufacture rapidly increasing and long degradation times, marine plastic litter is expected to be a growing issue over the next century. While we don't yet know the full extent of the impact of microplastics on the health of the marine environment or humans, the growing body of evidence suggest microplastic pollution is a contaminant of environmental and economic concern. Working with the Ellen MacArthur Foundation, and funding from Players of People's Postcode Lottery, the Plymouth Marine Laboratory are now reviewing all current literature on marine plastics, with the aim of determining the likely global impact on human wellbeing. This ground-breaking research is anticipated to encourage manufacturers, innovators, legislators and consumers to work towards a circular economy and the prevention of plastic litter entering the marine environment.

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TINKER, TAILOR, MAKER, ENGINEER? THE COMINO FOUNDATION

- How can we make science and engineering come alive for more young people and for more communities?
- What experiences should be on offer, both in schools and communities, if we are to be sure of having enough engineers in the future?
- Engineers need good theoretical understanding but is that all? Do they need hands-on experience as well?
- Why are so many 'makerspaces' emerging fuelled by spontaneous interest in designing and making things?
- Is 'just tinkering' with things of any value?

The Comino Foundation has been investigating the answers to these interwoven questions over many years.

The Foundation has its roots in innovation in manufacturing industry and its founder, Dimitri Comino was intent on bringing more creative approaches to both UK industry and UK schooling. For nearly 45 years the Foundation has worked with these two sectors on such ventures as the 1986 Industry Year initiative and the introduction of problem-solving to schools, but half a dozen years ago we felt that, despite our success in supporting schools, we were not doing enough in the commercial sector. So we looked around at what was happening that was interesting, had potential and might be effectively supported by a small charity. And we found 'the maker movement'.

All around the country groups were emerging. Working with the Royal Society of Arts, Manufactures and Commerce (RSA) and the Design and Technology Association in 2013 we held a 'Futuremaker' day in the basement of Somerset House to explore the field and its potential for schools. We were surprised by the number of people interested - 500 people attended - and by the level at which the school pupils involved could contribute. In Spring 2014 we called together people leading all the makerspaces we could then find as well others promoting the idea – some 24 people. By 2015 Nesta research had winkled out some 93 bases.[1] The pace of growth has been exciting. Many developments ensued from that 2014 meeting as it gave makerspace people opportunity to talk together, often for the first time. One of the outcomes, for example, was the Engineering and Physical Sciences Research Council funding of £467,000 to the Re-Distributed Manufacturing project based at the Royal College of Art which is exploring the potential of a group of makerspaces to collaborate in scaling-up production from emerging prototype to volume manufacture by providing a distributed interim production facility.

Prototype Makerspace furniture by Jas Tooze of the RCA for the Machines Room

We continue to support the networking of those involved through a series of Maker Assemblies[2] being held across the country focusing on the issues arising within the 'movement'.

Some makerspaces see themselves as potential innovation hubs developing new, potentially commercial products. Most are dedicated to learning within their local communities – establishing a membership model through which their members are learning new skills, new knowledge, working with new hardware and software. For instance:

Introduction to Making

Due to popular demand we are running an in-depth course on the processes and software packages used in Machines Room. We will introduce: drawing vectors in Inkscape, 3D printing and scanning, laser cutting, vinyl cutting . . . electronics, and CNC machining.

Machines Room, Shoreditch, web prospectus 2016 [3]

This concentration on learning and being open to what transpires offers huge potential for the future especially in a society where, as we are constantly told (eg McKinsey: Disruptive technologies), the rump of middle class, middle tier employment is about to go as a result of emerging technologies – leading potentially to a loss of 15 million jobs.

Occasionally makerspaces turn their back on commerce and resolutely concentrate on doing what they are doing for its own worth and interest. Some, typically with a mix of people with a range of skills and knowledge, explore new directions:

At MadLab we're seeing "maker" as a term beginning to shed its reputation as solely a concern for amateurs and hobbyists. This is only set to increase, as makerspaces continue to grow and draw together a catalytic community of scientists, professional engineers, tinkerers and maker-entrepreneurs in an environment which encourages fast hands-on experimentation with new technologies. Things like access to finance via crowdfunding certainly help also. It's now possible to launch a hardware startup with just 'a few people and their laptops.' [4]

Asa Calow and Rachael Turner, MadLab, Manchester

Learning through making; learning through exploring – these are powerful ideas, even more powerful when put into action. Recognising this, University College London have set up a makerspace open to all their staff and students: The Institute of Making. Why have they done that? Because they recognize that:

"Doing is a different way of thinking, we enable staff and students to conduct real-world research and enquiry, allowing them to discover unexpected outcomes and have a much more whole knowledge . . . Hands-on learning differs from, and is complementary to, academic scholarship. The Institute focuses on the making of physical objects through the transformation of materials, and champions this as a complementary alternative to traditional methods of scholarship

Elizabeth Corbin, Institute of Making, UCL

Thinking along similar lines, the Comino Foundation has been working with the Royal Academy of Engineering, the Royal Society of Arts and the Design and Technology Association to explore how an entrepreneurial mindset, together with the skills and knowledge development necessary to support it, can be developed in children. Professor Bill Lucas of the Centre for Real World Learning (CRWL) at the University of Winchester in the 2012 report 'Making It' identified the power of different ways for teachers and students to work actively together. The report described these approaches as 'studio teaching'. As well as liberating the higher-attaining students these approaches better supported some of the previously less-engaged:

"A small number of students, typically characterized by their lack of ability to focus, were picked out by teachers as being 'surprise' successes. Our studio learning approach was seen to give these learners the freedom to make their own decisions, which they found particularly motivating. These individuals attained above prediction." [5]

In their later work for the Royal Academy of Engineering, the CRWL, after studying how engineers think, identified six 'Engineering habits of Mind': Improving; Visualising; Creative Problem Solving; Problem Finding; Adapting and Systems Thinking.

The Science and Engineering Education Research and Innovation Hub (SEERIH), sponsored by Comino and the Primary Science Teaching Trust at

the University of Manchester,[6] has been investigating how to promote these habits of mind, using the concept of 'tinkering' as a teaching/learning approach in primary schools. Whilst cautioning against prejudice from popular conceptions of the word as:

'just tinkering with someone working without a clear goal or purpose, or without making noticeable progress' great value has been identified from these approaches such as

'. . more agile teaching approaches which contrast with the more frequently found objective-led approaches that are currently emphasised in UK school settings.'

Tinkering - a pedagogy for engineering education in the primary school? Dr Lynne Bianchi Dr Jon Chippindall, July 2016

The Hub's work draws from (mostly US) makerspaces, which they describe as an:

'increasingly visible network of makers, within tinkering studios, Tinkerlabs and Tinkergardens. In such spaces the intersections between Art, Science and Technology are blurred and what emerges are spaces in which young people can play with, make, refine, remodel or repurpose materials and machinery in creative purposeful pursuits.

SO FINALLY

Barriers are coming down – not least those between making; manufacturing; engineering and science. Also between time to learn and time to earn – makerspaces are as much learning communities as formal institutions of learning.

The role of institutions (universities and companies) is in question: IT specialists in particular can now go straight into collaboration in a hackspace, makerspace or online as entrepreneurs rather than go to University and risk learning out-of-date knowledge.[7]

Drawing conclusions from the developments we have seen as set out here, the Comino Foundation wants to see a continuation in the cross-fertilisation of ideas between industry, universities, schools and now . . the new makerspace locations. And for opportunities for learning at all stages to reflect the changes we've illustrated, involving people of all ages in hands-on activities to lead to the redefinition of 'learning' and an explosion in purposeful, creative thinking leading the way in economic regeneration.

David Perry, Trustee
José Chambers, Development Fellow
The Comino Foundation

References

1 Summary information on this survey can be found at: www.nesta.org.uk/blog/top-findings-open-dataset-uk-makerspaces

2 makerassembly.org

3 http://machinesroom.org

4 MadLab Manchester: www.madlab.org.uk

5 Making It: Studio teaching and its impact on teachers and learners http://bit.ly/2btSOXz

6 www.fascinate.manchester.ac.uk

7 To deflect this see developments such as the co-location of Google and St Martins College in Kings Cross – each looking for cross-fertilisation.

FARMING THE FUTURE WITH ROBOTS:

Science and Innovation Network supports the UK Agri-Tech Strategy

Dr Mario Rivero Huguet, SIN Officer Montreal (Canada)

The agriculture sector is experiencing major changes, pressures and challenges. Central to these challenges is the important forecast that by 2050, 60 per cent more food will need to be produced for the world's population.[1] A host of new technologies from autonomous tractors to agricultural 'big data' have the potential to ensure the production of enough food, while addressing the associated issues of climate change, environmental protection and shrinking resources. These emerging new technologies are fuelling what is being called the "precision farming revolution". The UK is now at the vanguard of agricultural technologies, pioneering new approaches to food and farming systems.

UK SCIENCE AND INNOVATION NETWORK ACTIVITIES ON PRECISION FARMING

As an emerging technology which requires innovation, collaboration and new approaches to overcome societal, environmental and economic challenges, the UK Government's Science and Innovation Network (SIN) was well placed to support UK's global leadership on agricultural technologies during the 2015 Milan Universal Exposition. At Milan Expo, SIN played a crucial role in promoting businesses and academics' participation and delivering high-level conferences. Besides, SIN Canada, China, Colombia, Europe, Israel, New Zealand, Turkey and the United States have hosted a series of activities aimed at engaging local scientific and business communities. The aim of such activities was to promote British excellence in precision farming and to develop joint international partnerships where co-ordinated programmes could benefit the UK Agri-Tech strategy and the overall economy. Some highlights of SIN-promoted activities:

- Creation of an international expert network which promotes scientific methods to detect and safeguard against food fraud and counterfitting;
- UK company, Trantor International, has deepened its ites with Turkish Universities;
- Incresased interest of Canadian agri-businesses to invest in the UK;
- To helping China to reduce its environmental footprint;

WHAT EXACTLY IS PRECISION FARMING ?

Based on the need to "produce more with less", precision farming – also known as precision agriculture – is emerging as an innovation-driven solution. The introduction of the new and disruptive farm technologies helps farmers to manage their farms in a more sustainable way. It involves data-based technologies, including satellite positioning systems like GPS, remote sensing, and the Internet, to manage crops and reduce and optimise the use of fertilisers, pesticides and water. Taking developments in engineering and associated technological innovations, precision farming opens up new dimensions of support and intervention, not only in the established disciplines of arable and livestock farming, but also in the emergent areas of urban and integrated farming.

In practice, precision farming changes the way a farmer works:

- Crops are not only harvested, but also mapped using a combination of sensors, digital photography techniques and geospatial technologies;
- Soil sensing systems provide information on the variability in soil productivity status;
- Fertilisers/chemicals are allocated more strategically/efficiently by exploiting spatial variations of soil fertility;
- Autonomous farm vehicles can control sow seeds and crop picking; and
- Satellite positioning is also being used to monitor and manage livestock.

Professor Simon Blackmore, Head of Engineering Director of National Centre for Precision Farming at Harper Adams University, says

"Agricultural robotics are now being developed in the UK to drive tractors, kill weeds with lasers to avoid using chemicals, pick and grade strawberries, mow grass, scout for pests, weeds and diseases (both aerial and ground based) and plant seeds. These changes will be very disruptive both in terms of the way we farm now and how we support the farming process".

It is estimated that approximately 60 per cent of Britain's farmland is now being managed by elements of precision farming methods, which include sensor systems, cameras, unmanned aerial vehicles, microphones, virtual field maps, analytics and GPS-guided farm vehicles.[2] Today, the technological infrastructure of precision farming is in place to support wider implementation. However, there are still obstacles and concerns to the adoption of agricultural technologies by

farmers. As well as the risk of insufficient return on investment, there is a lack of: expertise, cultural awareness, mobile connectivity, cost-effective and user friendly products, and operating systems compatibility.

UK AGRI-TECH STRATEGY AT THE FOREFRONT OF PRECISION FARMING REVOLUTION

In 2013, the UK government recognised the need for this pressing change and launched its Agri-Tech Strategy in partnership with industry and academia to encourage innovation in agriculture systems.[3] The strategy includes:

• Improve the translation of research into practice through a £70 million Government investment in an Agri-Tech Catalyst. The Agri-Tech Catalyst funding scheme helps businesses and researchers commercialise their research and develop innovative solutions to global challenges in the Agri-Tech sector.

• Increase support to develop, adopt and exploit new technologies and processes through £90 million Government funding for four new Centres of Agricultural Innovation. The first Centre, launched in October 2015 at Rothamsted Research (Hertfordshire), is applying informatics and big data in agriculture. The three new centres will officially be launched in Spring 2016. One of the next centres, the Agriculture Engineering and Precision Innovation Centre (Agri-EPI Centre) is an industry-led collaboration between the food supply chain, agricultural engineers, precision technology providers and leading UK academic institutes. The Centre aims to place advanced engineering at the core of UK agricultural science, and to use the data generated from sensor technology to create an understanding of the greatest opportunities and requirements for further research and development.

Robotic harvesters are already a reality in agriculture and will do much more in the future. © Harper Adams University

GLOBAL MARKET DEVELOPMENT

The global precision farming market is forecast to reach £2.3 billion by 2018, and in the UK the precision farming supply industry could be well positioned to both exploit this global potential and provide tools to enhance sustainability. Exports of tractors, agricultural machinery and outdoor power equipment from the UK have increased by 5 per cent since 2011[2]. The UK will be hosting the 11th European Conference on Precision Agriculture in Edinburgh in July 2017. The conference will give the rapidly growing sector the chance to show how far precision farming has come. It is expected to showcase cutting edge farming technologies including robotics for precision agriculture, unmanned vehicles, satellite sensing, as well as crop and soil proximal sensing.

FINAL REMARKS:

Considering the societal and environmental pressures of the future, the main challenge for agriculture will be its ability to ensure a high level of production while improving the protection of natural resources. Precision farming has emerged as paramount for the future of agriculture. The use of precision farming technologies allows farmers and growers to make more efficient and informed decisions on crops, animal husbandry and land management. Promoting precision farming seems to be economically, environmentally and even socially justifiable and the SIN has demonstrated to contribute and play a crucial role to it.

FACTS:

• The Science and Innovation Network (SIN) is jointly funded by the Department for Business, Innovation and Skills and the Foreign and Commonwealth Office.

• It consists of around 90 officers in 30 countries round the world, working to build science and innovation-related partnerships between the UK and their host country. The SIN Network creates important relationships to best use the value of science and innovation discoveries and investments overseas

• SIN aims to support UK growth by focusing on priorities such as energy, life sciences, agri-tech, space and information communications technology. SIN also supports UK efforts to tackle global challenges in particular climate change, antimicrobial resistance and dementia.

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KILLING THE GOLDEN GOOSE?
The Decline of Science in Corporate R&D

By: Ashish Arora, Sharon Belenzon, and Andrea Patacconi [1]

During the 19th and 20th century, Western Europe and the United States created a scientific industrial complex that greatly contributed to scientific progress and resulted in many important innovations. One key component of this scientific-industrial complex was the large corporate lab in corporations such as Bayer, Rolls-Royce, AT&T, Du Pont, and Xerox. These labs have been responsible for many important discoveries; such as the first aero engine, the transistor, the laser and the first computer with a graphical user interface, as well as numerous breakthroughs in medicine and pharmacology.

Since the 1980s, however, many large corporations appear to have reduced their engagement in science. Articles in the popular press lament the demise of top-flight corporate labs, crediting the rise of small research-intensive start-ups, often fueled by venture capitalists.

Other accounts blame the growing financial considerations that cloud the judgment of managers. Data from the National Science Foundation show that the share of basic and applied research in corporate R&D in the United States has declined from 28% in 1985 to 21% in 2009. Bell Labs – at one time a division of AT&T – provides a vivid illustration. At its peak, it employed about 25,000 scientists (including several Nobel Prize winners). Now, its global staff directory lists less than 500 researchers.

These, mostly qualitative, accounts raise important questions for scholars and policy-makers:

Can we more precisely quantify the extent to which the composition of corporate R&D has changed over time and across sectors? What economic forces are driving these changes? Are these changes a reason for concern from society's viewpoint? And, if so, how should policymakers respond?

THE EVOLUTION OF CORPORATE RESEARCH

Corporate investments in science began modestly. The first companies to establish internal labs were the big German chemical firms of the last quarter of the 19th century, soon followed by companies such as General Electric and Alcoa in the United States, which had also been founded on product and process innovations drawing on advances in physics and chemistry.

Other large U.S. firms such as the railroad companies and Western Union established industrial labs, mostly to evaluate the quality of inputs and by and large relied on external inventions.

Growing competition, anti-trust pressures, and the increasing output of university-trained PhDs led companies to increase their investments in internal research to generate new products and processes to fuel growth. The process gained momentum during the inter-war years, as corporations grew larger and became more determined to control and "routinize" innovation. Landmark discoveries (e.g., vacuum tubes, radio, synthetic rubber, nylon), the growing practical applicability of recently-discovered scientific principles, and the rapid increase in government funding in the United States led to more companies investing in internal research after World War II.

But corporate research often failed to deliver returns to shareholders. Discoveries such as nylon and the transistor were few and far between and even when fundamental advances in science or technology were made, the sponsoring firms often failed to profit from these advances. The graphical user interface, for instance, was invented in Xerox's PARC but it was other firms, most notably Apple and Microsoft, which reaped the rewards. By the 1980s, firms began to look to universities and small start-ups as sources of ideas and new products, using a mix of contracts, licenses, alliances, and outright acquisitions. As a consequence, many corporate labs were closed, downsized, or

redirected toward more commercial applications.

NSF data indicate that firms with more than 10,000 employees accounted for 73 percent of non-federally funded R&D in 1985. By 1998, this share had dropped to 54 percent, and to 51 percent by 2008. An additional indicator of the decline in the relative importance of large firms is the sharp drop in share of large firms in the R&D 100 awards winners: whereas 41 percent of the awards went to Fortune 500 firms in 1971, only 6 percent went to Fortune 500 firms in 2006.

Several factors contributed to the growing importance of small firms' research. A landmark piece of legislation within this was the Bayh–Dole Act of 1980 in United States, which dealt with intellectual property arising from federal government-funded research and made a key change in ownership of inventions made with federal funding. Before the Bayh–Dole Act, federal research funding contracts and grants obligated inventors to assign inventions they made using federal funding to the federal government but the new legislation permitted a university, small business, or non-profit institution to pursue ownership of an invention.

Encouraged by the Bayh-Dole Act, universities and other research institutions began to commercialize their discoveries more actively. University scientists - whose high-powered incentives and nimble ways are difficult to replicate in large, established firms encumbered by bureaucracy, politics, and the burden of past legacies – found it increasingly attractive to start their own businesses. Changes in the institutional and legal environment complemented these trends. As a result, start-ups can now more easily obtain financing from venture capitalists and SBIR (Small Business Innovation Research), as well as other U.S. government programs. Intellectual property rights have been significantly strengthened, starting from the early 1980s, first in the U.S. and subsequently in other countries.

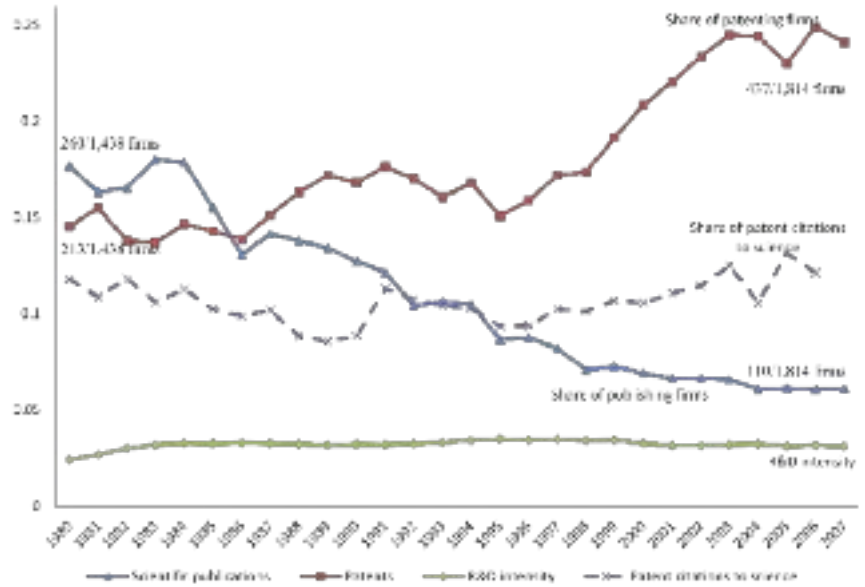
These developments have promoted a new division of labor where small start-ups specialize in scientific research and larger, more established, firms specialize in product development and commercialization. In this view, smaller firms have a comparative advantage in generating ideas whereas larger firms have an advantage in exploiting them and may subsequently invest in scientific capability to become effective buyers of knowledge.

Researchers have started to systematically document these more recent trends. For instance, in a recent survey of over 6000 manufacturing and service sector firms in the United States, 49% of the innovating firms between 2007 and 2009 report that their most important new product originated from an external source (e.g., customers, suppliers, or technology specialists). Some of our recent work (Arora, Belenzon and Patacconi, 2015) systematically documents a shift away from scientific research by large U.S. corporations between 1980 and 2007, and a move toward more applied (patentable) research. In this work, we link scientific publications in "hard science" (including engineering science) journals from the Web of Science to publicly traded firms in the United States, using the affiliations of the authors. Our primary firm sample consists of 1,014 R&D performing companies over the period 1980-2007.

Collectively, these firms account for 312,000 "firm publications" – scientific articles where at least one of the authors is a company employee.

Our evidence indicates that, during the period 1980-2007, large American firms have published less over time while patenting more. Figure 1 shows that the share of R&D performing firms that publish at least one scientific article in a given year has fallen from about 17% to about 6% between 1980 and 2007, whereas the share of firms that patent has risen from about 15% to about 25%. Over this time, the ratio of R&D to sales has largely remained stable. A similar pattern emerges when we examine changes within firms. Firms are reducing publication output at about 3% per year, controlling for sales and R&D expenditure, but are maintaining patenting rates over time.

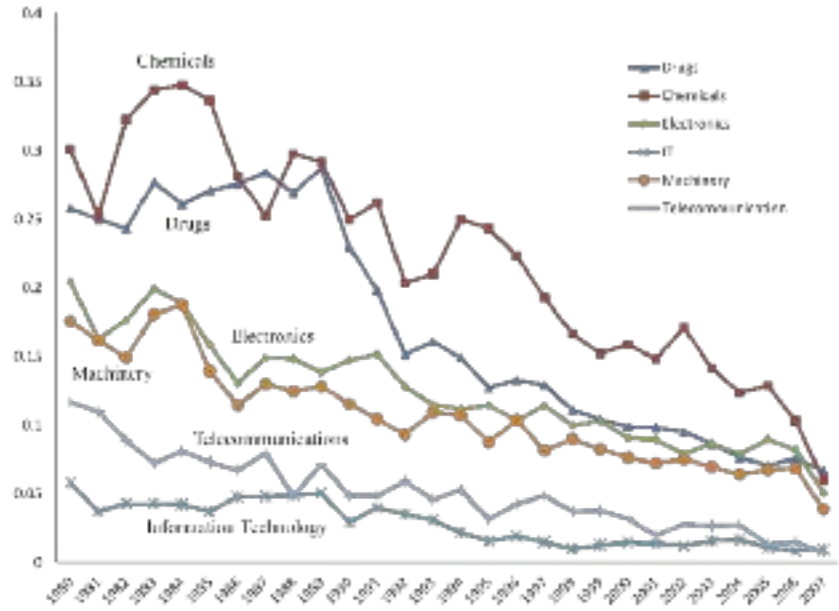
Figure 1: Publishing, patenting, and research: Publicly listed U.S. firms, 1980-2007



Note: This figure presents the share of publishing and patenting firms of all Compustat firms with positive R&D expenditures, over time. R&D intensity is R&D expenditures over sales. Patent citations to science is the ratio between patent citations to leading scientific journals and the total number of citations the patent makes.

As shown in Figure 2, these patterns are not driven by any particular industry, but are present across the board: The share of firms publishing in scientific journals has dropped in every major industry, including pharmaceuticals, chemicals, electronics and machinery. Such patterns are also visible among

Figure 2: Share of publishing firms by selected industries, 1980-2007



Note. This figure presents the share of publishing, of all Compustat firms with positive R&D expenditures over time by selected industries. Industry classification is based on four-digit main SIC code.

Western European firms, both public and private.

Using patent citations to the scientific literature, we also find no evidence that science is becoming less useful to innovation or that the science used in innovations is growing older.

Thus, the decline in large firms' research output cannot be explained away by a reduction in the usefulness of new science. Our results indicate that large firms are withdrawing from science largely because they expect lower future benefits from engaging in scientific activities. Lower private returns from internal science may result from several causes, including the greater availability of external science and technology, growing competition in the marketplace, and a narrower focus of many firms on a few core markets or technologies, which reduces the number of industrial segments to which the investing firm can apply the unpredictable fruits of basic research to.

LOOKING FORWARD

The implications of these findings for society, however, remain unclear. Here, we put forward some preliminary thoughts, but acknowledge that more research is needed to draw more reliable conclusions.

A pessimistic interpretation of our results is that private research in the Western world is in decline. Large companies can no longer emulate firms such as DuPont, AT&T or Merck, whose investments in the past have significantly advanced the frontiers of human knowledge.

Unless public funding can make up the deficit, technical progress will slacken and productivity growth will suffer. Managers in established firms, struggling to satisfy increasingly assertive investors, may be disinclined to make long-term risky bets on internal science. They may look to other means to achieve their growth targets, including international expansion and sourcing inventions and knowledge from outside the firm.

The last option, external sourcing of innovation, points to a less alarming interpretation. It may well be that other organizations – smaller firms and universities – are making up some or all of the shortfall in investment in research. According to this interpretation, what is happening is a reallocation of research from large labs to nimbler, more efficient organizations. But even if this interpretation is largely correct, we believe that reasons for concern still remain in three key areas:

Firstly, research conducted by small firms may be an imperfect substitute for research conducted by larger firms. Small firms' research may qualitatively differ from large firms' research because small firms may lack the resources necessary to carry out certain types of projects, or may face stronger pressures to deliver results quickly. For instance, some projects require the integration of multiple knowledge streams and commercial capabilities; all these may only be available in big firms. Thus, small firms may be good at producing some types of innovations (e.g., apps) but not so effective at producing others (e.g., the autonomous car).

Secondly, the best innovation ecosystems may be those that emerge when large and small firms interact. Studies have found a large innovation premium in regions where numerous small labs co-exist with at least one large lab, compared to regions of a similar size without many small labs or a large lab. One important reason appears to be the spin-off activity of large labs, which suggests the presence of significant positive externalities generated by large firms' research activities.

Thirdly, acquisition is a common exit strategy for start-ups. If large firms will not pay for the research capabilities of their targets, as our results indicate, start-ups will have to invest longer, until such time as the research bears fruit and the resulting innovations can be converted into patents and products. Not all organizations that are good at research are also good at converting their research into commercially-relevant forms. Requiring all researchintensive start-ups to move downstream will undoubtedly be inefficient. More importantly, it would dissuade some start-ups from investing in research, reducing the overall investment into an activity that is believed to have high social returns.

1 A. Arora is the Rex D. Adams Professor at the Fuqua School of Business, Duke University. He is also affiliated with NBER. S. Belenzon is Associate Professor at the Fuqua School of Business, Duke University. A. Patacconi is Senior Lecturer at the Norwich Business School, University of East Anglia.

CHIEF SCIENTIFIC ADVISER FOR WALES
Role and Research

Professor Julie Williams

I have been combining two challenging but exciting roles for almost exactly three years now. I am Chief Scientific Adviser for Wales (CSAW), while continuing my work as a lead researcher in the School of Medicine at Cardiff University for a day and half in each week.

It has been a demanding three years but we have seen pleasing progress in delivering the Welsh Government's ambitious plans to boost research capacity in Wales' universities and to enthuse our young people about science subjects and the varied, interesting and well-paid careers they can pursue, based on their STEM (science, technology, engineering and maths) qualifications.

Coming into the role, I found we had too little knowledge about the nature of research in Wales, although we did know we were not securing the proportionate share of the competitively-awarded research funding on offer – 4.9 per cent by analogy with our population. There was certainly no lack of quality. The Research Excellence Framework of 2014 showed a quality profile of 4* and 3* research mirroring the UK profile almost exactly. We had rankings for scientific excellence in our two largest institutions placing Cardiff sixth and Swansea 26th and a number of 'UK top ten' departments, with Civil and Construction Engineering at Cardiff, for example the top such research team in the UK. Likewise, Allied health professions, Dentistry, Nursing and Pharmacy at Swansea and Psychology, Psychiatry and Neuroscience at Cardiff were both second in the UK.

In the new measure of 'impact' we also performed extremely well with both 4* and 4*/3* combined figures above the UK average. Academic impact – advancing human knowledge and understanding is the core business of researchers. Economic and social impact – how we contribution to the economy, society, the creative and cultural life of our nation is sometimes obvious but scientists also act like business entrepreneurs. When I was Research Dean at the School of Medicine in Cardiff, we found that the 240 active researchers had created 500 research posts in 2012 – high-quality jobs which help drive the economy.

Jointly commissioned research soon showed that, comparing Welsh universities' research performance with key competitors, we used our funding more efficiently than almost any other small country. We had over twice our expected share of the world's most influential academic papers. In outperforming many countries of similar size that spend more money on research and R&D, we have a record that is worth celebrating. Wales' established university sector has a track record of success in science research - both curiosity-driven 'blue skies' work and more applied research. We are, of course, part of the wider UK science community, which is world leading.

Further work in 2015 by Professor Peter Halligan and Dr Louise Bright showed up the real reason for not gaining our fair share of competitive funding. As previously suspected, we simply did not have enough researchers. This was especially so in fields which attract grants from the highest spending Research Councils, such as the MRC and EPSRC. Wales needed 621 more researchers, some 600 of them in STEM-related disciplines.

We had already started on plans to increase Wales' research capacity. A programme called Sêr Cymru ('Stars Wales' in Welsh) is deploying up to £50 million to bringing in a number of objectively world-class academics, with their teams, to universities in Wales. Along with this, we funded and encouraged departments across Wales to brigade together to work collaboratively on areas of strength – both academic strength and strength in business capacity, to exploit research discoveries to benefit the economy. I'll say more about the need to back our areas of excellence within these larger fields below.

With the findings of Halligan and Bright, we have brought forward a second phase of Sêr Cymru. This now aims to fill the ranks below our Sêr Cymru Research Chair stars, to build critical mass around both our current and potential strengths. Funding of again around £50 million has been won from both Horizon 2020, under the Marie Skłodowska Curie COFUND scheme and through EU

Structural funds in Wales, with match-funding. The integrated use of funds from these two European sources, with match-funding from universities and the Welsh Government, to deliver this major programme is seen as a model of innovative good practice. We have just recruited the first tranche of 'rising star' fellows to lead the top teams of the future, further fellowships for talented researchers both from across the world beyond the UK and from closer to home, as well as some fellowships designed specifically to bring back able researchers who have taken a break in their careers, perhaps for childcare (We risk losing many of these, since it can be hard to get back into a fast-moving research field and we simply cannot waste this much training and talent). 51 fellowship offers have been made from an impressive shortlist of 64 candidates, prepared by the contributing universities.

I must stress the importance of sustained support and investment into strong research areas which are in Wales' long-term strategic interest. We have expertise in tidal research, which plays to the large tidal range along our coasts. In research within the wider field of green energy we have two of our Sêr Cymru research chairs. Professor James Durrant is working on polymer and organic photovoltaics, with important implications for more efficient future solar energy. Professor Andrew Barron, meanwhile, works on nanotechnology applied to fundamental energy research problems. Cutting edge plant science activity is undertaken at IBERS in Aberystwyth and the Biorefining Centre of Excellence or BEACON partnership between Aberystwyth, Bangor and Swansea Universities works in the field of conversion of biomass into biobased products, helping Welsh businesses in this field to thrive. We have ambitions to develop a strong research base in thermal hydraulics, aligned with the Wylfa Newydd nuclear power station on Anglesey. As I pointed out earlier, in neuroscience we have a range of world-leading research. The major CUBRIC brain imaging centre at Cardiff University, with its range of state-of the-art imaging modalities, is allowing new insights into brain activity and disease. Professor Yves Barde, another Sêr Cymru research chair, is a world-renowned neurobiologist and discoverer of BNDF (brain-derived neurotrophic factor, characterised as 'brain fertiliser'). He is now investigating genetic pre-disposition to common neurological disorders, such as depression and dementias. Other strengths in the medical sphere are mental health and psychiatry (including Professor Barde's work on depression). Wales is to host one of the seven centres of excellence that make up the new Innovate-UK-awarded Precision Medicine Catapult. Wales had recently been awarded its first Catapult centre lead too – in Compound Semi-conductors (CS). This comes of existing industrial strength in IQE, a global leader in the design and manufacture of advanced semiconductor wafer products (itself an early spin-out company from Cardiff University), coupled with continued highly-regarded research activity in the field at Cardiff and the attraction of our fourth Sêr Cymru research chair to Wales, in Professor Diana Huffaker (from UCLA), to lead a research centre on CS at Cardiff.

Another arm of the Welsh Government's science policy, where I have an important role in both encouragement and oversight, is the wide range of work ongoing both on formal STEM education and the related STEM engagement activity, outside the curriculum. We now have both a refreshed curriculum for science subjects and revised GCSE and A-level science qualifications coming through for Wales. The National Science Academy or NSA, which I oversee, has supported, in its current round of funding, some 20 engagement projects for the next two and a half years. It has deployed around three-quarters of its £2.2 million budget. Projected figures for this round should achieve 870 STEM enrichment events for over 186,000 pupils/students and 462 continuous professional development events for over 2,800 teachers, by March 2018.

A key aim of these NSA engagement activities is breaking down barriers to studying STEM subjects, especially subjects where girls are underrepresented. This forms a part of a much wider piece of work I commissioned soon after I took up my CSAW role, investigating the concerning lack of girls and women taking up some STEM subjects, such as physics and computer science. This is followed by a dearth of women going into science-rleated careers and the 'leaky pipeline' where we lose able female researchers and technical industrial managers through career breaks which dislocate their careers. We have received a report 'Talented Women for a Successful Wales' prepared by two leading female academic co-chairs and we are now starting to put their recommendations into effect.

Of course, my job title is Chief Scientific Adviser and, as such, I provide advice, either myself or by commissioning expert input on a given topic, to the First Minister and his Cabinet Secretaries and Ministers on a range of science-related policy issues.

All this is coupled with continuing in my research role at Cardiff University. Remaining active in research and firmly rooted in their scientific community is an important factor for the continued effectiveness of all Chief Scientific Advisers. I lead a team which has formed a large collaboration. This collaboration has now identified over 20 different genes which contribute to Alzheimer's Disease. These genes have implicated new mechanisms for the disease. Foremost are the roles played by inflammation and immunity in the development and progression of degenerative brain disease. Our work has presented new ideas and potential new targets for future drug development.

The research being done in Welsh universities today is extending the frontiers of knowledge; contributing to our economic competitiveness; improving the performance of our public services; and most critically enhancing the quality of life – for today and for future generations. Through the Welsh Government's support for scientific excellence, working with our partners in the universities and technology-focused industry, I'd like Wales to be recognised as a small country where great science happens. A place where young people and adults alike have fantastic opportunities to learn about and be awakened to the excitement of science. A place where talented researchers can develop successful scientific careers, taking advantage of the superb kit and quality of life that we can offer. The work that we're doing today is taking us closer to realising that vision.

IS THE HALDANE PRINCIPLE STILL RELEVANT?

The question "what about the Haldane Principle?" is often invoked in the UK when people are concerned about particular issues of research policy. The use of the term signals the need to pay attention to the tension between the needs of government and the freedom of researchers. For many the term offers a protection for fundamental research allowing researchers to undertake foundational, curiosity-driven research. Others are less positive about the concept, viewing it as a barrier to the focused use of research to tackle critical problems. The term tends to be used rather abstractly as a broad reference to allow us to talk about control in research funding. Before we tackle the question as to whether the Haldane Principle is still relevant it is worth reflecting a little on what it is and how it is used in practice.

A rather obvious initial question before we discuss its relevance is what is the Haldane principle and where did it come from? However, the answer is rather less clear. Indeed, authors such as David Edgerton have eloquently argued that there is in fact no Haldane Principle and that it was an invented tradition[1] of science funding. The work of the Innovation, Universities, Science & Skills Committee in 2009 reflects this rather uncertain history.[2] The principle has never being articulated as a clear prescriptive statement, instead it has come to be used to refer to the notion that decisions about what to spend research funds on should be made by researchers rather than politicians. Its practical use is as an index into debates about how tightly controlled research funding is and the associated issues of transparency.

The Haldane Principle can also be viewed as an articulation of how we have traditionally structured research funding. Research funding in the UK is predominantly managed through arm's length funding bodies such as ESPRC rather than directly through governmental departments. The autonomy of the bodies involved in our funding structures effectively instantiate the belief that detailed funding decisions are best made by researchers rather than politicians. The articulation of the principle by the Secretary of State for Innovation, Universities and Skills in 2008 outlined three fundamental elements[3]

- That researchers are best placed to determine detailed priorities;
- That the government's role is to set the over-arching strategy; and
- That the Research Councils are 'guardians of the independence of science'.

The articulation of these three elements suggests that questions about the relevance of the Haldane Principle are effectively questions about the relevance and role of the funding structures used in the UK. Consequently, it is worth us reflecting on the effectiveness of these structures and the health of the research base of the UK before we consider the on-going role of the Haldane Principle.

It is worth stressing that the UK has much to be proud of in terms of its research base. When internationally benchmarked the UK research base punches above its weight as a research nation.[4] The UK represents just under 1% of global population and just over 3% of R&D expenditure. The UK research base maximises the value of its research expenditure with investment in the UK producing more research and at a higher quality than in the rest of the world. This is reflected in the UK producing 8% of papers published and 16% of the world's most highly-cited articles. The UK has overtaken the US to rank 1st by field-weighted citation impact. The strength of the UK research base is also reflected in terms of its economic impact. When we compare the UK to other counties for which data is available we see that per unit R&D expenditure the UK ranks 1st for invention disclosures, 2nd for start-ups and spin-offs and 3rd for license revenue.

An analysis undertaken by EPSRC of the impact case studies submitted to REF 2014

further illustrates the significant economic contribution that can be linked to research funded through Research Councils.[5] A research investment of £7.8 billion from 1993 to 2013 contributed to £80 billion of economic activity during the five years from 2008 to 2013. This included £16 billion of cost savings in the public and private sectors. It also led to the creation of 400 new businesses, employing 50,000 people and contributing £4 billion to the economy in revenue.

It is clear that UK research is a success story in terms of both research excellence and its contributions to innovation and economic impact. This represents a testimony to our approach to supporting research. The Nurse review of Research Councils highlighted the significant influence that our research funding has within this success story and the resulting recommendation emphasised the need to build upon our existing structures.[6] The proposals within the Higher Education and Research Bill continue to emphasise an arm's length approach from government with and overarching organisation formed of the seven distinct Councils, alongside Innovate UK and Research England. Suggesting that the Haldane Principle they represent continues to have relevance to UK research and innovation funding.

The notion of the Haldane Principle provides a reminder of the need to be aware of the balance between immediate political challenges and longer term research drivers in how we structure research funding. It has remained relevant because it has evolved and changed over time. As a principle it tended to be rather diffuse, highlighting a set of sensitivities rather than prescribing a specific course of action. It has always been open to interpretation and this has led to the updates in how the broad principle is currently being used. The most recent of these is the 2010 statement by the Minister for Universities and Science[7] making the underlying principle clear:

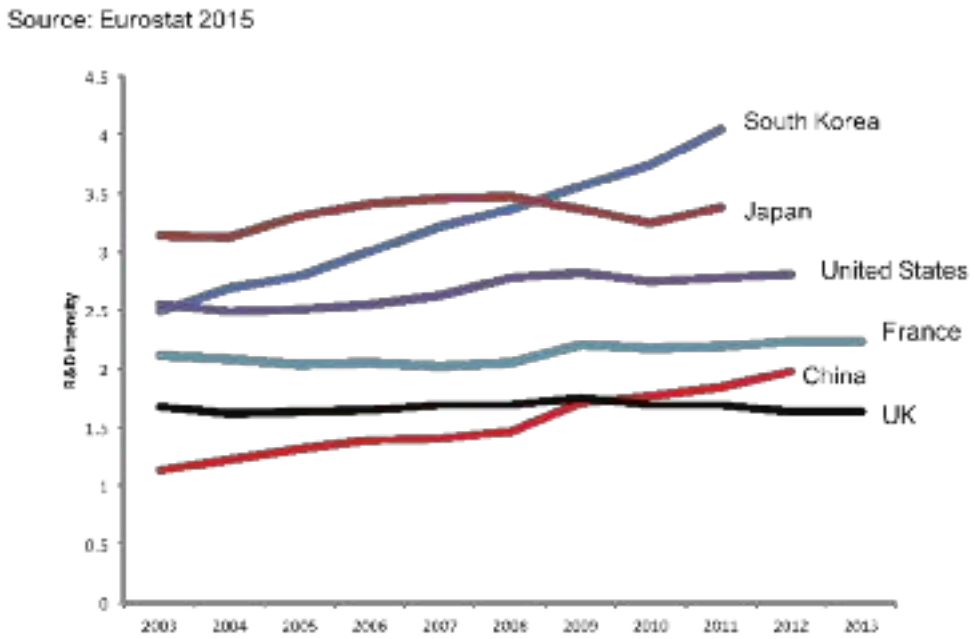
> *"The Haldane Principle means that decisions on individual research proposals are best taken by researchers themselves through peer review. This involves evaluating the quality, excellence and likely impact of science and research programmes. Prioritisation of an individual Research Council's spending within its allocation is not a decision for Ministers."*

It does, however, go on to highlight the importance of thinking about the balance on decision making carefully.

> *"…every Government will have some key national strategic priorities such as addressing the challenges of an ageing population, energy supply or climate change. The research base has an important role to play in addressing such priorities and the Research Councils, with the support of independent advice, have proposed research programmes to tackle them. It is also appropriate for Ministers to ask Research Councils to consider how best they can contribute to these priorities, without crowding out other areas of their missions. But it is for the Research Councils to decide on the specific projects and people to fund within these priorities, free from Ministerial interference."*

This separation of responsibilities and the need to think strategically about our research activities while continuing to ensure the importance of independent scientific judgement and peer review feels appropriate for our times and emphasises the continued relevance of the Haldane Principle.

International spending on R&D
Gross Domestic Expenditure on R&D (GERD) as % of Gross Domestic Product (GDP)



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THE IMPORTANCE OF METROLOGY IN REALISING OUR SYNTHETIC BIOLOGY POTENTIAL

Since 2012, significant progress has been made in establishing the UK as a world leader through its capacity in synthetic biology. 2016's 'BioDesign for the Bioeconomy' report from the Synthetic Biology Leadership Council celebrates the achievements but also makes the case for formalised standards that will realise the full potential of this important innovation area. Michael Adeogun (Division Head) and Max Ryadnov (Science Area Leader) from the Analytical Science Division at the National Physical Laboratory explore in more detail.

The UK aims to achieve a £10bn UK synthetic biology market by 2030, capable of delivering substantial societal and economic impact nationally and internationally. Synthetic biology provides new solutions to major challenges by aiding the manufacture of complex molecules and materials that are currently difficult, expensive or impossible to produce. By innovating advanced manufacturing processes, synthetic biology can help generate more sustainable and affordable materials, chemicals and energy.

Recognising this considerable potential and our national research expertise, the UK government commissioned the Synthetic Biology Roadmap,[1] published in July 2012. Significant progress has been made in the four years since the roadmap was published; the 2016 report[2] states that total investment into synthetic biology research in the UK is second only to the US and amongst the largest per capita in the world. A comprehensive national network has now been established, comprising synthetic biology research centres, synthesis facilities, centres for doctoral training and an innovation and knowledge centre to drive commercial translation. A rapidly growing community of SMEs engaged in developing straightforward, cost effective off-the-shelf technologies has also emerged and is actively pursuing a broad range of applications and products for different sectors ranging from healthcare to energy.

THE ROLE OF METROLOGY

This community, strengthened by innovations in miniaturisation, automation and metrology, is taking experimental science through the design-test-build phase to a new level of enhanced productivity and reliability. With such rapid progress, the 2016 plan states the need for technical standards to support this expansion. These standards are applicable to the biological parts – "bio-parts" – that are produced at the molecular and cellular level. To be used in the manufacture of different products in a predictable and reproducible manner these parts must be characterised; what they are made of, how do they assemble together and what are their functions in different situations. By also extending standardisation to cover the biological processes involved in manufacturing bio-parts, the speed of technological development can be increased while costs are reduced substantially.

Industry should play a central role in the standardisation of synthetic biology. This is an area

that we at the National Physical Laboratory (NPL), the UK's National Measurement Institute, are working on. As the UK's home of measurement, with over 100 years' experience in helping new technologies make the transition from lab to market, NPL is the place for supporting innovation and commercialisation in synthetic biology. NPL undertakes world-leading research in synthetic biology from new bio-parts and processes to innovative measurement approaches and fundamental standards that classify these parts. NPL provides the national capability for the testing and validation of synthetic biology technologies, ensuring the UK benefits from these amazing new technologies as soon as possible.

CASE STUDIES

The benefit of bridging the gap between science and commerce with metrology is clear. Standardisation will ensure the reproducibility of bio-parts and the processes behind their production, while well-characterised standards will accelerate the uptake of technologically advanced approaches by a broader range of markets. In particular this is important for growing SMEs that explore new challenges and enter new markets. NPL is providing bespoke measurements, infrastructure and know-how by engaging synthetic biology businesses directly.

For example, NPL is working with Ingenza Ltd, a Scottish industrial biotechnology SME with a broad customer base which applies synthetic biology to the manufacture of industrial products, such as in the production of protein therapeutics. Ingenza operates laboratories for the construction and optimisation of engineered anti-microbial strains; NPL is working with them to provide a measurement platform that enables the discovery and design of new antibiotics which will address the global concern of antimicrobial resistance. Discovery, design, even the enhancement of antibiotic potency, must allow for pre-clinical and clinical studies which rely on metrology for success. The choice of parameter to be reported, and consequently the meaning and interpretation of results by the researchers all rely on a basic measurement platform and a reliable clinical trial should be repeatable to this standard. On the other side of the coin, trial subjects need assurance around their safety and wellbeing; clinical practice requiring compliance with certain standards provides this.

Among their capabilities, Ingenza works to enhance industrial production processes and help the scale-up of synthetic biology technologies – an integral part of productivity and commercialisation of a business. As a 'young' sector, many synthetic biology research areas and projects are still concepts which need to be tested before they are scaled-up to commercialisation. There are many variables to factor in when looking to scale-up production of a synthetic biology product, all of which need to be referenced to standards to provide certainty in the right concepts. Being able to characterise and measure these potential products with certainty is a key attribute in deciding which synthetic biological products are adopted, and ultimately commercialised, by industry.

By enabling concepts to be translated more rapidly and reliably into commercially viable products or processes though metrology, the cost of entering the synthetic biology market may be reduced, its competitiveness enhanced and the delivery of its benefits and services accelerated. This will help the UK be competitive in synthetic biology for years to come. The importance of maximising the economic benefits is clearly recognised in the Roadmap and NPL is putting in place the protocols that will help bring this to fruition.

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Event on "THE IMPLICATIONS OF BREXIT FOR UK SCIENCE AND INNOVATION" – 4th September 2016

Guest speaker: George Freeman MP

George Freeman is the Conservative MP for Mid Norfolk and the former Parliamentary Under-Secretary of State for Life Sciences. Freeman was appointed chair of the Prime Minister's Policy Board in July 2016.

INTRODUCTION BY GEORGE FREEMAN

He started by highlighting the importance of groups such as the Parliamentary & Scientific Committee in facilitating dialogue on issues with science and innovation in Parliament. In his introduction, Freeman declared his personal views on Brexit; he was strongly in favour of remaining in the EU yet his constituency was one of the highest to vote leave. Freeman expressed that if Parliament asks the people what they think they hence have a duty to be bound by it. Referencing his local constituency, he said that it is clear to him that people want a very different relationship with Europe. For example, his constituency want to be in the common market but not in a political union and see a very different role for immigration.

Freeman highlighted that there is no 'playbook' for how to leave the EU, emphasising the need for the country to negotiate strategically and smartly to ensure the best outcome for the UK. He said that he had seen an extreme range of views in Parliament, describing those on the far right at unilateralists who thought the EU was doomed from the beginning. He noted that he's from the other wing and that he feels that "we need to respect what the British people are saying". He made a reference to the domestic policy issues (e.g. housing, cuts to local services, failing schools) felt amongst his constituency in Norfolk which aren't purely related to Brexit but certainly fuelled by Brexit. Freeman feels that we should want the Europe Union to succeed; "it's in our interest that it grows and succeeds". He adds that we should not be looking to withdraw from Europe but collaborate with it, as well as looking to explore the space outside Europe.

IMPLICATIONS OF BREXIT FOR UK SCIENCE AND INNOVATION

Based on the arguments the scientific community put forward on the benefits of the EU for UK science, Freeman expressed the difficulty that lies ahead for research teams in terms of recruitment and accessing funding. He added that if the UK wants to continue to be a science super power then we should fight for an interim way of working as well as a negotiating a long-term solution that also works.

Freeman offered three different recommendations on what science following Brexit should look like:

1. Science and innovation to become strategically more important to future prospects

Freeman warned that it is unlikely that we are going to have as good as entry into the single market post-Brexit and said that if our nation is to succeed as an economy outside of the 'European bowl of growth', he adds that we should place more importance on our science and innovation base than before.

Freeman feels that we should be heading in a direction where we can use our science to tackle global challenges. He believes the UK is brilliantly positioned to help other countries, referencing examples from the fields of medicine, agriculture and energy where we have positioned ourselves as international experts. He shares a view that the UK can provide the products, services and technologies to help the world combat global challenges, with our science and innovation being crucial to achieving that.

2. Connect our finance and science base in order to capture the commercial value of science

Freeman recognises that the UK is a leader in both the sciences and finance but says there is intermittent contact between these two worlds. He recommends that we need a strategic link between our city and science base in order to improve the commercialisation of our science. He adds that improvements are required in the capacity for UK companies to export their science, particularly to North American markets.

3. Opportunities to seize outside of EU regulation

Freeman addressed the fact that some areas of EU regulation haven't been helpful for science. He notes that some regulation is good for certain markets, but for example, EU regulation has been problematic for biotechs, GM, stem cells and the clinical trial directive. He feels that there are huge opportunities for the UK to frame an ethical, sustainable and responsible regulatory framework for the appliance of science. Freeman expressed positivity about the opportunities for the UK to be become the best and quickest place to obtain proof of concept data, particularly in the in the fields of healthcare, agri-tech or clean-tech.

Freeman summarises that if we improve our capacity to export science internationally, embrace global challenges and explore the

opportunities that come with freedom from the EU regulatory environment, he says "we may end up in a very good place." He closes by warning that the future negotiations should be done with science at the heart of it.

Stephen Metcalfe

Stephen Metcalfe was in agreement with George Freeman's points. He expressed the challenges moving forward by saying that he suspects that there are many people from the inside that don't know how we're going to make that journey from where we are now to where we want to be in the future. He calls for visible and tangible examples of how the Government are going to be supporting this and how we are going to move to our destination in order to reassure the general public about the upcoming uncertainty.

AUDIENCE Q&A

Question 1 (Professor Andrew George, Brunel University): "How do we explain to the 52% why their lives are better because of us (universities)?"

Freeman responds by agreeing with Professor George. He says from observations made from his constituency, there is a view that two economies are emerging; blue-collared, low skill world, and the rest enjoy the fruits of globalisation. He recognises the failure of communicating the value to the former of these economies. He adds that if people don't know why something matters then they are unlikely going to value it, concluding that communicating the importance of universities should be an ongoing task post-Brexit.

Question 2 (Paul Jackson, Engineering UK): "On access to the labour and skills market, there is a problem with the ageing population and demand for engineers, how are we going to deal with that so that companies are not short of the skills that they need?"

Question 3: "Do you think the Home Office has potentially taken on board the enormity of the new task that it will have if there is not to be an enormous slowdown of movement of people because we are changing from a completely free movement of people to a process which has free movement of the right people that we approve of. Can that free movement of professional skilled people be managed in a much more efficient way than the home office has traditionally managed these things? If so, many of the concerns of the scientific community could be addressed."

Freeman agrees that potentially some of the risks and difficulties could be mitigated if we embrace a different model in term of delivering. He refers to an example during the Ebola outbreak where we managed to cut all the regulation times from months to weeks. He adds that we need to become much better at talking between the private and public sector, different worlds and different cultures. He wants the best public servants to feel rewarded and supported to make this work.

Question 4 (Professor Patrick Bailey, London South Bank University): "What was interesting straight after the vote was the way the group European leaders came out and said so strongly 'well get out then'. Interestingly, I think one of the main reasons is they were so concerned of what the impact would be of Britain leaving the EU. What do we do – assuming the EU stays as it currently is but without us in it – what is your view as to, A. will it survive, and B. if it does survive, is it going to undergo such a dramatic change that some of the arguments that we've been having are going to be significantly more defined?

Freeman thinks that it is very unlikely that the EU is going to be recognisable and will undergo significant changes. Owing to the immigration problems, Freeman doesn't think it is sustainable for the EU to carry on as it is. He hopes that the shock of Brexit will snap the EU leaders to tackle the issues surrounding immigration. However, overall, Freeman thinks the EU will survive.

Question 5 (Jim, Foundation of Science & Technology): "Departments generally have a chief scientific adviser, when will a CSA be appointed for the two new departments dealing with Brexit?"

Freeman says that this is something that we do better than any other government – we have a CSA in almost every department.

Question 6 (Dr James Pearce-Higgins, British Trust for Ornithology): "There are a lot of environmental issues which are best dealt with on a continental level (biodiversity, air quality), I'm interested in your perspectives about how continue to engage positively with those environmental issues which are important to us on a continental perspective post-Brexit."

Freeman says that there are some problems such as air pollution and marine water quality which are intrinsically European. He agrees that European environmental policy issues are very important. He thinks that there is an opportunity for us, on the regulatory side, to put in place a much more distinctively British approach to the wider environment. He also believes that the Conservative government needs to be much more active in environmental campaigning which has traditionally been the focus of the left.

Question 7: "The Brexit campaign blamed experts as a dirty word. We seem to be in a society now where trust and believing in what experts say has gone. Have you any thoughts as to how we rebuild trust?"

Freeman agrees that there has been a push back against elites. Freeman feels it is a challenge for all of us to explain things which people find suspicious such as big data, big government. He thinks the scientific community should speak up and say 'we are your friends; science is your friend' in order to personalise and legitimise science as an endeavour. He adds that people think science has become a big business and part of big conspiracy of unaccountable power and that we should all club together to dismantle this misconception.

Question 8 (John Basset, Institute of Food Science and Technology): "What is the Government doing to try and boost skills within regulatory. What can we do as scientists to have a better input into the science that relays into policy?"

In terms of skills, Freeman thinks there is a huge opportunity post-Brexit for us to export our regulatory expertise. He thinks the world is going to want sophisticated agencies like NICE and the MHRA to do health economics so we should be training people on

how to set up a regulatory agency, to which nations around the world can subscribe to. He acknowledges this is not what the agencies have been tasked to do but if we want to make this work we should globalise better. In terms of policy input, Freeman thinks this country leads the way in terms of high quality science inputting into Government and ministers.

Question 9 (Professor Ian Boyd, DEFRA): "Can you advise the scientific community on how to best structure itself to engage with the exit negotiations?"

Freeman notes DEFRA's support in transferring science and innovation to the agriculture sector. In response to the question, he says we need to pull together a shopping list from all the country's key groups and industries and determine what their must haves and red lights are. Helping to stimulate that debate, he has set up a task force for the Life Sciences sector.

Question 10 (Elaine Cloutman-Green, Great Ormond Street Hospital): "With the discussion of how the NHS becoming increasingly more resource limited, how do we position ourselves to have better links with these new, innovative, small start-ups so that we can take advantage of that, rather than all that science and technology going overseas?"

He says that if we give those partnerships, academic institutions and hospitals funding freedoms and the freedom to integrate and adopt healthcare better, we could create accelerated access where our best clinical scientist are pulling through innovation and testing it, getting quicker access to patients and proving that these technologies work. He adds that Britain could become the best place in the world to do human translations science studies.

Question 11 (Professor Ian Haines, UK Deans of Science): "What do you think the Government could do to ensure that science and engineering manufacturing, development and research companies will be encouraged to stay in Britain and come to Britain after Brexit?"

Firstly, Freeman says that we need to speak positively about this opportunity and reassure companies that we're not about to go down an 'isolated, anti-globalised cul de sac'. Secondly, he says we need to reassure people that we will continue to fund science after Brexit. Thirdly, he thinks we can tell the story better of what science is doing for our economy and the wider world.

Question 12 (Philip Green, Royal Academy of Engineering): "The Prime Minister restated the need for industrial strategy. If we get an industrial strategy right then I firmly believe that it will provide a good framework for a lot of the things we need to get right now. Do you think this is the case?"

He thinks that the industrial strategy should be industry-led, that we should be looking at the emerging markets and focusing on the scientific disciplines that we are good at. He lists food, medicine and energy as key disciplines. The strategy should aim to get more out of how much we spend in the UK and help the industry to come together to get more benefit from the science and investment, i.e. produce more for less. He thinks we should follow suit the automotive business and export more science internationally, for example synthetic biology for which we could become the lead nation.

VIEWS FROM UK ENERGY PROFESSIONALS

Professor Jim Skea CBE FEI FRSA
Imperial College London
President, Energy Institute

Dr Joanne Wade FEI
Association for the Conservation of Energy
Chair, EI Energy Advisory Panel

The UK energy system is currently faced with three pressing issues: climate change mitigation, a sustained low crude oil price, and uncertainty and disruption caused by a pending exit from the EU. Given the scope, urgency and interconnection of these challenges, policy makers need a strong evidence base to inform decisions and strategy. One important source of such evidence is the expertise of professionals working within the energy industry.

The Energy Institute (EI)'s Energy Barometer gives access to the knowledge of a diverse and well-qualified set of these professionals: EI members from across a number of sectors and disciplines. The Energy Barometer is the product of an annual survey of the EI College, a group representative of EI members. In 2016, they identified the following challenges, and proposed policy solutions, linked to these three issues.

CLIMATE CHANGE MITIGATION

Professionals are not confident about the UK's ability to meet climate targets, even (and especially) the legally-binding 2050 target. Given the policies currently in place, professionals

expect the UK to fall increasingly short of the 3rd, 4th and 5th carbon budgets. 80% of those surveyed expect the UK to fall short of the 2050 emissions target. 57% think that we will fall significantly short of that target.

70% of those surveyed thought the Paris Agreement would not be sufficient to hold global temperatures to below a 2 C rise. This is fairly consistent with pre-Paris Agreement 2015 findings. Although this finding itself is not surprising, viewed alongside concerns about the 2050 targets it suggests that professionals do not think climate policies are going far enough.

The pessimism around the UK's ability to meet climate targets is seen to stem partly from a lack of clear policy signals to enable long-term investments in technology and infrastructure. These investments are in turn needed to enable the transition to a low carbon energy system. For example, policy uncertainty is seen by professionals to be hampering long term investment in key low carbon technologies such as carbon capture and storage (CCS), hydrogen, nuclear, and marine generation such as wave and tidal.

CRUDE OIL PRICE

In addition to its direct impacts within the oil and gas sector, the low oil price is seen as another disincentive to low carbon investment. Stifling the low carbon economy, drawing focus from energy demand, efficiency and climate and sustainability goals were among the main impacts of the low oil price identified. However, some potential opportunities were identified, including short-term lowering of transport costs and a chance to reduce subsidies to fossil fuels for the longer term.

As they did in 2015, professionals expect the oil price to rise slightly over the next 12 months. Professionals believe the main factors driving that price are the actions of oil producing nations, geopolitical instability, and demand levels in developing countries.

UK EXIT FROM THE EU

Brexit is a significant source of concern across the energy industry. Professionals overwhelmingly foresaw negative effects from a scenario where the UK leaves the EU but remains in the single energy market.

When asked how specific areas of the energy system would be impacted by Brexit, the areas expected to suffer the most were addressing climate change, support for research and innovation, and renewable energy development. The single area of the energy system seen to benefit (although only slightly) from this Brexit scenario was oil and gas production. The greatest risk of Brexit as perceived by energy professionals was the impact on access to skilled workers, movement of labour, and opportunities for UK companies abroad as well as EU companies in the UK.

This same group, the EI College, submitted written evidence via the EI to the Energy and Climate Change Committee's enquiry into "Leaving the EU: implications for UK energy policy". When asked, "What should be the Government's priorities on energy when negotiating the UK's exit from the EU?" and "What would a successful negotiation outcome look like?" the EI College drew out these top priorities:

- Maintain security of supply;
- Retain access to EU energy market, and allow EU to access UK market;
- Retain movement of labour and access to skilled workers;
- Maintain free flow of project finance;
- Continue to share information and participate in collective efforts affecting energy system;
- Maintain a strong commitment to the environment; and
- Ensure energy supplies remain affordable (domestic, commercial and industrial).

These recommendations echo many of the biggest concerns for the energy system as a whole, independent from Brexit. Some pointed out that the priorities for these negotiations should broadly reflect the existing priorities for energy policy. Following on from this written evidence, the EI held a debate on 12 October to further explore these questions. The issues above were refined into 3 top recommendations for negotiators to prioritise:

- **Access to the single energy market**

Continued access to the EU energy market will help meet future demand, decarbonisation targets and keep prices down for consumers. Negotiations should aim to maintain harmonised trading agreements and standards, as well as interconnection for electricity and gas.

- **Access to skilled labour**

Skilled people are critical for energy companies, centres for research and innovation, and academia. Negotiation outcomes should provide assurance for existing foreign

workers, researchers and academics. Although this is particularly true for science and technology focused industries like energy, it applies across the UK economy.

• **Clarity of process and timing**

A clear roadmap of the negotiation and transition process will provide clarity for the industry and importantly for investment and finance. Uncertainty around the Brexit negotiation process and timetable for leaving the EU threatens investment in energy projects at a time when key changes to infrastructure are needed and pressure from low oil prices is already challenging.

The EI also submitted evidence to the Royal Academy of Engineering's recent report, Engineering a future outside the EU, which had over 400 contributions from the engineering community. This report reiterates the importance of access to skilled labour post-Brexit, which is a particular problem for the engineering profession looking into the future. The joining of energy and industry through the new department of Business, Energy and Industrial Strategy presents an opportunity for a new industrial strategy which builds confidence among industry, manages the uncertainty around Brexit, and sends a strong message that the UK is open for business. Continued collaboration across engineering, energy and Government can help inform such a strategy through first-hand evidence from those in industry.

TACKLING CHALLENGES

Policy continuity

Given the interconnectedness of these challenges, the significant changes needed to meet climate goals, and a backdrop of uncertainty, it is important to establish a long-term, systems-level strategy. Stability in one area (policy) is needed in order to drive change and innovation in another (the energy system).

For the second year in a row, policy continuity has been named in the Energy Barometer as the biggest challenge for the energy system in 2016. Professionals are not asking for stagnant policy, rather a clear, long-term policy direction against which industry can plan.

A policy direction which supports the transition to a low carbon energy system through both supply and demand side measures is sought by energy professionals. Significant transformation of the heat and transport systems over the next 15 years is expected and regarded as essential. Critically, professionals point to continued decarbonisation of the electricity system as a fundamental manifestation of this transformation.

Investment

The low carbon transition will require increased investment across systems, in particular in efficiency within transport, heat, and electricity. In addition to suffering the negative impacts of the low oil price, investment in low carbon technologies was flagged up as most negatively affected by policy uncertainty. Professionals were asked where investment risk was high, but also where investment levels needed to change. Almost across the energy system, they identify the need for increased investment.

Traditional 'technologies' on the supply side are not the only ones flagged as needing investment. In fact, energy efficiency, in transport, buildings, and industry, is singled out as requiring the greatest increases over the next 3 years. Investment in efficiency is seen as an important way of meeting security, sustainability and affordability goals. A 'non-tech' area in need of greater investment, and often linked with efficiency measures, is behaviour change for demand reduction.

Electricity generation from fossil fuels was identified as the only area where investment should not be increased. This message comes consistently from professionals across sectors, and further reflects the need to transition our energy supply and demand towards a lower-carbon landscape. However, it is worth noting that maintaining security of supply during the low carbon transition will not be possible without contributions from the UK's oil and gas sector. Investment in added renewable capacity, continued interconnection, and domestic oil and gas supply will all be necessary.

Dialogue

Beyond the more familiar levers of policy and investment, professionals recognise the role for communication in tackling energy system challenges. The transformation of the energy system will require new approaches to communication between all stakeholders. Those within the industry recognise that 2-way communication with and involvement of the public is not currently a priority within their sectors. Energy professionals emphasised improving the level and quality of communication with stakeholders is essential if we are to transition to a low carbon economy smoothly and effectively. This is an area for needed attention across all sectors.

Given the significant role end users play in the energy system, there is a strong argument for involvement and dialogue as a new model for communicating across stakeholders, importantly including those outside the industry and policy realms. Dialogue between all stakeholders – end users, industry, NGOs and government - will help develop the best possible solutions, and ensure their effective adoption.

The integration of energy into the wider UK industrial strategy within the Department for Business Energy and Industrial Strategy provides an opportunity for dialogue and strong links between Government, energy users and the energy industry, leading to system-level solutions to the challenges we face.

The EI is in a good position to facilitate conversations with energy professionals, through the Barometer and other engagement and knowledge-sharing activities. We invite policymakers to become involved in this engagement by suggesting questions for use in the Barometer or identifying areas which could usefully be discussed.

On 25 October, the authors presented the results of the 2016 Energy Institute (EI) Energy Barometer report to the All-party Parliamentary Group on Energy Studies. The Barometer is one of several initiatives from the EI to connect energy professionals with policy makers. The 2016 Energy Barometer report, along with the full data set from survey responses, can be found at www.energyinst.org/energy-barometer.

OBITUARIES

PATRICK JENKIN, LORD JENKIN OF RODING

The Parliamentary and Scientific Committee was very sorry to hear of the recent death of Lord Jenkin of Roding.

He was our President for more than five years.

In this role he was always conscientious, reliable and polite to the nth degree. He was also warm and supportive to individuals.

He was one of those rare people who always seemed to have a twinkle in his eye, as if he was REALLY enjoying what he was doing.

He was one of that increasingly rare breed able to declare that he had never received a formal science lesson in his life! (Keith Joseph made the same claim). Patrick himself never stopped apologizing for this lacuna in his CV, although he clearly did his best to make up for it.

And yet Patrick espoused the benefits of science like few well qualified scientists. His lasting memorial, which is still regarded as THE bible for interaction between scientists and the lay public was the House of Lords Report which he chaired more than ten years ago. It has not been necessary to revisit this (only to implement it!) because it said it all.

He was also a talented singer and many of us will have enjoyed hearing him in the Parliamentary choir singing Messiah.

Alan Malcolm

ANNABEL LLOYD (1949 – 2016)

All Members of the P&SC will have been saddened at the news of the death last summer of Annabel Lloyd.

For most people Annabel simply was the Parliamentary and Scientific Committee. Firstly she had worked for it for more than two decades. However it was not just her longevity that was responsible for the respect and affection that was expressed

Her dedication to the organization, her fierce pride in its wellbeing, her total reliability and integrity were all remarkable. She had a formidable memory, and scarcely needed a filing system or a hard drive. The complete history of the P&SC was in her brain.

She bore her final illness with the stoicism we who knew her would have expected.

We received several hundred messages of condolence.

Alan Malcolm

DR H PETER JOST 1921 – 2016

We were very saddened to hear of the passing of Dr Peter Jost who died on 7th June 2016 aged 95 years.

The Parliamentary and Scientific Committee lost a loyal and valued member who had done much to support the work of the Committee for many years. Peter was responsible for the magnificent reception at Buckingham Palace to mark the Committee's 75th Anniversary.

Peter will be missed across the technology and materials community, the tribology community and wider scientific, technical and industrial communities around the world.

Appointed CBE in 1969, Peter was honoured by the heads of state of France, Germany, Poland, Austria and Japan, and in 1992 became the first honorary foreign member of the Russia Academy of Engineering. He was the first non-Chinese recipient of the Achievement for Tribology Gold Medal, awarded by the Chinese Tribology Institution. He held two honorary professorships and 11 honorary doctorates including, in January 2000, the first Millennium honorary science doctorate.

HOUSE OF COMMONS SELECT COMMITTEES 2017

BUSINESS, ENERGY AND INDUSTRIAL STRATEGY COMMITTEE

The Business, Energy and Industrial Strategy Committee is appointed by the House of Commons to examine the administration, expenditure and policy of the Department for Business, Energy and Industrial Strategy (BEIS) and its associated public bodies. It is chaired by Iain Wright MP.

On 14 July, the Prime Minister announced that elements of the Department for Business, Innovation and Skills would merge with the Department for Energy and Climate Change to become the Department for Business, Energy and Industrial Strategy. On 11 October 2016, the House of Commons Standing Orders governing the committee structure were amended to allow the Committee to be renamed in order to reflect this change.

The Committee was renamed on 17 October 2016 with the same membership as the previous Business, Innovation and Skills Committee. Iain Wright was elected as Chair of the Business, Energy and Industrial Strategy Committee on Thursday 18 June 2015.

The remit of the Committee reflects the responsibilities of the Department for Business, Energy and Industrial Strategy, and includes such issues as business regulation and corporate governance, energy and climate change (formerly covered by the Energy and Climate Change Committee), and science and innovation.

Members of the Committee also participate in the Committees on Arms Export Controls.

Contact: Business, Energy and Industrial Strategy Committee, House of Commons, London SW1A 0AA
Telephone: 020 7219 5777
Email: beiscom@parliament.uk

INQUIRIES

From start-up to scale-up: support for growing businesses Inquiry announced 20 March 2017

Business, Energy and Industrial Strategy Committee inquiry on how to help UK high-growth small businesses to scale-up

Electric vehicles
Inquiry announced 15 March 2017

Business, Energy and Industrial Strategy Committee inquiry on role of electric vehicles in transition to low-carbon economy

The CMA's investigation of the UK energy market
Inquiry announced 31 January 2017

Business, Energy and Industrial Strategy Committee's one-off evidence session on the CMA's investigation of the UK energy market

EDUCATION COMMITTEE

The Education Committee monitors the policy, administration and spending of the Department for Education and its associated arms length bodies, including Ofsted.

The Committee consists of eleven backbench Members of Parliament. The Committee's Chair is Neil Carmichael MP, Conservative Member of Parliament for Stroud.

The Committee is an investigative Committee rather than a legislative Committee: it sets its own programme and chooses subjects for inquiries. For each inquiry, a press notice is issued listing the terms of reference and inviting interested parties to send written submissions.

For most inquiries, the Committee will also hold question and answer "oral evidence" sessions with witnesses. These are held in public, normally in a Committee Room at the Houses of Parliament.

Neil Carmichael was elected as Chair of the Education Committee on Thursday 18 June 2015.

Contact: Education Committee, House of Commons, London SW1A 0AA
Telephone: 020 7219 1376
Email: educom@parliament.uk

INQUIRIES

School funding reform
Inquiry announced 27 January 2017

Nick Gibb MP, Minister for School Standards, and Tom Goldman, Director of Education Funding at the DfE, give evidence along representatives of the Institute for Fiscal Studies and the Education Policy Institute on the Government's recent

proposals to reform the way in which schools and local authorities receive funds for education.

Appointment of the Chair of the Office for Students

Inquiry announced 16 February 2017

Subject to the passage of the Higher Education and Research Bill, the Office for Students will combine the roles of the Higher Education Funding Council for England and the Office for Fair Access.

The Committee considers Sir Michael's professional competence and personal independence as part of his suitability for the role.

ENVIRONMENT, FOOD AND RURAL AFFAIRS COMMITTEE

The Environment, Food and Rural Affairs Committee (EFRA) is appointed by the House of Commons to examine the expenditure, administration and policy of the Department for Environment, Food and Rural Affairs (Defra) and its associated public bodies.

The EFRA Committee is one of the 19 Select Committees related to Government Departments, established by the House of Commons under Standing Order No. 152.

The Committee chooses its own subjects of inquiry on environmental, agricultural subjects. Depending on the subject, external deadlines, and the amount of oral evidence the Committee decides to take, an inquiry may last for several months and give rise to a report to the House; other inquiries may simply consist of a single day's oral evidence which the Committee may publish without making a report.

Neil Parish was elected as Chair of the Environment, Food and Rural Affairs Committee on Thursday 18 June 2015

Contact: Environment, Food and Rural Affairs Select Committee
House of Commons, London, SW1A 0AA
Telephone: 020 7219 7341
Email: efracom@parliament.uk

INQUIRIES

Post-legislative scrutiny: Flood and Water Management Act 2010

Inquiry announced 26 January 2017

The Environment, Food and Rural Affairs Committee launches an inquiry into how effectively the Government has implemented the Flood and Water Management Act 2010. The Committee is calling upon interested parties for views on whether the Government has implemented measures in the Act in a timely, proportionate and effective manner.

This is a short inquiry into specific implementation issues since the Committee does not intend to revisit broad flood risk management roles and governance issues addressed in its previous Future flood prevention inquiry.

Performance of the Rural Payments Agency

Inquiry announced 19 December 2016

In spring 2016 the EFRA Committee produced a Report into the Rural Payments Agency's (RPA) performance the previous winter. This Report scrutinised the work of the RPA in making accurate and timely Basic Payment Scheme payments to farmers and made recommendations on how to improve the RPA's future performance.

The Committee has opened a new inquiry to monitor the RPA's performance in winter 2016-17. The Committee would welcome submissions on all aspects of the RPA's work but especially its performance in making Basic Payment Scheme payments.

Countryside Stewardship Scheme

Inquiry announced 17 March 2017

The Committee has opened a new inquiry into the performance of the Countryside Stewardship Scheme.

The Countryside Stewardship Scheme provides financial incentives as part of the Common Agricultural Policy for land managers to look after their environment.

It is managed and administered by Natural England, a non-departmental public body sponsored by Defra.

Feeding the nation: labour constraints

Inquiry announced 02 February 2017

Inquiry into the challenges to the food supply chain from shortages of workers.

UK food production depends on securing an adequate supply of labour to get the harvest in and to process the produce. But farm and factory businesses have reported, both prior to and since the EU referendum, that they find it hard to hire enough workers.

Each year farms rely on tens of thousands of temporary workers, with some 80,000 of these workers currently coming from outside the UK.

ENVIRONMENTAL AUDIT COMMITTEE

The remit of the Environmental Audit Committee is to consider the extent to which the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development, and to audit their performance against sustainable development and environmental protection targets. In the previous Parliament (2005-2010), the Committee's programme included inquiries on climate change and environmental fiscal measures ('green taxation'), as well as sustainable development and environmental protection.

Unlike most select committees, the Committee's remit cuts across government rather than focuses on the work of a particular department.

Mary Creagh was elected Chair of the Committee on 10 February 2016.

Contact: Environmental Audit Committee, House of Commons, London SW1A 0AA
Telephone: 020 7219 5776
Email: eacom@parliament.uk

INQUIRIES

Coffee Cups and Plastic Bottles: disposable packaging

Inquiry announced 04 March 2017

The Environmental Audit Committee launch a new inquiry into the damage being done to the environment by disposable drinks packaging, focussing on the impact of plastic bottles and coffee cups. The inquiry will look at what actions are being untaken by industry and Government to reduce waste generated by coffee cups and plastic bottles, and investigate possible solutions.

Work of the Natural Capital Committee

Inquiry announced 23 February 2017

This is a one off session examining the work of the Natural Capital Committee following the publication of their fourth State of Natural Capital Report in January 2017.

Sustainability in the Ministry of Justice

Inquiry announced 15 March 2017

The Environmental Audit Committee is calling for written evidence about the role that sustainability plays in the Ministry of Justice's (MoJ) departmental policy-making, governance, procurement and operations. This will compliment work carried out by the National Audit Office and underpin a one-off hearing with the Department

UK's role in Arctic sustainability

Inquiry announced 16 March 2017

In light of recent and ongoing political and environmental change, the Committee will examine the extent to which the government's approach to the Arctic is fit for purpose including how its promotion of scientific research and business best practise increases its influence among Arctic States and reduces environmental harm in the region.

Climate Change Adaptation Inquiry announced 09 March 2017

This is a one of session on climate change adaptation in light of the recent publication of the Government's Climate Change Risk Assessment 2017.

This assessment draws primarily on the independent Evidence Report commissioned from the CCC's Adaptation Sub-Committee. The session will begin with a panel of representatives from the CCC and the Adaptation Sub-Committee to discuss their Evidence Report. Followed by a panel with Lord Gardiner, Parliamentary Under-Secretary for Rural Affairs and Biosecurity, to discuss the Government's response and long term climate change adaptation policy.

HEALTH COMMITTEE

The Health Committee is appointed by the House of Commons to examine the policy, administration and expenditure of the Department of Health and its associated bodies

The Committee chooses its own subjects of inquiry. Depending on the subject, external deadlines, and the amount of oral evidence the Committee decides to take, an inquiry may last for several months and give rise to a report to the House; other inquiries may simply consist of a single day's oral evidence which the Committee may publish without making a report.

Dr Sarah Wollaston was elected as Chair of the Health Committee on Thursday 18 June 2015.

Contact: Health Committee, House of Commons, London SW1A 0AA
Telephone: 020 7219 6182
Email: healthcom@parliament.uk

INQUIRIES

Childhood obesity: follow-up

Inquiry announced 04 January 2017

The Government needs to take more robust action to tackle the impact of deep discounting and price promotions on the sales of unhealthy food and drink, says the Health Committee in its follow up report into childhood obesity.

Sustainability and Transformation Plans

Inquiry announced 31 March 2017

Following publication by NHS England of the Next Steps on the NHS Forward View, the House of Commons Health Committee is announcing an inquiry into sustainability and transformation plans.

Next Steps says :STPs began life as pragmatic vehicles for enabling health and care organisations within an area to chart their own way to keeping people healthier for longer, improving care, reducing health inequalities and managing their money, working jointly on behalf of the people they serve. They are a means to an end, a mechanism for delivering the Forward View and the key national priorities in this Plan.

SCIENCE AND TECHNOLOGY COMMITTEE

The Science and Technology Committee exists to ensure that Government policy and decision-making are based on good scientific and engineering advice and evidence

The Science and Technology Committee is unusual amongst departmental select committees in that it scrutinises the Government Office for Science (GO-Science), which is a "semi-autonomous organisation" based within the Department for Business, Energy and Industrial Strategy.

GO-Science "supports the Government Chief Scientific Adviser and works to ensure that Government policy and decision-making is underpinned by robust scientific evidence". The committee therefore has a similarly broad remit and can examine the activities of departments where they have implications for, or made use of, science, engineering, technology and research.

Stephen Metcalfe was elected as Chair of the Science and Technology Committee on Wednesday 19 October 2016.

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INQUIRIES

GO-Science Annual Report 2015-16

Inquiry announced 20 January 2017

The Science and Technology Committee held a one-off evidence session on the Government Office for Science Annual Report 2015-16.

Research integrity Inquiry announced 10 January 2017

The previous Science and Technology Committee reported on "Peer review in scientific publications ' in 2011, after which Universities UK coordinated the establishment of a 'Research Integrity Concordat'. The Parliamentary Office of Science and Technology (POST) has recently published a POSTnote which discusses trends and developments on fraud, misconduct and mistakes in research and the publication of research results. It indicates that the trend in misconduct/mistakes in publishing is still upwards. There has also been a so-called 'crisis in reproducibility' of research.

Industrial Strategy: science, research and innovation
Inquiry announced 16 February 2017

The Science and Technology Committee welcomes the Government's industrial strategy Green Paper, but it could give more room for discussing its links with Brexit. That means that the industrial strategy is not yet being fully configured to shape our Exit negotiations, but it will also have to be progressively updated to reflect the results of those negotiations as they proceed.

Setting up UK Research and Innovation: The Chief Executive role
Inquiry announced 15 March 2017

This was a one-off evidence session on Setting up UK Research and Innovation: The Chief Executive role held on Wednesday 15 March 2017

The Draft Spaceflight Bill Inquiry announced 02 March 2017

On the 21 February 2017, the Government published a Draft Spaceflight Bill to "provide for the creation of a regulatory framework to enable commercial spaceflight activities to be carried out from spaceports in the United Kingdom". Following on from its report on Satellites and Space, published in June 2016, the Science and Technology Committee will be examining the Draft Spaceflight Bill.

Algorithms in decision-making
Inquiry announced 28 February 2017

This topic was pitched to the Committee by Dr Stephanie Mathisen (Sense about Science) through the Committee's 'My Science Inquiry' open call for inquiry suggestions, and has been chosen as the first subject for the Committee's attention following that process. It follows the Committee's recent work on Robotics and AI, and its call for a standing Commission on Artificial Intelligence.

TRANSPORT COMMITTEE

The Transport Committee is charged by the House of Commons with scrutiny of the Department for Transport. Its formal remit is to examine the expenditure, administration and policy of the Department of Transport and its associated public bodies.

Mrs Louise Ellman was elected as Chair of the Transport Committee on 17 June 2015.

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INQUIRIES

Airports National Policy Statement
Inquiry announced 22 February 2017

The Transport Committee looks at the Government's draft Airports National Policy Statement.

Vauxhall vehicle fires Inquiry announced 02 February 2017

The Transport Committee questions representatives of Vauxhall and the Driver and Vehicle Standards Agency (DVSA) about Vauxhall Zafira and Corsa fires and safety recalls, and how the automotive industry can best deal with vehicle fires.

HS2: CH2M contract Inquiry announced 07 April 2017

The Transport Committee questions the Secretary of State and Sir David Higgins, Chair of HS2 Ltd, about CH2M's recent decision to withdraw from a major HS2 contract.

Drones Inquiry announced 30 March 2017

The aim of the Transport Committee's inquiry is to consider how the benefits of drone technology can be maximised within a robust safety framework.

Airspace management and modernisation
Inquiry announced 27 January 2017

The Committee is particularly interested to receive submissions addressing some or all of the following:

• The role of Government in facilitating improvements to the airspace

• The need for modernisation, in terms of the economic and environmental sustainability benefits, and the risks for the aviation industry and wider economy from maintaining the current airspace structures

• The essential changes that need to be made to UK airspace, particularly those associated with the development of an additional runway in the South East

• Progress of the Civil Aviation Authority's Future Airspace Strategy in achieving its core objectives of reducing congestion, improving safety and taking advantage of new technologies to enable a more efficient airspace system

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

RECENT POST PUBLICATIONS

Research Integrity

January 2017 Post Note 544

Integrity in research refers to the behaviours and values that result in high quality, ethical and valuable research. This POSTnote considers current approaches to fostering an environment conducive to good research in the UK, and detecting and preventing practices that fall short of expected standards

UK Trends in Infectious Diseases

January 2017 Post Note 545

Vaccination, antimicrobial drugs and improved hygiene mean that infectious disease has been overtaken by non-communicable disease (cancer, cardiovascular disease and diabetes) as the main cause of death globally and in the UK. However infections are still a significant health and economic burden to the UK.

This POSTnote looks at recent UK trends in infectious disease, with a focus on those infections for which vaccines are not yet available, and where the development of antimicrobial resistance is a serious concern

Reform of Freshwater Abstraction

January 2017 Post Note 546

In some parts of the UK, high levels of water abstraction are reducing the quantity and quality of surface water (rivers, lakes) and groundwater (water accumulated in spaces in soil and rocks). This POSTnote sets out the challenge of balancing competing requirements for freshwater, and summarises proposed reforms to the abstraction system in England and Wales and their implications

Environmental Crime

January 2017 Post Note 547

Environmental crime is generally used to describe any illegal activity that harms the environment. It can also have serious human health and social impacts. This POSTnote outlines the different types of environmental crime and options for tackling them.

New Plant Breeding Techniques

February 2017 Post Note 548

New breeding techniques have developed rapidly in recent years, allowing plant breeders to introduce new, or modify existing, traits. There is debate over whether some of these techniques constitute genetic modification (GM) as defined in EU Directive 2001/18 and are thus subject to the various EU GM regulations. This note outlines some of the new techniques, their applications and the regulatory challenges they raise.

This note outlines some of the new plant breeding techniques developed recently and looks at their applications and the regulatory challenges they raise

Green House Gas Removal

February 2017 Post Note 549

The 2015 Paris Agreement called for a balance between sources of Greenhouse Gas (GHG) emissions and their removal by 2100 to halt global temperature rise. This POSTnote explains why Greenhouse Gas Removal (GGR) techniques may be required to achieve this goal, outlines the benefits of and concerns about them, and considers policy options.

Future Energy Efficiency Policy

February 2017 Post Note 550

Improving energy efficiency means using less energy (such as electricity, heat and transport fuel) to produce the same output or service. Examples of measures to improve energy efficiency include: insulating a home so that it needs less heating to reach the same temperature; installing a motor that uses less electricity to perform the same role in a manufacturing plant; and inflating car tyres to the correct pressure to reduce drag when driving and cut fuel use.

This POSTnote outlines the benefits and costs of future improvements in energy efficiency across various UK sectors. It then describes the barriers to energy efficiency measures, outlines options for future energy efficiency policy and summarises analyses of the effectiveness of different policy options.

Dietary Advice, Pregnancy and Breast-Feeding

March 2017 Post Note 551

Dietary advice given to women before, during and after pregnancy is intended to support both maternal and infant health, and is based on the best available evidence. This note focuses on the latest UK dietary advice given to women from family planning through pregnancy and into breastfeeding. It examines the science behind the advice, trends in its take up, how it compares with international advice and options for improving take up.

This note focuses on the latest UK dietary advice given to women from family planning through pregnancy and into breastfeeding.

HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE

The Science and Technology Committee has a broad remit "to consider science and technology". It scrutinises Government policy by undertaking cross-departmental inquiries into a range of different activities. These include:

- public policy areas which ought to be informed by scientific research (for example, health effects of air travel),
- technological challenges and opportunities (for example, genomic medicine) and
- public policy towards science itself (for example, setting priorities for publicly funded research).

In addition, the Committee undertakes from time to time shorter inquiries, either taking evidence from Ministers and officials on topical issues, or following up previous work.

The Earl of Selborne was appointed as Chairman in May 2016.

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INQUIRIES

Nuclear research and technologies

Inquiry announced 26 January 2017

The Committee intends to revisit the conclusions and recommendations of its report Nuclear Research and Development Capabilities published in November 2011. It will investigate the developments that have taken place since the publications of the report and what more needs to be done to ensure the UK can meet its future nuclear energy requirements.

The Committee will look specifically at the upcoming decision by the Department for Business, Energy and Industrial Strategy on a small modular reactor (SMR) design for the UK; and the roles of the National Nuclear Laboratory (NNL) and the Nuclear Innovation and Research Advisory Board (NIRAB).

Science and Technology and the Industrial Strategy

Inquiry announced 03 March 2017

The Government published a Green Paper," Building our Industrial Strategy" on 23 January.

In the Green Paper the Government states that it wants to build an industrial strategy that addresses long-term challenges to the UK economy. The Government's aim is to improve living standards and economic growth by increasing productivity and driving growth across the whole country.

In this short investigation, the Committee will concentrate on the science, technology and innovation aspects of the Industrial Strategy Green Paper. It will seek perspectives on the proposals contained within the document and seek to highlight any omissions. The strategy contains 'ten pillars', one of which is investing in science, research and innovation. However, science and innovation is threaded through many of the other pillars of the strategy and the Committee will be investigating where science, technology and innovation can make a significant contribution to any of the ten pillars.

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. Thirty-one 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 undertaking and supporting a broad range of research across the physical, life and computational sciences. We operate world class, large-scale research facilities in the UK and Europe and provide strategic advice to the UK Government on their development. We partner in two of the UK's Science and Innovation Campuses. We also manage 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.

Association of the British Pharmaceutical Industry

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The Association of the British Pharmaceutical Industry (ABPI) represents innovative research-based biopharmaceutical companies, large, medium and small, leading an exciting new era of biosciences in the UK. Our industry, a major contributor to the economy of the UK, brings life-saving and life-enhancing medicines to patients. Our members are researching and developing over two-thirds of the current medicines pipeline, ensuring that the UK remains at the forefront of helping patients prevent and overcome diseases. Topics we focus on include:

- All aspects of the research and development of medicines including clinical research and licensing
- Stratified medicine
- Vaccines, biosimilars, small and large molecules, cell therapy and regenerative medicine

AIRTO

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AIRTO – Association of Innovation, Research & Technology Organisations – is the foremost membership body for the UK's innovation, research and technology sector, representing 80% of organisations in the 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 £5.5bn from clients both at home and outside the UK, and employ over 47,000 scientists, technologists and engineers.

AMPS

Contact:
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M50 3SG.

Website: www.amps-tradeunion.com

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

We have produced a training programme funded by the EU on diversity and helping women managers remain in the workplace after a career break. This training programme is aimed at both men and women and is intended to address the shortfall in qualified personnel in the chemical and allied industries.

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

Biochemical Society

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The Biochemical Society works to support the advancement of the molecular biosciences; facilitating the circulation of knowledge and supporting innovation, raising awareness of the importance of our discipline in addressing societal grand challenges.

We achieve our mission by:

- Supporting the next generation of biochemists
- Bringing together molecular bioscientists; fostering connections and providing a platform for collaboration and networking
- Promoting and sharing knowledge through meetings, publications and public engagement
- Highlighting the role of molecular biosciences in interdisciplinary and translational research, while supporting the fundamental science that underpins applied studies

The British Ecological Society

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Twitter: @BESPolicy

The British Ecological Society's mission is to generate, communicate and promote ecological solutions. The Society has over 5,000 members worldwide, publishes five internationally renowned scientific journals and organises the largest scientific meeting for ecologists in Europe. Through its grants, the BES supports ecologists in developing countries, public engagement and research. The BES informs and advises Parliament and Government on ecological issues and is committed to ensuring that policy-makers have access to the best available evidence. The BES welcomes requests for assistance from parliamentarians.

British In Vitro Diagnostics Association (BIVDA)

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

British Nutrition Foundation

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www.foodafactoflife.org.uk

The British Nutrition Foundation (BNF), a registered charity, delivers impartial, authoritative and evidence-based information on food and nutrition. Its core purpose is to make nutrition science accessible to all, working with an extensive network of contacts across academia, education and the food chain, and through BNF work programmes focussing on education in schools and nutrition science communication.

British Pharmacological Society

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The British Pharmacological Society is a charity with a mission to promote and advance the whole spectrum of pharmacology. It is the primary UK learned society concerned with drugs and the way they work, and leads the way in the research and application of pharmacology around the world.

Founded in 1931, the Society champions pharmacology in all its forms, across academia, industry, regulatory agencies and the health service. With over 3,500 members from over 60 countries worldwide, the Society is a friendly and collaborative community. Enquiries about the discovery, development and application of drugs are welcome.

The British Society for Antimicrobial Chemotherapy

Mrs Tracey Guise
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www.e-opat.com | www.nas-pps.com
lwww.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 5,000 members who work in all areas of immunology, including research and clinical practice.

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

British Society of Soil Science

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The British Society of Soil Science (BSSS) or "BS cubed" as it is fondly known was founded in 1947 by a number of eminent British soil scientists. It was formed with the aims: to advance the study of soil; to be open to membership from all those with an interest in the study and uses of soil; and to issue an annual publication.

Brunel University London

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Brunel University London is an international research active university with 3 leading research institutes:

Institute of Energy Futures: Led by Professor Savvas Tassou, the main themes of the Institute are *Advanced Engines and Biofuels, Energy Efficient and Sustainable Technologies, Smart Power Networks*, and *Resource Efficient Future Cities.*

Institute of Materials and Manufacturing: The main themes of research are *Design for Sustainable Manufacturing, Liquid Metal Engineering, Materials Characterisation and Processing, Micro-Nano Manufacturing*, and *Structural Integrity*. The Institute is led by Professor Luiz Wrobel.

Institute of Environment, Health and Societies: Professor Susan Jobling leads this pioneering research institute whose themes are *Health and Environment, Healthy Ageing, Health Economics Synthetic Biology, Biomedical Engineering and Healthcare Technologies*, and *Social Sciences and Health.*

Brunel University London offers a wide range of expertise and knowledge, and prides itself on having academic excellence at the core of its offer, and was ranked in the recent REF as 33rd in the UK for Research Power (average quality rating by number of submissions) and described by The Times Higher Education as one of the real winners of the REF 2014.

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

ctpa

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www.thefactsabout.co.uk

CTPA is the UK trade association representing manufacturers of cosmetic products and suppliers to the cosmetic products industry. 'Cosmetic products' are legally defined and subject to stringent EU safety laws. CTPA is the authoritative public voice of a vibrant and responsible UK industry trusted to act for the consumer; ensuring the science behind cosmetics is fully understood.

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

Energy Institute

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The Energy Institute (EI) is the chartered professional body for the energy sector, supporting over 22,000 individuals and 200 companies worldwide. The EI provides learning and networking opportunities, professional recognition and technical and scientific knowledge resources on energy in all its forms and applications.

The EI's purpose is to develop and disseminate knowledge, skills and good practice towards a safe, secure and sustainable energy system. It addresses the depth and breadth of the energy sector and informs policy by providing a platform for debate and scientifically-sound information.

A registered charity, the EI serves society with independence, professionalism and a wealth of expertise in all energy matters.

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.

Fera

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Fera provides expert analytical and professional services to governments, agrichemical companies, food retailers, manufacturers and farmers to facilitate safety, productivity and quality across the agrifood supply chain in a sustainable and environmentally compatible way.

Fera uses its world leading scientific expertise to provide robust evidence, rigorous analysis and professional advice to governments, international bodies and companies worldwide. Our food integrity, plant health, agri-tech and agri-informatics services ensure that our customers have access to leading edge science, technology and expertise.

First Group

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FirstGroup is the leading transport operator in the UK and North America.

Our services help create strong, vibrant and sustainable local economies and our opportunity is to be the provider of choice for our customers and communities. During the last year around 2.5 billion people relied on us to get to work, to education, to visit family and friends and much more.

GAMBICA Association Ltd

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

The Geological Society

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The Geological Society is the national learned and professional body for Earth sciences, with 12,000 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

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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

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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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Reg Charity number: 269815

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

IOP Institute of Physics

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The Institute of Physics is a leading scientific society. We are a charitable organisation with a worldwide membership of 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. Its members are medical physicists, clinical and bio-engineers, and clinical technologists. It 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

The Institution of Chemical Engineers

With over 42,000 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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Established in 1818 and with over 86,000 members in 167 countries worldwide, ICE is a leading source of expertise in infrastructure and engineering policy and is widely seen as the independent voice of infrastructure. ICE provides advice to all political parties and works with industry to ensure that civil engineering and construction remain major contributors to the UK economy.

Institution of Engineering Designers

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The only professional membership body solely for those working in engineering and technological product design. Engineering Council and Chartered Environmentalist registration for suitably qualified members. Membership includes experts on a wide range of engineering and product design disciplines, all of whom practise, manage or educate in design. **New for 2015: Chartership for Product Designers (CTPD).**

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 over 163,000 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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As the world's oldest biological society, the Linnean Society of London is an essential forum and meeting point for those interested in natural history. The Society holds regular public events, publishes three peer-reviewed journals, promotes the study of the natural world with several educational initiatives and is home to a world famous library and collection of natural history specimens. 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 3,800 researchers world-wide and dedicates over €850 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 through the Met Office Hadley Centre. 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.

MICROBIOLOGY SOCIETY

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The Microbiology Society 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.

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

Advancing the science of nature

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We challenge the way people think about the natural world – its past, present and future

We use our unique collection and unrivalled expertise to tackle the biggest challenges facing the world today.

We are leaders in the scientific understanding of the origin of our planet, life on it and can predict the impact of future change.

We study the diversity of life and the delicate balance of ecosystems to ensure the survival of our planet.

We help enable food security, eradicate disease and manage resource scarcity.

We inspire people to engage with science to solve major societal challenges.

THE UNIVERSITY OF NORTHAMPTON

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The University of Northampton is an institution 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 an Ashoka U 'Changemaker Campus' status university recognising our commitment to social innovation and entrepreneurship.

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 97 per cent of research at the University recognised internationally according to the Research Excellence Framework 2014, the University is ranked in the top 1% of the world's 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 3500 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.

Rainbow Seed Fund

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The Rainbow Seed Fund is a £24m, early-stage venture capital fund dedicated to kick-starting promising technology companies emerging from the UK science base. The Fund is backed by ten UK publicly-funded research organisations and the Department of Business, Innovation and Skills and holds investments in some of the UK's most innovative companies in areas as diverse as novel antibiotics, research into Alzheimer's disease, "green" chemicals and airport security. The Fund is managed by Midven, a specialist venture capital company. We are prepared to invest early and help build a proposition to attract additional investment and get to market.

risksolutions

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Risk Solutions helps our clients make better decisions in a complex and uncertain world.

Using traditional qualitative and quantitative methods, combined with cutting-edge participative approaches, we work with clients from across the public and private sectors, their stakeholders and customers, to bring a depth of understanding of the issues and to develop consensus about how to tackle them.

Our small, highly motivated and client focused team delivers:

- policy design, appraisal and decision support
- risk assessment and risk based strategies and plans
- evaluation, assurance and organisational review, and
- training, coaching and guidance.

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. Our scientific vision is to document and understand global plant and fungal diversity and its uses, bringing authoritative expertise to bear on the critical challenges facing humanity today.

Kew's strategic priorities for science are:

1. To document and conduct research into global plant and fungal diversity and its uses for humanity.
2. To curate and provide data-rich evidence from Kew's unrivalled collections as a global asset for scientific research.
3. To disseminate our scientific knowledge of plants and fungi, maximising its impact in science, education, conservation policy and management.

These priorities enable us to curate, use, enhance, explore and share Kew's global resource, providing robust data and a strong evidence base for our UK and global stakeholders. Kew is a non-departmental government body with exempt charitable status, partially funded by Defra.

The Royal Institution Science Lives Here

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www.richannel.org
Twitter: ri_science

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 Biology

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The Royal 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.

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 over 50,000 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 Underwater Technology

Society for Underwater Technology
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The SUT is a multidisciplinary learned society that brings together individuals and organisations with a common interest in underwater technology, ocean science, and offshore/subsea engineering. The society was founded in 1966 and has members from over 40 countries, including engineers, scientists, other professionals and students working in these areas.

Science Chemistry Innovation

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The Society of Chemical Industry (SCI) is a unique multi-science and multi-disciplinary forum that connects Scientists and Business people. Established in 1881, as a hub for innovation, by leading scientists, inventors, entrepreneurs and investors, SCI continues to work in this way. Many current SCI members include leaders and innovators representing many different areas of industry and academia.

SCI's community promotes applied science through more than 100 conferences and events each year, 7 leading scientific journals and Chemistry and Industry magazine. We also support and celebrate science through bursaries and awards for a spectrum of scientific areas.

Society of Cosmetic Scientists

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

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

Society of Maritime Industries

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

Universities Federation for Animal Welfare

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Registered in England Charity No: 207996

UFAW, 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

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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

PARLIAMENTARY AND SCIENTIFIC COMMITTEE

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www.scienceinparliament.org.uk
follow us on Twitter @ParlSciCom

Monday 19th June 2017, 5.30pm
Discussion Meeting:
Space

Monday 17th July 2017, 4.30pm
Annual General Meeting
Followed by Discussion Meeting, 5.30pm
Medical Mycology

ROYAL SOCIETY OF BIOLOGY

Tuesday 27th June 2017
Parliamentary Links Day
Links Day is the largest science event on the Annual Parliamentary events calendar, and is organised by the Royal Society of Biology on behalf of the science and technological community. The event has a different theme each year and brings together scientists, learned societies and Members of Parliament.
Please contact Karen Pated at events@rsb.org.uk for more details.

THE ROYAL SOCIETY

Details of all events can be found on the events calendar at events@royalsociety.org
For scientific meetings queries:
scientific.meetings@royalsociety.org

THE ROYAL INSTITUTION

Details of all events and booking information can be found at www.rigb.org/whats-on

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

POST organises events that connect Parliamentarians to leading experts from the research community and other sectors, including government, the third sector and business on a range of topics.
Details can be found at:
www.parliament.uk/mps-lords-and-offices/offices/bicameral/post/post-events/

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Published by Parliamentary and Scientific Committee, 3 Birdcage Walk, London SW1H 9JJ. Published four times a year. The 2016 subscripton rate is £80. Single numbers £20. ISSN 0263-6271

FAREWELL AND HELLO

It is with sadness that we say farewell to Professor Alan Malcolm who will be retiring this summer after five years as Executive Secretary of the Parliamentary and Scientific Committee. I am extremely grateful to Alan for his service and dedication.

Alan pictured left, STEM for Britain Awards

I am delighted to announce that he will be succeeded by Dr Isabel Spence.

Isabel's early life was in Chemistry (Masters and Doctorate) at the University of Warwick.

Since then she has worked both in Government (BIS), and for Learned Bodies (Royal Society of Chemistry and Microbiology Society) in Policy and Public Affairs.

Stephen Metcalfe

Isabel

The Parliamentary and Scientific Committee

NOTICE OF ANNUAL GENERAL MEETING

Monday 17th July 2017 at 4.30pm

Boothroyd Room, Portcullis House, House of Commons

(Please check the room allocation at www.scienceinparliament on the day)

Chairman

Stephen Metcalfe MP

THE ANNUAL GENERAL MEETING WILL BE FOLLOWED BY DISCUSSION MEETING at 5.30pm

"Medical Mycology"

STEM for BRITAIN 2017

Exhibition of Posters by early-career research scientists, engineers and mathematicians.