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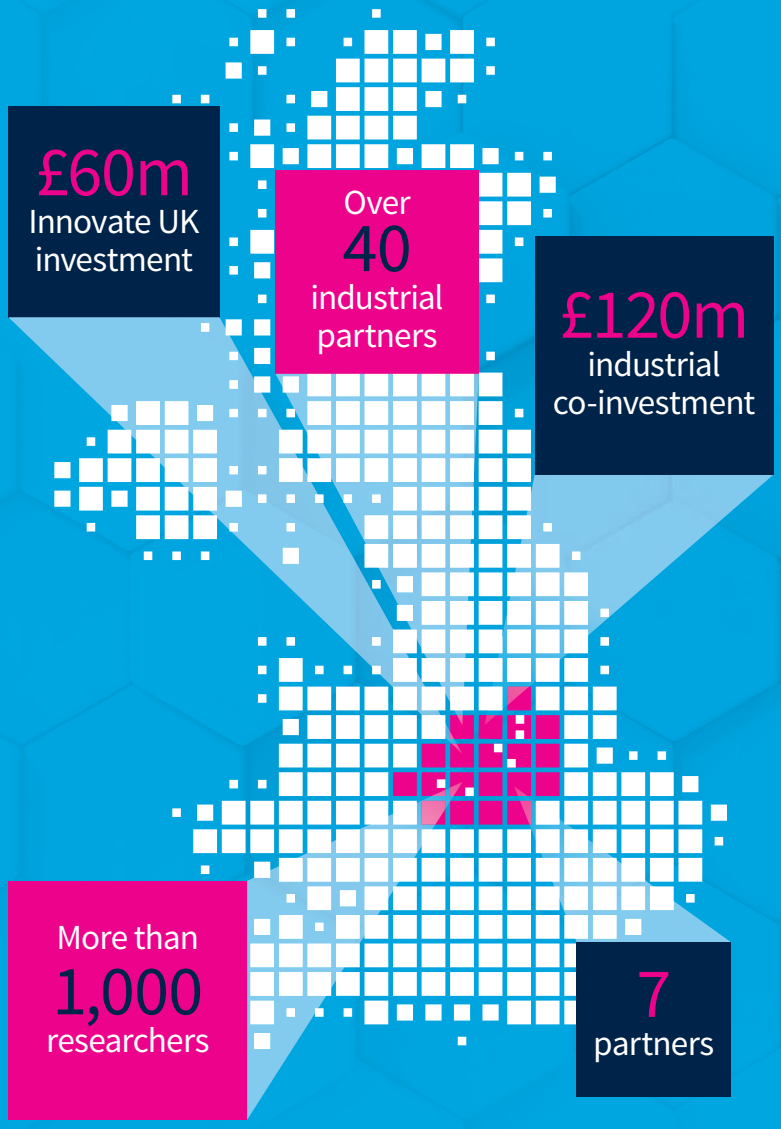

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Stephen Metcalfe MP, Chairman, Parliamentary and Scientific Committee

Welcome to the Spring edition of *Science in Parliament*. As ever it has been a busy start to the year for both myself and the Parliamentary and Scientific Committee. Our opening meeting on *'Data as a resource'* drew a capacity audience fascinated in the potential of data but also concerned about some of the ethical issues presented. Many of the issues presented by our excellent speakers are included in this edition. We also include a summary of the meeting we held jointly with the APPG on Food and Drink Manufacturing where we discussed the Science of Food Manufacturing.

As the Government Envoy to the Year of Engineering – the campaign that will see government join forces with industry to give thousands of young people direct and inspiring experiences of engineering throughout 2018 – I have been busy around the country visiting projects. You can discover more about the Year of Engineering in this edition and find out more about how you can get involved in this celebration of Engineering.

I was pleased to see many fascinating engineering projects alongside those from the biosciences, physical sciences and mathematics at the finals of our Annual Poster Competition STEM for BRITAIN. Details of the winners can be found on the website www.stemforbritain.org.uk and we will be publishing a special STEM for BRITAIN edition of *Science in Parliament* in the Summer.

I hope you will enjoy the plethora of other topics presented in this issue from the up and coming science surrounding microbiomes both within and around us to how science and engineering can help us with the real challenge of achieving the ambitious CO_2 reduction targets set by Government of 50% compared with 1990s levels by 2030, and an 80% reduction by 2050.

SCIENCE IN PARLIAMENT

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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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SCIENCE AND FOOD MANUFACTURING

The food and drink manufacturing industry is the biggest manufacturing sector in the country – bigger than the automotive and aerospace industries combined. The food supply chain employs almost 4 million people and generates £112bn of value to the UK economy each year. The food and drink manufacturing sector contributes £28.8bn to the economy.

Then, how does the food and drink sector continue to deliver the wide variety of safe, affordable food to consumers? With Brexit making exports so key – how can we build on food and drink's £20 billion in global exports?

The answers to these and many other questions are of course through science and innovation *to deliver productivity and growth*. During December's meeting of the Parliamentary and Scientific Committee and the All Party Parliamentary Group (APPG) for Food and Drink Manufacturing, attendees were enlightened by speakers from the food and drink sector on a breadth of topics that demonstrated how technologically advanced the industry is.

Introduced by Chairmen Stephen Metcalfe MP (for the Parliamentary and Scientific Committee) and John Stevenson MP (for the APPG for Food and Drink Manufacturing) examples were given of how science has and is transforming the food and drink available. Manufacturers offer greater variety, higher quality, and more convenience than ever before, and tomorrow's consumer will have different needs again to those of today. Central to these changes is the investment in science, research and innovation – used to increase shelf life, reformulate products to improve diets, and drive productivity and efficiency. It was illustrated that maintaining the sector at the forefront of technology is vital, and underpins the success of the UK's largest manufacturing sector.

First to present was Helen Munday, Chief Scientific Officer at the Food and Drink Federation, who set the scene, including giving details on the dimensions of the sector. This included the fact that the sector contains many small and medium enterprises (SMEs), in fact 96% of businesses fall into this category. Therefore, technology transfer can look very different for these organisations compared to the highly sophisticated multi-national organisations (many of which have research and development laboratories in the UK). Helen also talked about the huge diversity of scientific and technology skills that are needed within the industry, from sensory scientists, to microbiologists, and process engineers.

Next to present was John Bows, Research and Development Director at PepsiCo. John was speaking in his capacity of Chair of the Institute of Physics (IOP) Physics in Food Manufacturing Group. He reflected on his own personal views expressed as follows (which do not necessarily reflect the position or policy of PepsiCo Inc.)

"Working in the food manufacturing sector, I know how important physics is. Much of the technology used, and many of the innovations that make the sector competitive, are underpinned by physics. It's central to improvements in products themselves. And physics-based skills are applicable throughout the industry, from breaking problems down to first principles, through generating testable hypotheses and working with complex maths, to creating simulations to make predictions as to how food will behave.

But there's a general lack of awareness of this elsewhere. That crucial role of physics in the food sector needs to be fully recognised – and taken full advantage of. If we create the conditions in which food manufacturing can flourish, the sector will create benefits for us all. Fail to do so and we risk losing it to overseas competitors.

In 2015 Roger Eccleston (Sheffield Hallam University) and I approached the Institute of Physics because we saw a need for physics within food manufacturing to grow. We identified an opportunity for physics to enable growth within the sector by using physics-based research to solve its pre-competitive challenges, and also spotted a chance for the industry to play a central role in solving some genuine fundamental physics problems.

Taking on the challenge, the IOP created a pilot programme of open innovation in food manufacturing, culminating in the IOP publishing the 'Health of Physics in Food Manufacturing' report in 2016.

The food sector faces global challenges including population growth, globalisation, food security, minimising environmental impact, and dealing with concerns of health and nutrition. A multi-disciplinary approach is necessary to tackle these and physics has a critical role to play, from soft condensed matter research, insights from computer modelling and advanced measurement techniques.

Food manufacturing is a large, diverse sector in which physics plays a crucial role and which can benefit enormously from physics-based innovation. Physics is a significant lever in food manufacturing – it tackles all of the industry's main challenges. But if the sector is to

reach its full potential, the science base that supports it needs investment – and that investment must be directed appropriately."

Next to speak was Professor Tim Foster, Director, EPSRC Centre for Innovative Manufacturing in Food. Tim spoke of the funding landscape that supports the food manufacturing sector in the UK. He highlighted that the RSC/IChemE report Food: T*he Vital Ingredient*, launched in Portcullis House in 2009 reported on the need for fundamental research within virtual centres of excellence, in order to keep the UK food manufacturing industry at the forefront of global food science and innovation. To this end three centres were funded in 2013 ('EPSRC Centre for Innovative Manufacturing in Food', the 'Centre for Sustainable Energy Use in Food Chains' and the 'National Centre of Excellence in Food Engineering'), which collectively have developed 80 researchers (future research leaders), enabled a national network of leading academics to be developed and which have acquired £17m in additional funding. The funding for these three centres finishes at the end of 2018.

Additionally, moving towards a regenerative circular economy it identifies a new bioeconomy strategy that will develop new low carbon bio-based products and processes, and the need for zero avoidable waste and a doubling of resource productivity by 2050. In addition, and in response, the UK food industry has identified the need for the development of low-cost, nutritionally balanced, consumer-preferred products that are based on sustainable sources of materials through valorisation of UK agricultural produce and food-process side-stream materials. Also novel flexible and scalable manufacturing solutions and digital technologies to maximise productivity for food processors and manufacturers. This will enable new food production and delivery models to provide better access to food, through developing a more consumer centric, flexible, dynamic and sustainable food system.

In order to deliver against this mission the three afore mentioned centres have combined with an overall vision 'to make the UK the most efficient converter of biomass to deliver safe food for a healthy nation with the lowest environmental impact', and are seeking government support to enable this to happen, and to continue to develop the talent pool for future prosperity.

Professor Ian Noble, Senior RDQ Director – Mondelez International, and member of the Agri-Food Technology Leadership Council was the final speaker at the event, bringing to life how science has enabled all aspects of the transformation to our modern, developed food system delivering safe, affordable, nutritious and high quality food for all, addressing the challenges of the 20th Century.

A visit to a modern food manufacturer can be a surprise for many, encountering for the first time the levels of science and technology used: from analytical chemistries also found in the pharmaceutical sector; computational modelling, in-silica simulation and material sciences also adopted in the aerospace sector and process automation, sensor technologies and control systems at levels common in state of the art manufacturing. It is the combination of understanding the underpinning chemistry, physics, microbiology and engineering sciences at length scales from 'molecular to microstructures to final products' acting simultaneously that has enabled the transformation to our modern food system.

The challenge ahead of us all is to deliver the advances in science with the UK's world class academic groups, needed to address the challenges of our 21st century global food system: environmental sustainability, productivity, biodiversity, food security and our modern lifestyles. Successfully translating scientific breakthroughs into world leading commercial technologies will be vital to enable our largest and most geographically diverse manufacturing sector to continue nourishing the UK's population and its economy.

IT IS TIME FOR A NATIONAL STRATEGY FOR ENERGY INNOVATION

Gordon Waddington, CEO of the Energy Research Accelerator (ERA)

Gordon Waddington is the Chief Executive of the Energy Research Accelerator (ERA). In this article he argues that there is now an urgent need for a national clean energy strategy in order to ensure that the UK can achieve its aim of reducing CO_2 levels by 80% by 2050.

The great challenge of the 21st century is how to address the issue of climate change. To quote just two of the climate change statistics, the 21st century has seen 17 of the 18 warmest years on record and if the Greenland ice sheet melts sea levels will rise by approximately 8 metres.

Statistics on the effects of climate change are everywhere but it remains really hard to see practical solutions that will reverse this trend without massive damage to our domestic or the global economy. We can see how to slow things down: recycling more; electric vehicles; better insulation; switching from coal to gas; all electric aircraft etc. but it is very difficult to see enough ideas genuinely to reverse global warming. Our current efforts are all good, they buy us time, but we need to be prepared to look out beyond our current initiatives to ensure we are developing solutions for the long term.

AMBITIOUS CO_2 REDUCTION TARGETS

The UK government is quite rightly taking the climate change issue very seriously and has set ambitious CO_2 reduction targets. Our target for 2030 is to cut emission levels by 50% compared with 1990s levels, but to reduce that even further to an 80% reduction by 2050. However if you have ever tried to lose weight you will know that it's relatively easy to lose the first half of your target, but losing the last few pounds is always a lot harder. The same will be true of the effort required to achieve our 2050 climate change target. In fact the target may well prove to be impossible if we only have our current range of ideas.

The 2030 targets are challenging enough but it is already possible to see the technologies that will help us get there. Improvements in solar and wind power generation, breakthroughs in battery and hydrogen storage technologies, new carbon capture techniques, the phasing out of coal fired power stations, combined with the determination of the motor industry to move towards more electric and hybrid vehicles, will all help us to achieve the targets. There is therefore a pathway emerging that can help us reach the 2030 goal over the next 12 years.

ERA is investing in facilities to support a range of new innovations including Vehicle to Grid technologies

Indeed within these fields there are excellent things being developed today. Some of these can be seen in the government's Faraday Challenge around battery technologies that was announced last year. One of the proposals is around a project to support electric vehicles to work smartly with the grid. Vehicles that can take electricity from the grid when demand is low and return it when demand is high, could help to even out peaks and troughs and make the grid more efficient, particularly important when the calculations show that if we all start charging our electric cars when we get home at 6pm, and the grid is structured the way it is today, entire sections of our electrical infrastructure will fail due to overload.

Another very different example of demonstrated technologies is at the Trent Basin housing development in Nottingham. A community energy project working in conjunction with the University of Nottingham and the City Council has recently installed the largest community energy battery in Europe. Supplied by Tesla and providing 2.1MWh of storage, this battery allows residents to store energy being generated by on-site solar panels. This can then be used to sell back electricity to the grid at peak times, generating profits for their local community energy company, and significantly reducing energy bills for residents.

Professor Mark Gillott from University of Nottingham using the Trent Basin interactive energy system display

DISRUPTIVE TECHNOLOGIES

However, to achieve a further 30% reduction in CO_2 emissions between 2030 and 2050, a further series of significant steps are likely to be required. We are going to need many more ideas to solve the myriad issues that will arise as we move towards a low carbon future and always with an eye on the bigger picture of whether or not we are actually reducing harmful energy creation.

The 12 years to the start of this period is not very long to move complex ideas from the laboratory through a demonstration phase and ultimately into economically viable solutions. Work on the 30% reduction required between 2030 and 2050 needs to be underway in our academic institutions now if we are to generate enough ideas to deliver on our target. We need to be working on the development of new, disruptive technologies, and on things that today perhaps don't seem to make sense. We need truly creative thinking; new ideas that will change the world and we need to be prepared to create the environment where such ideas can thrive.

If we have to start thinking now about how we achieve the 2050 targets, and we don't yet know what all the technologies will be that will contribute to the overall solution, then we need to accelerate and integrate the energy research work by creating the environment that will allow energy research, innovation and entrepreneurship to thrive.

The transport sector accounts for over a quarter of all CO_2 emissions, and while sales of hybrid and electric vehicles are steadily increasing, they still account for less than 5% of the UK car market. One of the issues that concerns motorists is the relatively short range of electric vehicles, and even if the range increases to something close to conventional vehicles, something that is very challenging with Lithium Ion batteries, the time it takes to recharge batteries is still likely to be very off putting for motorists unless something changes. Remote charging or even charging whilst moving could transform the transport sector and might even make electric lorries practical, but the bigger picture requires us to recognise that this potentially will increase massively the demand for electricity, because the energy has to come from somewhere.

CREATING A PIONEERING SPIRIT

America continues to create an amazing environment for innovation. Silicon Valley and Elon Musk's SpaceX Falcon Heavy Rocket are excellent examples of the pioneering spirit of American technology and the UK is capable of creating a

similar pioneering spirit in particular areas; clean energy can and should be one of those areas. Historically the UK has been one of the world leaders in energy technologies: Calder Hall was the world's first industrial scale civil nuclear reactor and John Goodenough in 1980 working in Oxford created the modern re-chargeable Lithium Ion battery. These are just two examples where the UK led the world technologically. Sadly in both of these cases we are no longer world leaders, others have passed us, but we have the people with the skills and the determination to be world leaders in clean energy in the future. In order to harness the best that the UK has we must be prepare to work together, the best of academia, the best and most agile industries both big and small and government. We need a national clean energy strategy.

The Energy Research Accelerator in the Midlands, the Joseph Swan Centre at Newcastle, Energy Systems Research at Strathclyde and Cardiff, are just some of the examples of initiatives up and down the country established to accelerate the fundamental work on clean energy. The challenge though is to harness this work into a coherent whole. We need to focus on working with industry to use academic capabilities with industrial muscle and determination to deliver practical solutions. We need encouragement by government to think long term, beyond the life time of one Parliament or Brexit to find and deliver the solutions for the 20 years beyond 2030. If we get this right it can also create many export opportunities

There are good examples of best practice out there today. With £60m of funding from Innovate UK, and bringing together the six Universities of Aston, Birmingham, Leicester, Loughborough, Nottingham and Warwick, plus the British Geological Survey, the Energy Research Accelerator (ERA) is providing a springboard for energy research acceleration. Furthermore The Industrial Strategy Challenge Fund provides an unprecedented £4.7bn to work on a limited number of areas where the UK can lead the world. Two of the Industrial Strategy's four 'Grand Challenges' - Clean Growth, and The Future of Mobility - are heavily focused on finding new low carbon energy solutions. The restructuring of the work of the Research Councils and Innovate UK into UKRI to try and ensure that the research undertaken is relevant should make a difference, and the creation of the Energy Systems Catapult all help to provide focus.

A NATIONAL CLEAN ENERGY STRATEGY

The Government together with MPs of all parties can help to create a climate that encourages and supports innovation between academia and industry on energy projects. Big companies have been working with universities for decades, but for the majority of smaller businesses, the idea of working with a university is not something that they would consider, believing it to be expensive and not knowing what they have to offer, or how they could collaborate together.

If we get this right the UK can be one of the beacons across the planet where countries look for inspiration on this most pressing of problems and we cannot afford to sit waiting for others to come up with the answers.

We need a national clean energy strategy, and I make no apology for repeating myself on this point. We need Energy Innovation Zones across the country, where the brightest minds in the UK, who have expertise to contribute on clean energy, can work together. We need a lot more practical economic ideas that can help us deliver the 2030-2050 target. By working together we can develop and exploit new disruptive technologies that will help us to achieve the low carbon future that is so vital not just for the future of the UK but the world.

The Energy Innovation Centre at Warwick University is at the forefront of battery research

ENERGY EFFICIENT MOTORS ON AN INDUSTRIAL SCALE

Dr. Christopher Donaghy-Spargo
BEng PhD CEng
Assistant Professor of Electrical Engineering & Deputy Director of Future Energy Systems in the Department of Engineering
Durham University, UK

Innovative energy efficient electric motor technologies can significantly reduce industrial electricity demand on a global scale, saving process-intensive industries money while helping to combat climate change.

It is worth starting with the fact that total energy consumption of the entire globe is approximately more than 100,000 TWh, which is the amount of energy that has undergone processing from primary forms into usable forms (electricity, heat, etc. at the point of use). The total production is higher (around 20%) due to losses in the transformation processes and its transportation from its initial place of supply to the domestic and industrial consumers. The amount of energy produced is a vast amount by any standard and has been increasing annually (e.g., in 1975 the consumption was approximately half of what it is now) and thus the production of useful energy, its supply, and efficient end-use is a global *grand challenge*. This challenge is not only technical in nature, but there are also significant economic and political issues to be tackled. It is of a global nature, and it is multi-faceted. It requires input from not only academia, relevant industries, the financial sector, and trade organizations, but also policymakers – there are many stakeholders, including the public. Of course, there is no easy solution, and it will be a long road to securing a sustainable and economically viable energy infrastructure for the future. One way to assist this endeavor is to generate an increasing amount of useful energy using renewables, or else reduce the demand, perhaps by increasing energy efficiency?

Concerning the UK and Europe, the *Energy Efficiency Financial Institutions Group* (EEFIG) suggests that there is a vast potential for energy savings (energy efficiency) in both buildings and industry[1]. Energy efficiency can mean reducing overall energy demand. This can be achieved by increasing supply security through reduced reliance on imported energy (presently around €400bn per year), enhancing the competitiveness of UK & EU industry, as well as acting to address, somewhat, the global environmental challenges. Action must follow to meet the demanding targets for 2020, 2030 and beyond, as agreed by world legislators. Global energy efficiency drives are explicitly backed up by various international governmental agreements, for example, the Paris Agreement and more specifically from the European Commission, where on 30th November 2016 the Commission proposed an update to its *Energy Efficiency Directive,* including a new 30% energy efficiency target for 2030[2]. So, there is some traction here.

However, here we are primarily concerned with electrical energy. Global electricity consumption is approximately 21.36 trillion kWh (a CIA Fact Book estimate from 2014[3]), which is the equivalent of over 2 billion 1kW kettles boiling away, 24 hours a day, 365 days per year – a tremendous amount of Earl Grey to be consumed, one might say. It is interesting to note the fact that over 45% of the global electricity energy demand is utilized by electric motor systems; according to various reports such as the Department for Business Innovation & Skills[4], the International Energy Agency[5] and Global Industry Analysts. Inc[6]. The analysis of which was taken on board by, and significantly influenced, a recent report entitled "Technological Feasibility Studies for Super- and Ultra-Premium Efficient Motors" by an international working

group the International Council on Large Electric Systems (CIGRE)[7]. This report goes on to claim that improving the energy conversion efficiency of industrial electric motors by 3% (which is possible with technology currently available), yields the potential to save over 350TWh (>100 nuclear power plants, each rated at 1GW) of annual electricity demand. A staggering sum equating to a Carbon Dioxide Equivalent ($C0_2E$) of approximately 260 million metric tonnes, based on the United States Environmental Protection Agency methods.

The scale of the potential savings is not surprising, perhaps, when we consider the scale of industrial and manufacturing activity in the UK and Europe at large. In the heavily industrialized regions (e.g. the US and China *et al*.), where just about all industrial processes involve some form of rotary motion: this is where the "electric motor" converting electrical power into rotary mechanical power is deployed. Applications such as fans/blowers, mills, pumps and conveyor belts on production lines, to name but a few, are commonplace and typically operate 24 hours per day, 365 days per year at thousands of geographical locations, with each of those locations (factories) containing hundreds/thousands of electric motors. The annual sales volume for electric motors is in the billions. Not limited to the UK, or even Europe and the USA – the scope of the energy efficiency improvements amongst industrial motor drive systems encompasses every industrialized nation.

Therefore, it is clear from these studies that improvements in industrial electric motor efficiency represent a significant opportunity to reduce global energy demand and industrial operating expenditure on electricity. Of course, this is inherently complemented by a fall in greenhouse-gas emissions, as above – which in turn will allow us to halt, or at least slow down the rate of rise of the surface temperature of the Earth considering the +2°C target.

Concerning the UK, some government work has already identified this. Most recently, the Department for Business, Energy & Industrial Strategy's Digest of United Kingdom Energy Statistics report in 2016[8] stated 26% of UK electricity use is in 'industry', consuming 92GWh – the second largest consumer – showing that this is a significant energy vector in the UK. An earlier Department for Business, Innovation & Skills report from 2011 states[4]:

"Industrial electric motors account for more than 60% of all [UK] electrical energy consumption."

This statement covers consumer goods (spinning microwaves and washing machines, etc.) – it also suggests that like the EU and CIGRE *et al*., that there is a vast room for improvement in energy efficiency in this arena with great benefits to be realized, *if*, energy efficiency gains can readily be obtained. This same conclusion is identified in the 2012 Department of Energy & Climate Change independent report *"Capturing the full electricity efficiency potential of the U.K."* compiled by McKinsey & Co to accompany the "Electricity Demand Reduction: Consultation" on options to encourage permanent reductions in electricity consumption[9]. These studies published by significant international institutions in the UK, the EU and beyond constitute a compelling case for action on policy in this area.

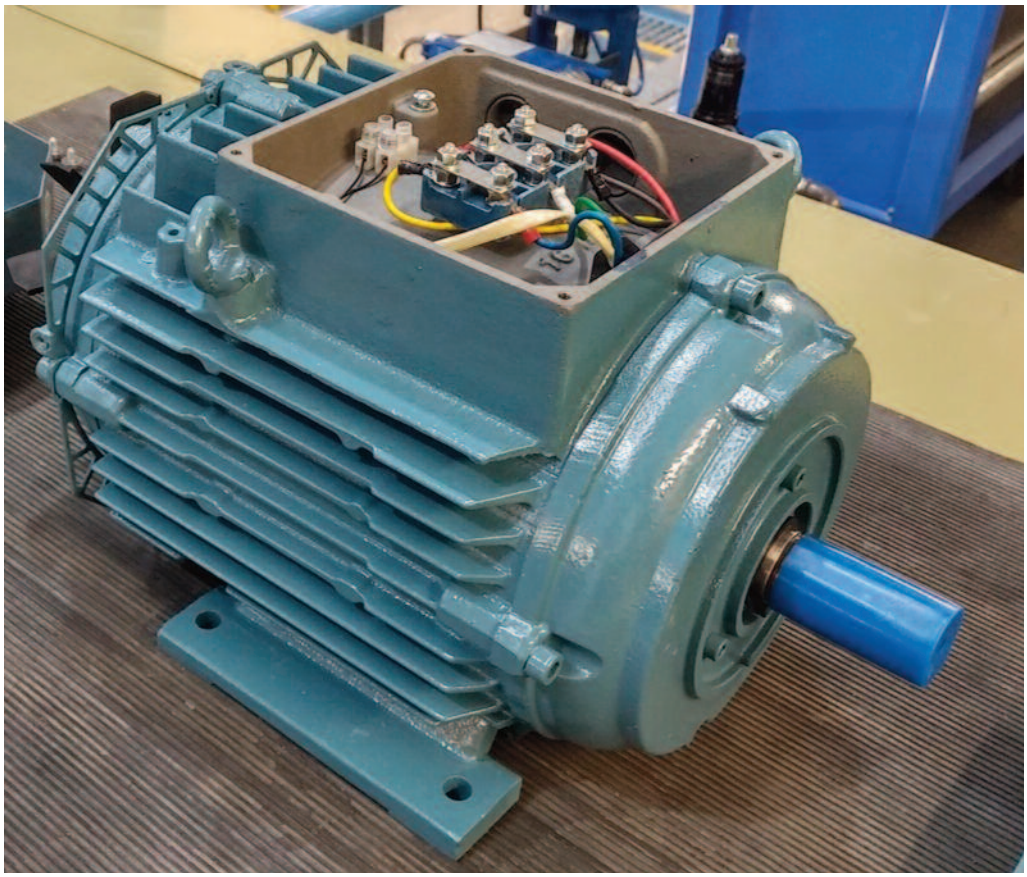
Following the recent referendum vote for Brexit, the Durham Energy Institute at Durham University (which has expertise in the technological challenges associated with increased efficiency of industrial motor drive systems), submitted

evidence[10] to the House of Lords' EU Energy and Environment Sub-Committee report on Brexit: Energy Security[11]. The evidence stated;

"The UK government should, post-Brexit, incorporate an ambitious energy efficiency and energy demand reduction directives in to UK policy framework, particularly in heavy industry with an emphasis on higher efficiency electric motors. The UK should seek to match or exceed the EU legislation (existing and future) on this matter to ensure security of supply by reducing demand through the adoption of new and appropriate technology."

With this, the industrial electric motor drive system market represents an area of opportunity for the UK in Energy Efficiency policy; it deserves further consideration and research regarding policy frameworks and technological advancement in order to realize our long-term energy efficiency targets, assist with energy security and sustainability, and contribute to combating climate change.

The technical question is "How do we obtain the energy efficiency increase?" The motor technology selection is of importance here but does not answer all the follow-up questions as one technical solution does not suit all – again, there is no simple answer. That said, the solution is to be found by considering a range of engineering options such as new and improved materials and manufacturing techniques utilized in motor construction, improved motor designs and choice of inherently more efficient motor technologies. The framework of possibilities is outlined in the CIGRE technical feasibility report[7] which concludes that the 3% energy efficiency increase is possible in accelerated time frames (2020 onwards). This conclusion is backed up by the author's work and recent analysis[12] of a new type of motor technology to replace the traditional 'induction motor'. It is true to say that modern manufacturing and process intensive industries are underpinned by Victorian technology. An innovative technology, well placed to replace this Victorian infrastructure is called 'Synchronous Reluctance', the technical details are omitted here, but it suffices to say that an efficiency improvement of 2-4% (each motor) can be readily obtained by its adoption. Hence, we must encourage motor manufacturers, governments, academia and broader industry to engage in an international response to climate change by tackling the energy efficiency of industrial electric motor drive systems. The response must encompass innovative energy efficient electric motor technologies coupled with a relevant policy framework to encourage the necessary engineering research and development, both in industry and academia, and the adoption of new energy efficient technology by traditionally conservative industries. This innovation could save process-intensive industries money while reducing energy demand and assisting in combating climate change and improving energy security.



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MAKING DATA WORK

Mandy Chessell CBE FREng
Distinguished Engineer: IBM

We have a guilty secret. Digital technology has created an instrumented and interconnected world. The technology itself is advancing in speed and capacity. It is getting smaller and cheaper, making it practical to embed network connected digital technology everywhere – from personal possessions, homes, offices and public buildings to machinery, transport and the broader environment. The result is that data is being collected about most aspects of our daily lives and the environment we live in.

The digital technology platforms we use today are implemented using open standards. An open standard is a set of rules for exchanging data and commands that is freely available for all to use. The open standards embedded in the Internet enable disparate computer systems to connect and share data. The effect is that we can duplicate and distribute data at an increasingly fast pace. This means data can be made available wherever and whenever it is needed.

Faster processing platforms and advanced algorithms increase our ability to process this growth in data, creating the potential for smarter infrastructure (such as our power and transport networks), new businesses, more advanced healthcare and better use of natural resources.

Despite these advances, many organisations are struggling to make effective use of data. At the same time, the seemingly ubiquitous collection, linking and distribution of data from our different daily activities is creating concerns for individuals' privacy, safety and security. These two issues seem to contradict one another, but in fact they have a common cause.

Peeling the layers back, what makes data difficult to consume is that it typically flows without context.

What do we mean by context? This is the description of the situation and assumptions that were in place when the data was collected and processed.

People learn to adapt the information they disseminate automatically to their context. For example, imagine you are in Florida USA on holiday and an American asks you, in casual conversation, where you live. A five year old may chant their address when asked where they live, but as an adult we know there are different ways to answer, depending on the context. In this first example, you may answer "In the UK". If asked the same question by someone wishing to send you something by post, you would give your postal address, and if standing in your street and asked where you live by a new neighbour, you may point and say "over there".

The data values we use depend on the context in which we are using it. Computers are more like 5-year olds. They need explicit instructions. So, data needs to be labelled to define which data to use in which circumstance.

Once data is labelled, computer systems become smarter because they are able to use the right data for the right situation. The labelling should also indicate which data values need special protection and which data to use for each new digital service. This labelling is the fundamental underpinning of good governance.

The technical term for the data labels is "metadata" – metadata simply means "data about data".

Digital photographs are a good example of where metadata enhances the usability of data. When you take a digital photo, the camera adds additional information to the image such as the current date and time, your location and the setting of the camera. This additional information is the metadata.

Knowing where and when a photograph was taken makes it more useful. Photographs of the same location can be compared to show how the location is changing over time. Understanding the environment, such as light-levels, and camera settings when the photo was taken helps photographers (and programs) to learn what are the best settings for different situations. Thus, with metadata, data becomes more useful.

The problem today is that most data does not have metadata. The teams building digital services that use data from many different sources often need to reconstruct the metadata for the data they are using. This is time consuming and error prone.

Open data sites, such as https://data.gov.uk/ have invested in basic metadata, and so have some of the more experienced commercial data brokers. However, most data is still exchanged without metadata.

There are two main causes: missing open standards and a lack of automation in metadata management within our digital platforms.

It is not that there are no open standards for metadata. In fact there are thousands of them – but each covers a tiny scope and they do not integrate

together to cover the breadth of data needed for today's digital world. There are also significant gaps in our open standards for metadata that make it harder to establish trust to share and consume data.

Trust is more than security. Metadata needs to cover the terms and conditions (license) under which the data can be used, the requirements for its governance, and the provenance (origin and processing history) of the data that enable a consumer to determine whether they can trust the data they receive. These missing standards mean that data sharing agreements need to be established on a case-by-case basis through legal documents that then need to be encoded into the workings of the digital systems that will implement the exchange of data. This process slows down the advance of the digital economy and does not make it any safer. It simply impedes the progress of organisations that wish to behave responsibly and provides no impediment to the criminal use of data.

Establishing the right open standards is step one. These standards need to be embedded into our digital platforms so that metadata capture, management and use is automated.

Automation brings accuracy and reliability to metadata capture in addition to speed. Humans, in general, are poor at consistently maintaining metadata because it is a repetitive task and the person making the effort does not immediately realise the benefit. Think about traditional photography when photographs were printed on paper. How many people consistently wrote on the back of the photos where and when they where taken, who was in the picture and what was the situation? Some people did, making those photographs more valuable, but most did not.

Digital photography changes this. Metadata capture is embedded in the camera, it is managed automatically, and it is stored in an open standard format. We can load our photos from different manufacturers' cameras and mobile devices into a photo management app (application program). The photo management app can organise and manage our photographs because the metadata about the photos is always there and is in a standard format. Individuals can optionally enhance this metadata to add information such as the names of any people in the photograph and why it was taken. This additional information becomes part of the photograph's metadata and will be transferred with the photograph when it is sent to someone else.

We need to change our digital platforms and practices to ensure all data has automated, standardized metadata embedded within it. This requires work on the open standards themselves, a focus on adoption within the technology and the establishment of communities of practitioners that understand the importance of metadata in their use of data and embedding this best practice into their professional work.

I am one of the leaders in an international, multi-company group that includes IBM, ING Bank and Hortonworks. We believe that metadata is so important that we need to change the technology industry to ensure metadata is ubiquitous, standardized and automated to a level that means our digital economy can share and use data effectively and responsibly.

Our aim is to create a set of open standards that covers all of the metadata and the governance frameworks needed for a data-driven enterprise. These standards stitch together existing open standards like a patchwork quilt and add the missing standards for terms and conditions, governance and provenance. The Open Group is assisting with their expertise in establishing open standards.

Part of our group is implementing these standards in an Apache Software Foundation (ASF)® open source project called Apache Atlas, so the reference implementation is free for anyone to use.

Finally, we are building a consortium through the Open Data Platform Initiative (ODPi) that has two goals. Firstly, to create compliance test suites to help data tool vendors to become compliant in the standards, Secondly, to build a team of subject matter experts willing to build encodings of regulations, industry specific terminology and rules in the open standards. Organisations can download and use them to bootstrap their adoption of good practice and compliance to regulation.

How can parliament help? Adoption is key and we need to get the word out plus recruit people and organisations to the cause. In particular, parliament and the UK governance can help by:

- Publicising the importance of metadata to the digital economy.
- Encouraging the use of open metadata standards in all stages of data processing.
- Adopting the open metadata, and related governance practices in government's digital services and standards.
- Providing feedback on the development of the open metadata standards so they cover the needs of the UK digital economy.
- Providing encodings of the UK's data regulations in the open metadata standards so that the interpretation of the regulation is clear and organisations can download and use the encoding in the open source reference implementation of the open standards (or any commercial product that implements the open standards) to adopt rapidly best practices in their governance of data use.

To understand more, these references may be useful:

- **In Data Management and Use: Governance in the 21st Century the Royal Society and British Academy describe the importance of the governance of data use and recommends the creation of a new, independent body to steward the overall data governance. The recent establishment of the "Centre for Data Ethics and Innovation" reflects these learned societies call for a stewardship body. It also may be an organisation to coordinate the adoption of open metadata standards within the UK.**
- **In Open Metadata and Governance details of the Apache Atlas reference implementation for open metadata standards are provided.**

DATA IN REAL-LIFE CANCER THERAPY

Dr Bissan Al-Lazikani, Head of Data Science, The Institute of Cancer Research, London

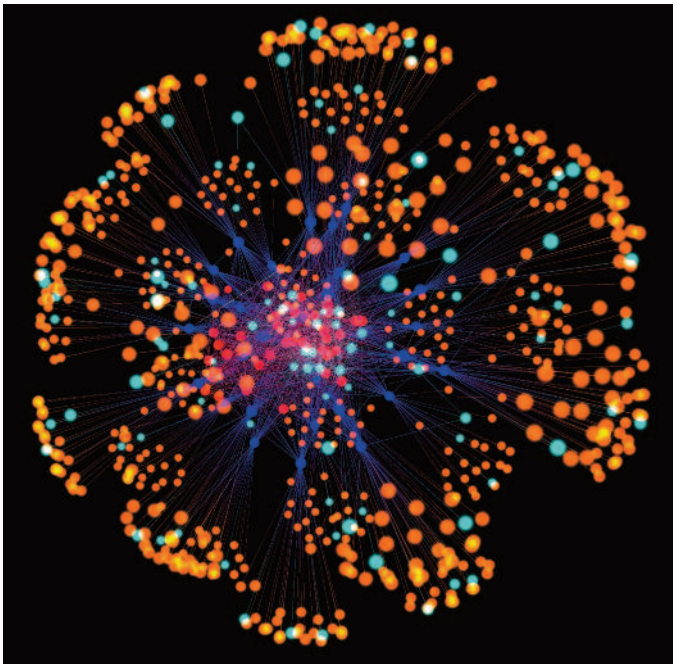
Data has been described as the fuel for the fourth industrial revolution. We're generating data at an astonishing rate, and using it to drive decisions across every aspect of society – from transport to finance, the environment to healthcare. Big data – meaning not just huge volumes of data, but the complex integration of multiple data sources – has become a hot topic. But while the potential of Big Data seems almost limitless, it brings with it a new set of challenges that must be addressed if we are to use it to its full potential.

One field that is being revolutionised by Big Data is cancer research. We are generating incredible quantities of complex and varied data about cancer as advances in technology have made it faster and cheaper to collect. At The Institute of Cancer Research, London, we believe that using Big Data effectively will help us meet the huge challenges in improving cancer survival. By sharing and integrating complex datasets, we can identify new approaches for treating cancer, predict which treatments might most effectively be combined, or calculate a patient's chances of responding to a treatment, or experiencing side-effects from it.

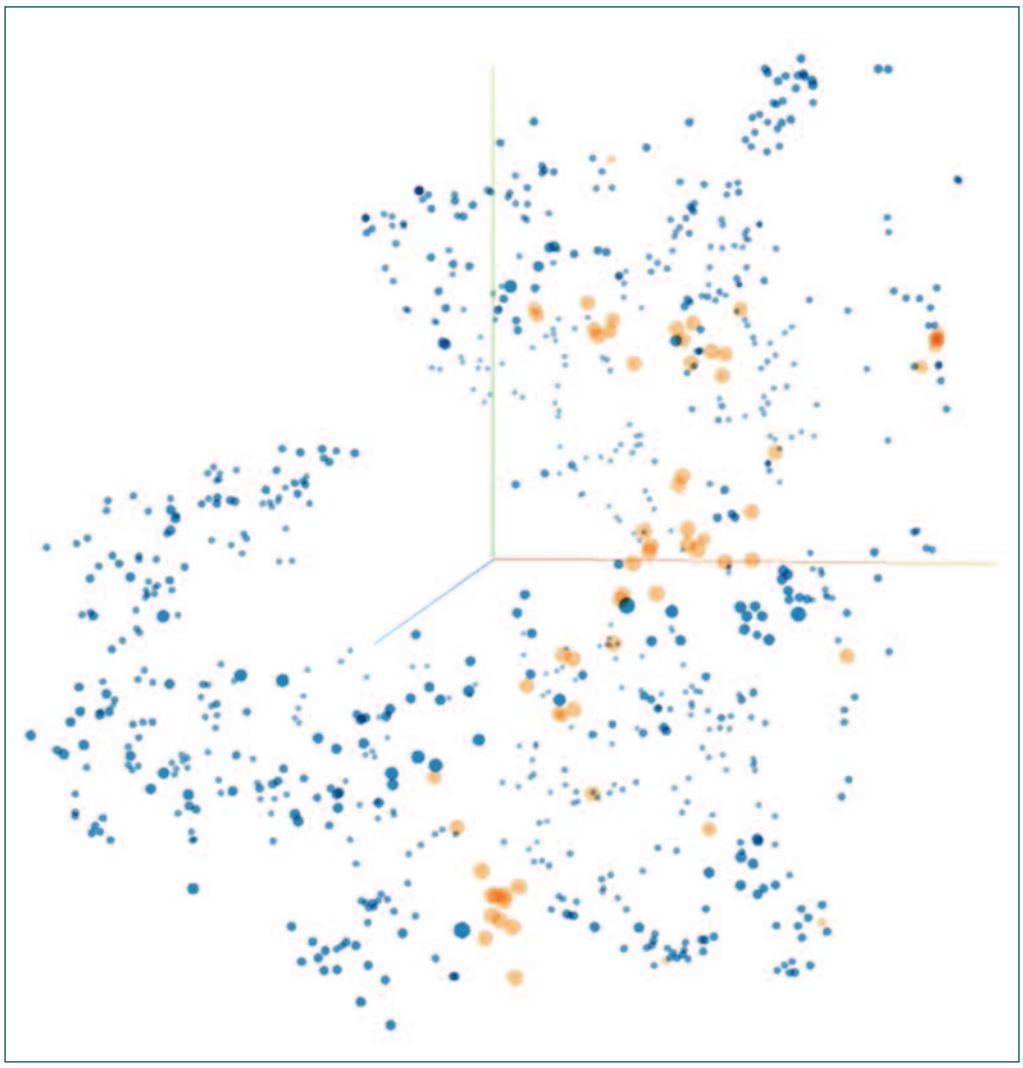
FINDING NEW DRUG TARGETS – DRUGGING THE 'UNDRUGGABLE'

In 2011, I and my colleagues in the Cancer Research UK Cancer Therapeutics Unit at The Institute of Cancer Research (ICR) developed canSAR[1], the world's largest and most intelligent database about cancer. Seven years later, canSAR contains more than 10 billion experimental measurements mapping the actions of one million drugs and chemicals on human proteins, as well as genomic data, structural data, images of cells, tissues and the whole body, chemical, pharmacological and radiotherapy data, and clinical notes. This resource is provided by the ICR and Cancer Research UK free of charge, and to date has been used by more than 200,000 researchers in 175 countries – helping to improve outcomes for patients all over the world. [2]

CanSAR is driving wonderful innovation in cancer research. We have used it to identify 46 previously overlooked but potentially 'druggable' cancer targets[3]. CanSAR uses sophisticated machine learning and artificial intelligence to take our current knowledge of what makes a good drugs target and discovers a whole new range of possibilities. These properties include simple characteristics such as whether a protein's



A network view of data from patients from the CHIIP trial (a radiotherapy clinical trial run by the ICR), this data was used in the study described in the article (30 patients with single nucleotide polymorphisms (SNPs), clinical variables and dose-volume histograms (DVH)).



A t-Distributed Stochastic Neighbour Embedding (t-SNE) visualisation of some CHHIP trial data where patients with a specific side effect are shown in orange and those without it are shown in blue (in this case the side effect is rectal bleeding)

function can be 'switched off', to more complex data like its atomic structure. Using canSAR, we can then take this information and learn what a good drug target looks like – and so in turn predict from lab data which targets seem most promising.

Of the 46 targets we identified, 10 are now being investigated in drug discovery projects, two of these at the ICR. Approaches like this are allowing us to identify entirely new ways of fighting cancer, which will lead to step changes in outcomes for patients. We currently only have drugs targeting 5 per cent of the 500 or so cancer-causing proteins in our bodies, so there are a lot of untapped possibilities left to explore.

PREDICTING PATIENT RESPONSES - INFORMING PERSONALISED THERAPY

We can also use Big Data to help direct choices about how to treat patients in the clinic. A recent study at the ICR applied Big Data analytics to information from more than 700 men given radiotherapy to treat their prostate cancer. This included medical history, genetics, radiotherapy dose and reported side-effects[4].

My colleague Dr Navita Somaiah and I used artificial intelligence to highlight which information might predict sensitivity to the side-effects of prostate radiotherapy. At the moment, there is no way to adjust doses of radiotherapy according to how sensitive a patient might be to the side-effects. This means that some men are receiving too much radiation, with its associated side-effects, while others are given too little and so their chances of successful treatment compromised. Our study highlighted a range of characteristics that were shared amongst those men who suffered side-effects, including specific types of mutation in their DNA.

With further validation, this information could be used to create personalised treatment plans for men with prostate cancer, adjusting doses to ensure patients receive an effective amount of radiation while minimising side-effects. It's an approach that could also be applied to a range of other cancers.

WHAT DO WE NEED TO GET THE MOST OUT OF BIG DATA?

These examples demonstrate how integration and analysis of Big Data can uncover information that could not be observed by working on smaller pools of data in isolation. But by its very definition, Big Data indicates a volume, complexity and diversity of data which challenges our current capabilities to analyse and handle. So how should we go about handling all this data in a way that makes it as useful as possible to cancer researchers?

The UK is waking up to the benefits of Big Data research. Projects involving Big Data and artificial intelligence are generating great interest – and funding – through the Government's new industrial strategy[5] and Sir John Bell's life-sciences industrial strategy[6]. But there is still plenty that we need to do to capitalise on this exciting new field.

Perhaps the biggest challenge in using Big Data is not so much the volume of information, but the diversity of data types and sources that often need to be brought together. Often, data collected in different organisations is recorded in different formats that may not be compatible with each other. We need to ensure information is collected and annotated in clinical trials and routine treatment in a way that maximises the benefit to patients. We need to establish clearer protocols for collecting data and to educate clinicians and other staff, to drive changes in the culture surrounding data storage and exchange. In instances where different data standards are required in different organisations, we need

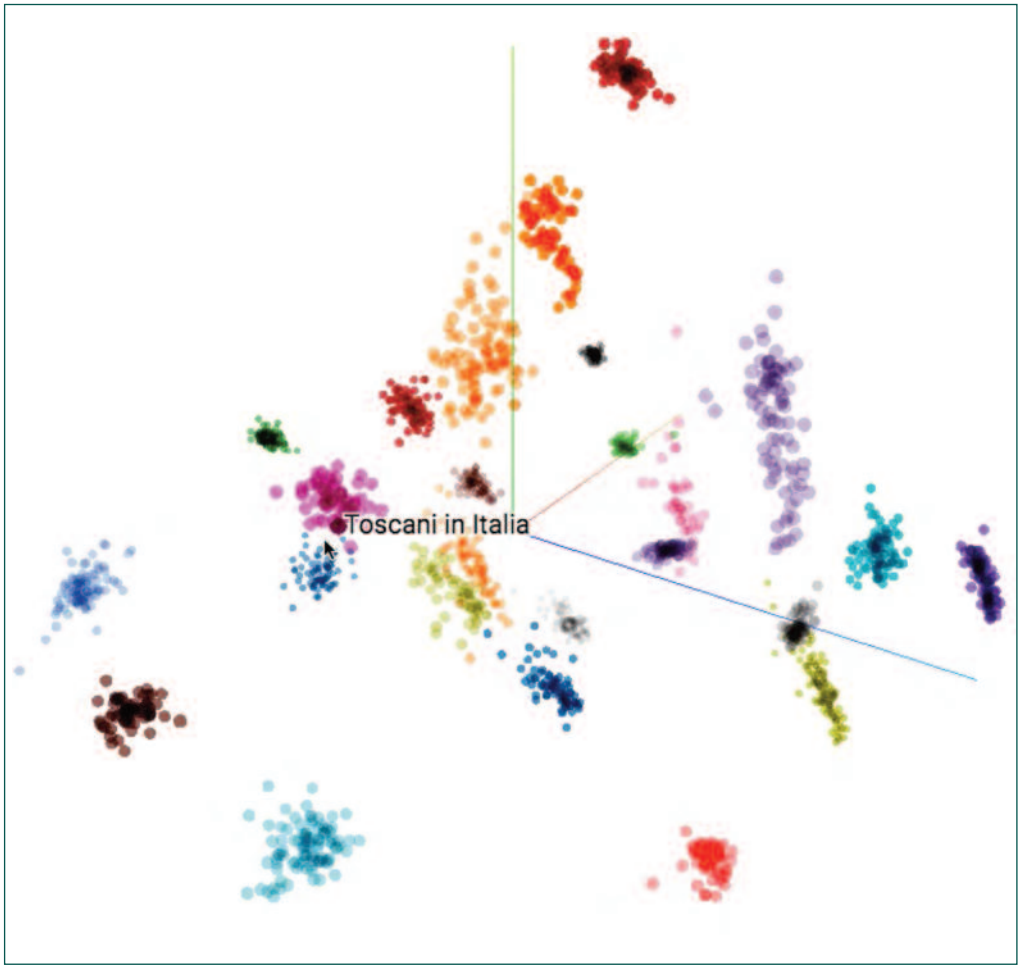
to adapt data formats to make them as compatible as possible. It will be essential to agree common sense solutions both for now and the future.

We also need to get the greatest possible benefit out of the data that we collect from patients to maximise the impact of our research. Researchers must work together with patients to ensure that research delivers value to them. More information needs to be provided to both the public and clinicians to enhance their understanding of the value of Big Data, of how data is stored and used, and the safeguards that exist to protect privacy and security.

Regulations must focus on how we use data, more than the precise prescription of processes for data collection and storage. We did not know five years ago what crucial medical questions can be answered with today's technology, and today we cannot begin to predict what powerful medical insights future technologies would enable us to gain. This means we must have the foresight to collect broad enough data in an ambitious and responsible way to ensure that we do not artificially limit our ability to advance therapy in the future. That's going to require new standards for gaining patient consent in a flexible, secure and traceable way so that data can be used in future – maximising the research we can do and its benefits for people with cancer. Focusing regulation on the use of data also allows valuable data to be collected easily, maintained and used for public good, while putting in place strong safeguards to prevent and admonish its misuse. If systems are in place to ensure data are stored securely and traceably, preventing data collection and access out of fear of misuse is unnecessary, damaging to research – and ultimately harmful to patients.

Research organisations also need people with the right skills to deliver a Big Data approach. Big Data is a rapidly expanding field. Because we are seeing such rapid technological change, higher education institutions need to train people with fundamental skills that will allow them to adapt to future changes, rather than in specific technologies that risk becoming out of date. We need training and internship programmes to build the skills base in mathematics, statistics and computer science, along with a relaxation of visa restrictions for people with skills relevant to Big Data. As with all medical research, Big Data requires an international approach to share data across borders and ensure a diversity of people are working on society's big problems.

We are in the midst of a data revolution and the potential for beneficial change is huge. The hope is that if academic organisations can work together – with Government and industry – Big Data can become a central pillar of medical research, delivering significant improvements in outcomes for patients with cancer and many other diseases.



A t-SNE of genomic data from 2000 patients in 26 populations.

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DATA AS A RESOURCE: FOR WHAT? AND FOR WHOM?

Simon Burall
Senior Associate of Involve,
Programme Director of Sciencewise

The role of the public in deciding

There are two sides to the debate about the use of data by government. More effective use of data and data science will help the government to identify areas of acutest needs, and better design more targeted public services. More effective use of data can also help to drive efficiency savings to the benefit of the economy overall.

However, there are also significant concerns about the increasing use of data by the government. The most obvious relate to the impact on privacy and the extent to which the public is consenting to all of the ways its data is being used. There are also wider concerns. Some relate to questions about the quality of the data that is being used, and therefore the accuracy of the conclusions that are being drawn. Others relate to the government's capacity to use the growing mass of data effectively. Finally, as data drives service redesign and delivery there will be winners as well as losers; there are risks that increasing reliance on data driven decisions will exacerbate existing inequalities rather than reduce them, for example.

As a result of the tensions and trade-offs inherent in decisions about whether or not to use data in particular cases, there is an urgent need to engage the public in this wider set of questions.

The UK has extensive experience of engaging the public on complex, controversial issues relating to science and technology innovation. For example, the Department for Business, Energy & Industrial Strategy (BEIS) has supported the Sciencewise programme for well over a decade. In this time, the government has run over 50 deliberative dialogue projects to better understand what the public thinks about a wide range of scientific innovations, and critically why they think this.

These dialogues have helped the government take into account the social, ethical and moral perspectives of the public as it has designed and delivered public policy including in a number of areas related to data such as developing ethical data science projects, data openness and reuse by government, and the forensic use of DNA data. A significant number of Sciencewise projects have had a direct impact on the resulting policy, helping to design governance and regulation to ensure that it meets the concerns of the public.

Experience shows though that, while public engagement can bring significant benefits, it can also fail for a number of reasons. The most significant of these is that effective engagement is too often seen to be synonymous with convincing the public that the risks resulting from the use of a technology have been mitigated. The 'deficit model', as it is called, roundly failed to convince consumers that they should accept GM crops. While consumers were concerned about safety, they also wanted to engage in questions similar to the wider set of trade-offs I identify above in the debates about the use of data.

A second reason that public engagement often fails is that government departments are often very unclear about the purpose they are to serve. As a result, many attempts to engage the public try to educate people about the issue and understand what they think about it and engage them actively in solving specific issues while also demonstrating that they are robust and demographically representative. Each of these purposes requires very different tools and techniques. The resulting failure to have clarity of purpose means that little of value is achieved.

Finally, far too many engagement processes are commissioned very late in the policy making process and give the public very little time to engage, find out more about the specific issue and contribute effectively. Giving the public limited time to respond sends them the message that they aren't important and neglects the fact that they can't just drop work and family commitments to engage on the government's terms. If engaging the public is critical, then making sure they have time to do so is equally important.

The use of data in both the public and private sectors has the potential to impact across a wide range of public services. The government has limited understanding of what the public considers acceptable in terms of how their data is used. It is critical that they are engaged as an important factor in determining the parameters of such usage, and how bad practice should be governed and regulated, otherwise we risk a backlash similar to that experienced in response to genetic modification.

UNLOCKING THE MICROBIOME

Dr Paul Richards, Policy Manager and Roya Ziaie, Policy Officer, Microbiology Society

Exploring and exploiting microbiomes is a rapidly emerging area of microbiological science and innovation. Dr Paul Richards and Roya Ziaie in the Policy team at the Microbiology Society explain how the Society's recently published policy report *Unlocking the Microbiome* identifies opportunities and challenges of microbiome research for health, agriculture and biotechnology.

Microbes are everywhere and affect almost all aspects of our lives. We cannot see them, but our world would not function without them. Bacteria, viruses, fungi, protists, archaea, algae and other microscopic life forms are on us and in us, in the air, soil and water, and in our food. They are in and on the surfaces of everything in our homes, workplaces and other environments. Most do not harm us and many are essential for the good health of humans, animals and the planet. Microbes help keep the planet healthy by recycling waste and supplying nutrients. Agricultural systems would not function without some while others are harmful pests. Industry uses microbial processes to produce foodstuffs and drugs, benefiting society and creating wealth.

Yet microbiomes, including the microbes and their genes, present largely unexplored resources for better understanding disease and environmental processes, and discovering many more useful functions and compounds for industry and biomedicine.

Advances in technologies such as microbial genomics alongside approaches bringing together skills and knowledge across disciplines such as bioinformatics, microbiology and biochemistry are now enabling researchers around the world to better explore, understand and harness the diversity and functions of microbiomes. This is leading to new discoveries and helping tackle challenges such as antimicrobial resistance, food security and sustainability.

Our growing knowledge of microbiomes is not just receiving attention from scientists, but also industry, funders, regulators, and end-users such as clinicians and the public. In 2016 the USA launched a National Microbiome Initiative; the European Union invested over €1.4 billion in microbiome-related research between 2007 and 2015; and UK Research Council BBSRC with other partners has invested in the £75 million Quadram Institute for Food and Health, which has the microbiome as a focus.

Recognising the growing interest in microbiomes, the Microbiology Society has published a report - *Unlocking the Microbiome*. Informed in consultation with a wide-range of experts in the UK and Republic of Ireland, the report makes 10 recommendations about how scientists, decision-makers, industry and other stakeholders can collaborate to progress microbiome research.

The Chair of the Society's Microbiome Expert Working Group, Professor Julian Marchesi and other experts discuss recommendations made in the Microbiology Society's *Unlocking the Microbiome* report at a launch event held at the Royal Society in November.

Whether working on microbiomes in humans, livestock or soils, it is clear the research community see common opportunities and challenges.

The human microbiome, particularly the gut microbiome, has received the most attention. Scientists are now able to investigate in much greater detail the important functions of the human microbiome, including its role in digestion and nutrition, and the protection it provides against pathogens. There is interest in how factors such as genetics, diet, antibiotics, and even birthing approaches affect the development of the microbiome from infancy to old age. Links have been found between changes in the microbiome and a variety of diseases including chronic respiratory conditions, obesity, inflammatory bowel diseases, antibiotic-resistant infections and even mental health.

While much more research is needed into these links, priority is being given by scientists and industry to target the microbiome to develop novel diagnostics, therapeutics to treat and prevent disease, and interventions and nutritional products to promote health.

Tackling the global challenge of antimicrobial drug-resistant infections is one area of focus. Scientists are exploring the potential to reduce antibiotic usage, for example, using prebiotics and probiotics to promote microbiome diversity and functions that protect

against infection; and developing novel antimicrobial biotechnologies such as bacteriophage to target drug-resistant bacteria without affecting the rest of the microbiome.

Faecal Microbiota Transplant (FMT) from healthy donors to treat patients suffering from antibiotic-resistant *Clostridium difficile* infection is perhaps the current main example of microbiome research beginning to be translated into the clinic. However, with FMT and other potential novel microbiome therapeutics and products, ongoing discussions are required about regulation and clinical governance

The potential role for the microbiome in the development and treatment of some cancers has also been gaining interest. Evidence that the gut microbiome can affect people's responses to cancer treatments, has raised the possibility of modulating the microbiome to improve patient outcomes.

Like research on the human microbiome, there is a growing focus on building knowledge of livestock microbiomes with a view to improve animal health and productivity and reduce transmission of foodborne disease. There is even the potential to modulate rumen microbiomes with diet to reduce greenhouse gas emissions.

Agricultural interest also extends to crops, with scientists building knowledge of soil and plant microbiomes ultimately to inform farming practices and develop biotechnologies such as biopesticides and biofertilisers to enable more sustainable farming. Recognising this potential, Centre for Agriculture and Biosciences International (CABI) and Rothamsted Research recently launched a UK Plant Microbiome Initiative, with a focus on building industry-academic links. Our report highlights the importance of building such links to progress all areas of microbiome research and translation.

We also heard from scientists hoping to use genomics and approaches like synthetic biology to optimise microbiomes used in industrial biotechnology, such as anaerobic digestion to produce bioenergy.

Scientists and representatives from government and industry discuss opportunities and challenges for microbiome science at a workshop in London.

Microbiologists are investigating largely unexplored microbiomes in oceans and other environments for useful microbes and microbial genes that could be used for industry, medicine and bioremediation of pollution, and to better understand the impact of climate change.

Building the scientific evidence base will be key to future translation of microbiome research. In health, more research is needed on links between the microbiome and different diseases, using data gathered from much larger numbers of people, both to assess if changes in the microbiome are a contributing cause and/or result of a disease, and to identify underlying biological mechanisms. Such knowledge will be vital to identify targets for new therapies and reliable biomarkers for diagnostics.

Scientists and other stakeholders we consulted highlighted the need for researchers to work with industry, funders, learned societies and other stakeholders to develop research skills, infrastructures and capabilities to address microbiome knowledge gaps and opportunities. One need identified was addressing skills gaps such as in bioinformatics and microbiology. Increasing support for interdisciplinary research collaborations and knowledge exchange at local, national and international level was another.

Decision-makers and scientists increasingly recognise the need for a 'One Health' approach spanning health, agri-food and the environment to tackle challenges such as antimicrobial resistance. The interface between these areas perhaps presents some of the most exciting opportunities for future innovation, such as enhancing knowledge of microbiomes from farm to fork to our guts to improve nutrition, health and food safety and quality.

Improving sharing and access to data and resources will also be vital to ensure researchers can access well-maintained and accurate datasets and biobanks. A positive example highlighted to us was the Medical Research Council's Cloud Infrastructure for Microbial Bioinformatics (MRC CLIMB), providing free microbial informatics storage and analysis tools for UK microbiologists.

Similarly, developing best practices and standards to minimise variability between sampling, analysis and data collection techniques is seen as essential for progressing microbiome research, enabling high-quality, reproducible and comparative research across the community.

Our increasing knowledge of microbiomes could have significant impacts and implications for society. Scientists need to work with policy-makers, educators, journalists and the public to ensure that the potential of this emerging science and innovation is communicated accurately, people are enabled to make informed decisions about medical interventions and products, and scientists are always regarded as a trusted source of information. At the launch of our report, it was interesting to hear from researchers at the University of Oxford who have been engaging members of the public in microbiome research and exploring issues social science can help address.

Importantly, we want to see action on some of the recommendations we have made. In 2018 we will be working with our community and other stakeholders to help address some of the opportunities and challenges they have identified and would welcome hearing from anyone with an interest microbiome science and microbiology more generally.

The Society's *Unlocking the Microbiome* report and related policy briefings are available at: www.microbiologysociety.org/microbiome.

A YEAR TO INSPIRE THE ENGINEERS OF TOMORROW

Government and industry are joining forces in 2018 to tackle the engineering skills gap – and MPs can play a vital role in bringing the profession to life for young people across the UK.

Jo Parry, Head of Year of Engineering Communications

Transport Secretary Chris Grayling, Education Minister Anne Milton and HMG Envoy for the Year of Engineering Stephen Metcalfe MP meet engineering apprentices at the Skills Show in Birmingham.

Engineering is an integral part of all our lives, from the warmth and light in our homes, to how we work, travel and keep in touch. With investment in major infrastructure, medical and environmental challenges to solve, and ground-breaking new technology, the vital role engineering plays in industry and society is here to stay.

Against this backdrop, the opportunities in engineering for today's young people are vast. The profession offers not only a secure and well-paid career but – perhaps more importantly for those considering their next move – the chance to be creative, innovative and to shape the future of the world around them.

But outdated perceptions about jobs in the profession, and who these jobs are for, means that the UK faces a major shortage of engineers – and a challenge in encouraging young people to consider engineering careers.

Research from Engineering UK has found that only one in three parents knows what people in engineering do, and in 2017 it was estimated that the industry would need 186,000 skilled recruits each year to 2024. Ensuring we have the right skills to build a thriving economy is at the heart of the Government's Industrial Strategy – and engineering makes a major contribution to the UK economy, accounting for 26% of our GDP.

Tackling this skills gap also means addressing the profession's poor record on

Launching the campaign at an engineering workshop at Sharples School in Bolton with HMG Envoy for the Year of Engineering Stephen Metcalfe MP and Remap, a charity that uses engineering to help people with disabilities.

diversity – the engineering workforce is 91% male and 94% white.

To begin the task of closing this gap and widening the pool of young people who consider engineering careers, government has joined forces with more than 1,000 industry partners to make 2018 the Year of Engineering. The campaign aims to transform perceptions of engineering and give young people across the UK a million direct and inspiring experiences of the profession – whether that's through the chance to meet an engineer at their school, a behind the scenes tour or an interactive workshop or challenge.

Throughout the year, the campaign is highlighting the role that engineering plays in everything from sport and special effects to social care, with inspiring activities being delivered by partners including Airbus, BAE Systems, the BBC, Ocado, Usborne, Siemens and Shell.

In November, former Chair of the Science and Technology Committee Stephen Metcalfe MP was appointed HM Government Envoy for the Year of Engineering. He explains why MPs have a crucial role to play in ensuring schools, colleges and businesses across the UK seize the opportunity to inspire the next generation of engineers.

"The value of engineering skills is frequently underestimated, outdated perceptions of the profession are still widespread, and the industry continues to suffer from a lack of diversity in its workforce.

The Year of Engineering aims to tackle these challenges, so it's vital that the campaign is championed across government, parliament and industry.

We know how much enthusiasm there is in all parts of the profession to encourage engineers of the future. We want this campaign to unite those ambitions, and pledges of support from my fellow MPs will be vital in helping to drive this across the country."

At an event in Parliament last December more than 30 MPs committed to supporting the campaign in their constituencies. Pledges included connecting schools with local employers and encouraging businesses to take part in open doors events for schools and families.

MPs have been fulfilling this commitment across the UK, from Fareham MP Suella Fernandez meeting engineering apprentices to Banbury MP Victoria Prentice working with local schools to highlight engineering courses available at nearby colleges. Wiltshire MP Michelle Donelan organised an engineering festival which brought 3,000 schoolchildren face to face with local employers.

By championing engineering role models and bringing young people face to face with engineering opportunities, we can send a clear message that engineering careers are a chance for all young people, regardless of gender, ethnicity or social background, to have a real impact on the lives of those around them.

To find out more about the Year of Engineering, including resources for partners and supporters, visit the website. You can also follow the campaign on Twitter and Instagram.

Schoolchildren meeting engineers at an Inspiring the Future event organised by Year of Engineering partner Education and Employers

Transport Minister Jesse Norman with members of the First Lego League at the Parliamentary Launch of the Year of Engineering

TACKLING THE SKILLS GAP – HOW MPS CAN SUPPORT THE YEAR OF ENGINEERING

- Contact engineering employers in your constituency to find out how you can support their involvement in the campaign.
- Connect schools with local businesses, colleges and universities which could provide inspiring speakers or activities for their students.
- Organise an event to celebrate engineering achievements and opportunities in your constituency.
- Engage with local media to raise awareness of the campaign and help transform perceptions of engineering among parents and teachers.
- Share your support on social media, using the hashtags #YoE and #inspireanengineer

For more information and advice on how you can support the campaign, please contact the team via yearofengineering@dft.gsi.gov.uk.

VOICE OF THE FUTURE 2018

Students and young scientists put MPs and Ministers in the hot seat at this year's Voice of the Future on Tuesday 13th March in the House of Commons. It was a select committee with a difference: a role reversal. Its 'Members' were scientists and engineers and most of its 'witnesses' were MPs.

Newly-appointed science minister Sam Gyimah MP and a range of other political figures were quizzed on topics as diverse as fake news, artificial intelligence (AI), plastic waste, gene-editing, self-driving vehicles and mental health in academia, as part of the annual Voice of the Future event which is organised by the Royal Society of Biology on behalf of the science and engineering community (www.rsb.org.uk/VOF).

Welcome: Rt Hon John Bercow MP

The event gives students and early-career scientists, representing over a dozen science organisations and several schools, the chance to scrutinise politicians and their advisors in a House of Commons committee room.

Gyimah, who was recently appointed Minister for Universities, Science, Research and Innovation in January, took a range of challenging questions on the underrepresentation of women in science and, of course, how the government would ensure Brexit did not have a negative effect on UK science.

In response he set out a number of measures that the government had announced to help EU citizens get visas to study and work here, and said the government would take advice from the Independent Advisory Committee on Migration to further mitigate against a potential drain of non-UK talent.

"Our success in science is in part predicated on having the best minds collaborate and work together. We are under no illusions that to retain our world-leading position in research and innovation we need the best minds to come here, freely."

Later, Gyimah ruled out regulation targeted specifically at gene-edited crops, and said that the Government's ambition to raise science spending to 2.4% of GDP by 2027 would be "a game-changer" that attracts more people to science.

Chi Onwurah MP, Shadow Minister for Industrial Strategy, Science & Innovation, said the Labour Party would raise spending on science to 3% of GDP and would have immediately guaranteed the rights of EU citizens post-referendum in order to help keep close ties with the EU.

She also commented that the lack of security in academic careers was part of the wider problem of a lack of workers' rights in the UK and that the area is a priority for Labour campaigns.

Further panel debates involved members of the Science and Technology Select Committee and the director of the Government Office for Science, Dr Rupert Lewis, who explained how the Government receives and acts on scientific advice.

As well as immigration, diversity was a recurring theme among the young and early career scientists' questions, with many asking what the government is doing to support scientific careers for women and those from BME and lower socioeconomic communities.

The two schools involved – Queens Park Community School and Wallington High Schools for Girls – said their A level science students had found the experience hugely valuable as


Panel 1: Sam Gyimah MP, Minister of State for Universities, Science, Research and Innovation


Panel 2: Chi Onwurah MP, Shadow Minister for Business, Energy and Industrial Strategy

did all those older scientists and engineers drawn from the UK's leading scientific organisations including the Royal Society, the Royal Academy of Engineering, the Royal Society of Biology, the Institute of Physics, the Council for the Mathematical Sciences, the Royal Society of Chemistry, the Open University and many more.

Broadcast live on Parliament.TV, this year's Voice of the Future discussion generated enough interest online that once again the event's hashtag, #VOF2018, was trending locally on Twitter.

Panel 3: Science & Technology Select Committee colleagues: Stephen Metcalfe MP, Carol Monaghan MP, Martin Whitfield MP

Panel 4: Dr Rupert Lewis, Director, Government Office for Science

RADIOTHERAPY - CANCER TREATMENT OF THE FUTURE

As the science of radiotherapy advances, how can we keep patient quality of life at the heart of the service?

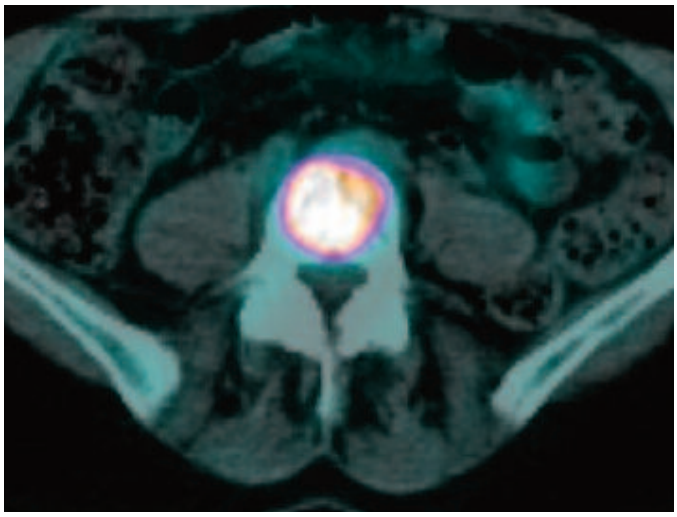
Dr Alexandra Stewart
Chair British Institute of Radiology External Affairs Committee
Clinical Lead for Oncology,
Royal Surrey County Hospital

Professor Andy Beavis
Past Chair British Institute of Radiology Radiation Physics and Dosimetry Special Interest Group
Head of Radiation Physics/Consultant
Queen's Centre for Oncology and Haematology
Castle Hill Hospital, Hull

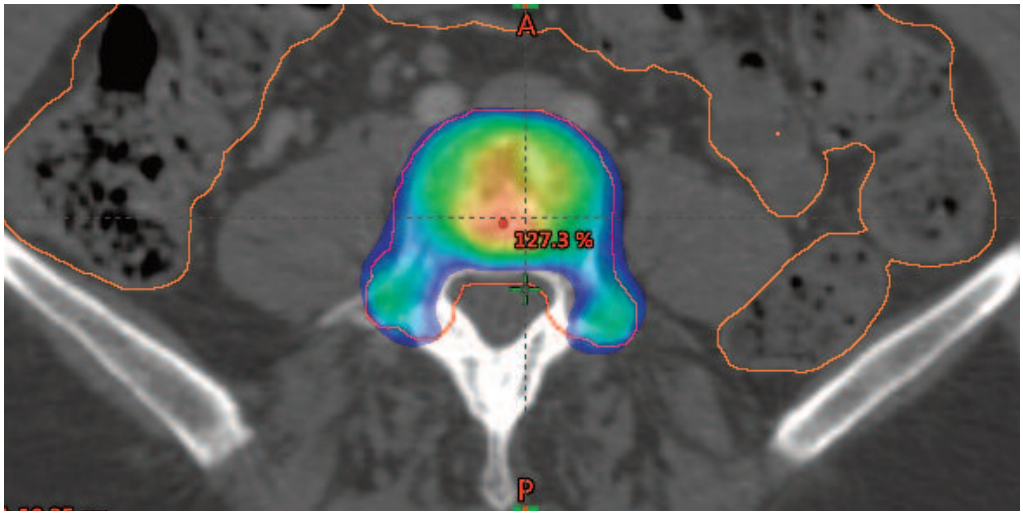
Previously in *Science in Parliament* the authors introduced radiotherapy, from its initial inception to state of the art developments[1]. Radiotherapy is the treatment of solid cancers with radiation. Given its utilisation of technology and the rapid pace of development, radiotherapy delivery is subject to constant evolution. Since the previous article, cancer treatment has gone through marked changes in England. We present the developments and some of the accompanying challenges.

To recap, intensity modulated radiotherapy (IMRT) is an advanced radiotherapy technique which allows an increased dose to be delivered to a cancer and surrounding areas at risk whilst decreasing doses delivered to surrounding normal tissues.

IMRT can be 'forward planned' or 'inverse planned'. Forward planning uses modifications to standard treatment fields to define, rapidly a radiotherapy dose distribution but in a more sophisticated manner. Inverse planning utilises more algorithm



Fused axial PET CT image showing a focus of cancer within the spinal column



Radiotherapy plan showing a stereotactic radiotherapy field highly conformed to the spine with minimal dose to surrounding normal tissues (normal bowel outlined with thin orange line, radiotherapy target of vertebral body outlined with thin red line, colourwash demonstrates where radiotherapy dose will be delivered.)

based planning using a longer, more complex technique to sculpt the radiation dose and further improve dose delivery.

Treatments are planned, delivered and verified using an array of medical imaging modalities and equipment in order to ensure accuracy and precision. Contemporary techniques are referred to as Image Guided IMRT or IG-IMRT. Stereotactic radiotherapy takes the IMRT and delivers a highly focused dose in a small number of treatments.

THE STATE OF THE NATION – IMRT.

The Radiotherapy Innovation Fund[2] (RIF) in 2012/13 aimed to bring the percentage of patients treated with advanced radiotherapy techniques with curative intent to a minimum of 24% in each centre. This aspirational level arose from a 2009 National Radiotherapy Implementation Group publication that gave guidance on the number of patients likely to benefit from IMRT. It stated that 24% of patients should receive 'inverse planned IMRT', with the maximum benefit of the available planning/treatment and delivery design technology. A further 9% (breast treatments) should receive 'forward planned IMRT' where benefits are still delivered but realised with 'cheaper resources'.

During 2011/2012 the average level of IMRT across England was reported as 6.8%, almost doubling by August 2012 to 13.6%, with large disparity between centres. By April 2013 the immediate impact of RIF was seen in an increase of average IMRT use to 22.3%. From the Radiotherapy Data Set information (available via the CancerStats website) use of IMRT almost doubled again to 42.1% by March 2017 and data at the time of writing suggests this level is sustained. The data set shows that out of 54 English NHS departments only 2 do not achieve the 24% level, however we believe this is due to regional arrangements meaning that patients requiring IMRT are treated at the 'hub' centre with 'simpler' radiotherapy delivered at smaller local centres. 35 centres reported more than 40% usage and 5 more than 50%.

The actual use of inverse planned IMRT is potentially even higher than the statistics suggest given that centres are discouraged from coding breast treatments as planned and delivered using 'inverse planning'. Whereas the more expensive technology may not be considered necessary for these treatments, the planning process can be more efficient and may utilise staffing resources to best effect.

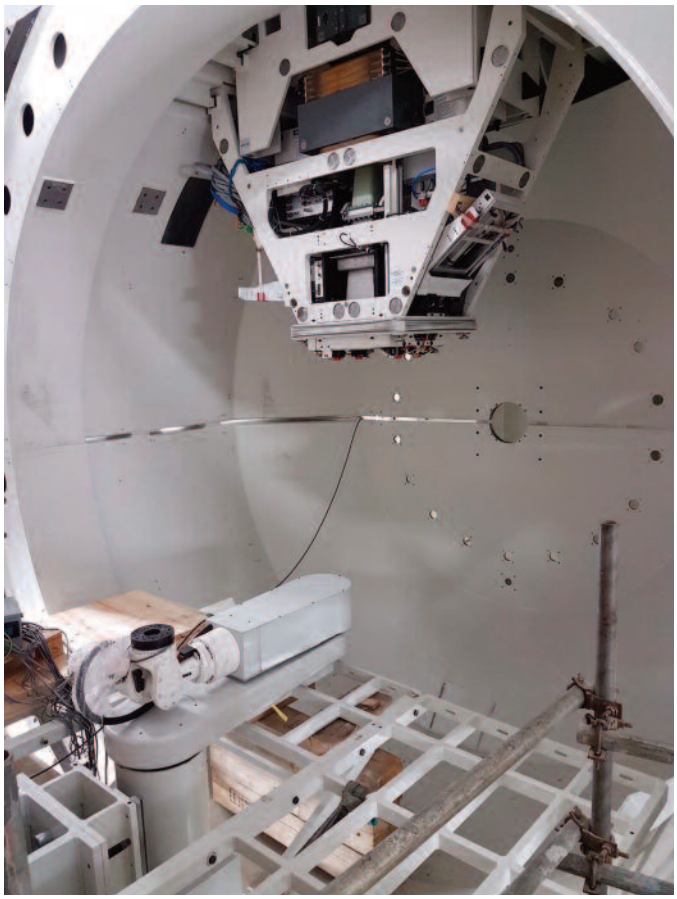
THE STATE OF THE NATION – PROTON CENTRES

Conventional radiotherapy is delivered using X-rays. Protons are heavy nuclear particles which can deliver radiotherapy treatment but have a more defined range of delivery so do not travel as far past the target area as X-rays do. This offers further advantages to add to the arsenal in the war on cancer; however, equipment and facilities are typically significantly more expensive than those for X-ray radiotherapy. Whereas IMRT is arguably the ultimate X-ray radiotherapy approach, proton radiotherapy can further reduce the risk of side effects. This feature is particularly useful in the treatment of children who will enjoy, hopefully, a long life post radiotherapy, the quality of which could be reduced by any side effects. Since 2008 a proton service, via an overseas referral programme, has been available for NHS patients. However, patients have to travel long distances and stay away from home for long periods, often with accompanying family members.

In 2012, Department of Health approval was given for two national proton centres to be developed. Treasury approval was given in 2015 for two facilities to be built at a cost of £250 million in Manchester (Christie) and London (UCLH). These projects are progressing well. The Manchester centre has had the key equipment installed and is set for first clinical treatments by the end of summer 2018 with a view to be running at full capacity by 2020.

The London centre is expected to be treating patients by the middle of 2020. The NHS-supported national centres will be commissioned to treat 1500 patients a year against an agreed referral guideline of treatments that deliver tangible benefit over that expected from conventional or IMRT radiotherapy. Private providers are also building proton radiotherapy centres in the UK and at this time three are under construction with others having been announced.

The picture (top right next page) shows a comparison of an X-ray IMRT delivery on the left and a Proton delivery on the right. The overlaid colours represent the delivered radiation dose. The underlying grey is the Computerised Tomography (CT) image representing the patient's brain and eyes. Both treatments are designed to treat the cancer that is present in the area coloured in red/yellow (high dose). The low dose areas are coloured blue and the grey areas are receiving extremely low radiation dose levels. Clearly the Proton plan gives much less dose to the brain and in the case of a child will reduce



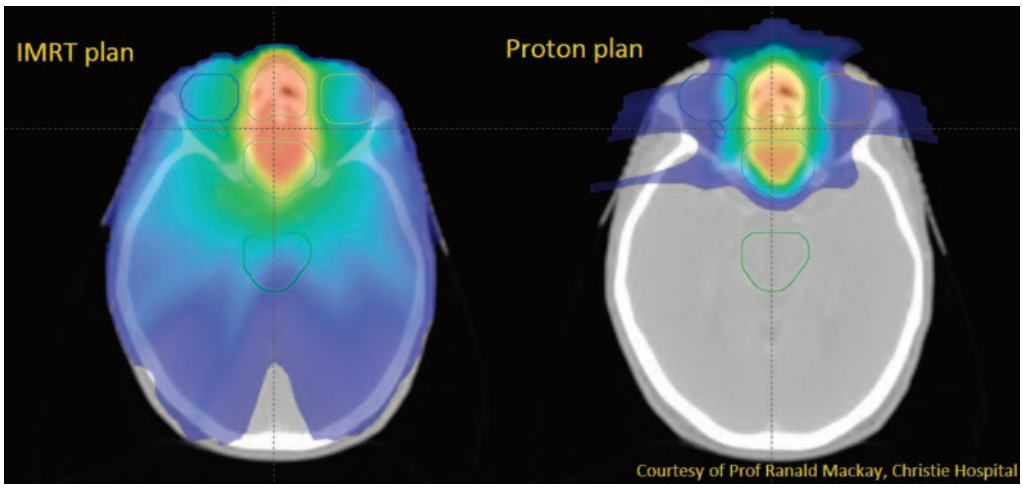
One of the treatment gantries under installation at the Christie Proton facility in Manchester (picture courtesy of Prof Ranald Mackay.)

the risk of developmental issues as the child grows into adulthood.

THE CHALLENGES

Whereas technical radiotherapy skills and experience are developing in the large majority of centres, one of the remaining limiting factors is the dearth of trained clinicians (Clinical Oncologists). One view, as radiotherapy becomes more complex, is to centralise specialist services to better utilise the staffing resources available. On the positive side this concentrates expertise in a small number of centres and maintains quality by ensuring high patient numbers, it also decreases costs associated with expensive machinery. However, it can result in patients having to travel long distances for treatment, often in patients who were selected for radiotherapy because they were frail or unfit. Recently a superior and more expensive stereotactic radiotherapy service for lung patients was commissioned in a small number of centres. This meant that patients were asked to travel away from local centres many of which had the equipment and capability to provide the cheaper treatment. Experience indicated that some refused this superior treatment as they did not wish to or were not fit to travel long distances. It could be argued that stereotactic radiotherapy is just a complex form of IMRT that centres delivering IMRT are capable of learning. Decreasing the number of centres delivering it just disadvantages patients and delays the development of specialised radiotherapy nationally. The number of centres commissioned to provide the stereotactic service has now been increased.

An alternative view is that networking of centres to create regional collaboration could provide or share clinical and technical leadership to reduce 'postcode lottery' or the need for patients to travel long distances each day. This approach is currently being promoted as a way to modernise the national radiotherapy service. To facilitate effective networking of expertise and clinical governance better IT networking throughout the regions is needed and the senior leadership from each centre will be required to spend time meeting with peers in the other departments. Ideally, this would be supported by appropriate funding to backfill the loss of clinical time; however given the overall economic challenges this is not currently under consideration.



Comparison of an X-ray IMRT plan and a proton plan for the same patient.

THE CHALLENGE OF RADIOTHERAPY

As we are keeping more patients alive for longer using advanced radiotherapy techniques we must place increased focus on survivorship. It is not enough to deliver curative treatment; we must also examine the impacts of that treatment on a patient's ability to work, have a family and maintain a quality of life. We must ensure that treatment options are offered to a patient that take into account long-term function as well as chance of cure.

For example, a form of highly localised radiotherapy in low bowel cancer called the Papillon technique can be used to avoid a lifelong colostomy bag in suitable patients. This comes at the cost of a slightly higher local recurrence rate but with overall survival rates appearing to equal that of surgery even in those who experience local tumour regrowth. Many patients will accept that higher risk of regrowth and choose this approach to try to improve their long-term quality of life. Many surgeons would rather offer the treatment with the highest chances of cure but the paternalistic era of medicine has passed and patients are now becoming increasingly informed about their treatment choices and assessing their own choice of risk and benefit. We have to be able to find ways to deliver the information to our patients that helps them make these choices and ways to collect outcomes from patients based not only on cure or relapse but also on the impact of treatment on life.

In conclusion we are moving towards a more modern and safer radiotherapy service in the UK with enthusiasm to embrace technology and improve cancer outcomes. The impact of technology development on the costs of treatment in individual centres cannot be under-estimated but it is important not to centralise specialised services to such an extent that patients do not choose the optimal radiotherapy technique because of logistical reasons. As we develop radiotherapy services we must keep the patient at the heart of our decision making and ensure that focus is maintained on the patient's life after treatment and not just curing the cancer.

References:

1. Stewart A, Beavis A. Radiotherapy-The state of the nation. *Science in Parliament*. 2014;71(4):18-19.
2. The Radiotherapy Innovation Fund. An evaluation of the Prime Minister's £23 million Fund. https://www.cancerresearchuk.org/sites/default/files/policy-radiotherapy-innovation-fund.pdf

HOUSE OF COMMONS LIBRARY

The Science and Environment Section (SES) is one of eight teams in the Research Service in the House of Commons Library. The Library provides confidential, impartial and bespoke briefing to Members of the House of Commons and their offices on a daily basis supporting the full range of parliamentary work, from policy development to constituency issues. We also produce a series of briefing papers on topical issues, published on the internet and available in hard copy around the Parliamentary Estate.

The Library continues to produce material around the debate on Brexit. For example we have produced briefings on the Withdrawal Bill and issues that have arisen as it has progressed through Parliament. In the last few months we have also published briefings on specific issues such as Brexit and the Environment, Brexit: UK Agriculture Policy and Euratom.

We have also published, and continue to update, briefings on issues such as the Nuclear Safeguards Bill, Energy Price Cap Bill, Organ Donation Bill (a Private Member's Bill), Animal Sentience, Air Quality and Brexit and Medicines. Over the rest of the session you can watch out for our briefings on future Bills on Agriculture and Fisheries, as well as more work in the coming months on a range of topical issues such as Electricity Grids, Tidal Lagoons, Obesity, Microplastics and Bees.

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PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

NEWS FROM POST

The POST team has seen a number of changes this spring: Acting Director Dr Chandrika Nath has been appointed Director of the Scientific Committee on Antarctic Research and will be leaving POST in May. Communications Manager Naomi Stewart left in January to become a Communications Officer at London School of Hygiene and Tropical Medicine and Lef Apostolakis, a freelance science writer, has been appointed as a replacement. Dr Lorna Christie was appointed as a Physical Sciences Adviser in POST in January.

Representatives from the House of Commons are still being appointed to the POST Board. In the interim, we continue to be represented by our acting chair Adam Afriyie MP, with the support of the vice-chair Lord Winston and members from the House of Lords, alongside external members.

At the January POST Board meeting topics chosen for future publication were:

- Reducing antibiotic use in UK agriculture
- Small modular nuclear reactors
- Biometrics
- Approaches to dealing with stalking and harassment
- Developing non-academic skills for the future labour market

BRIEFINGS

The following briefings have been published since mid-November:

Decarbonising the Gas Network
November 2017 POSTnote 565

The burning of natural gas for heating contributes 14% of the UK's greenhouse gas (GHG) emissions. Decarbonising, or reducing the carbon content of the UK gas supply is one option for reducing the emissions from heating. This POSTnote looks at the contribution that two alternative gases, hydrogen and biomethane, could make in achieving this goal.

Environmental Earth Observation
November 2017 POSTnote 566

Earth observation (EO) is the process of gathering information about the Earth from a range of sensors to provide monitoring data at a range of scales. This POSTnote outlines some of the environmental uses and benefits of EO data, the potential opportunities from advances in relevant technologies and challenges facing the effective use of EO data.

Regulating Advanced Therapies
November 2017 POSTnote 567

Advanced Therapy Medicinal Products (ATMPs) are complex biological medicines which promise to transform the treatment of many diseases. There is debate as to how the development of

ATMPs is affected by various factors including EU regulation and affordability. This POSTnote discusses ATMP development and regulation, and how this might change after Brexit.

Science Diplomacy
January 2018 POSTnote 568

Science diplomacy refers both to the role scientific research activities can play in fostering positive international relations and to the use of diplomacy to support international science. It can be used in many ways, for example to promote national interests, address cross-border issues or tackle global challenges. This note outlines how science diplomacy is interpreted, the institutions and mechanisms through which it is conducted and current efforts to understand how it works. The note also considers the role science diplomacy could play post-Brexit as the UK maintains relationships with the EU while cultivating new ones further afield.

Overseas Electricity Interconnection
January 2018 POSTnote 569

Electricity markets in the UK, Ireland and continental Europe are physically linked by 'interconnector' cables. These benefit energy system operators and consumers by reducing prices. They can also help integrate renewable electricity and ensure security of supply. This note discusses these benefits, proposals for future increases in interconnection and the potential effects of Brexit.

Parental Alcohol Misuse and Children
February 2018 POSTnote 570

Multiple studies on parental alcohol misuse show it has significant negative effects on children's physical and mental well-being. Such effects can be experienced over the short- and long-term, and can continue throughout life.

This POSTnote outlines what is known about the prevalence of PAM in the UK, and reviews evidence about its effects. It also describes services available for affected children.

The Ageing Process and Health
February 2018 POSTnote 571

Biological ageing results from the accumulation of damage within cells, leading to a loss of function and, ultimately, cell death. The underlying mechanisms of ageing are also risk factors in the onset of frailty, disability and long-term diseases. This POST note examines the biological basis of ageing, the potential to manipulate the ageing process and to use such knowledge to promote better health later in life.

UK Fisheries Management
February 2018 POSTnote 572

Following EU withdrawal the UK will have full responsibility for fisheries policy and management within its waters. This POSTnote summarises the science used to inform management, current approaches to EU fisheries, and challenges and opportunities for future UK fisheries management

EVENTS

In February, POST hosted an event, chaired by Holly Lynch MP, which brought together leading academics and industry stakeholders to discuss the science used in underpinning fisheries management and the opportunities and challenges ahead for fisheries management in the UK. We also held a meeting that brought together representatives from the Higher Education Funding Council, Chairs of the four main subject panels for the next REF exercise and senior staff from across Parliament to inform the assessment framework for the next REF exercise – REF2021 – and ensure that parliamentary understandings and experience of impact feeds into next REF assessment exercise.

In March, POST's social science advisers held a one-day training programme at Nottingham Trent University aimed at academics and relevant staff from universities that have been shown to engage less with Parliament.

HOUSE OF COMMONS SELECT COMMITTEES APRIL 2018

Details of Committees and Inquiries with relevance to Parliamentary and Scientific Committee Members are shown below. Further details of membership of House of Commons Select Committees and their inquiries can be found at http://www.parliament.uk/business/committees/

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.

The BEIS Committee is chaired by Rachel Reeves MP.

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

RELEVANT INQUIRIES:

Clean Growth Strategy – Inquiry announced 27 November 2017

The Clean Growth Strategy, published in October 2017, outlines how the Government expects the UK to meet its target of cutting emissions by 80% by 2050, while talks at COP23 in Germany were aimed at clarifying issues around the Paris Agreement which commits countries to the goal of limiting the global rise in temperature by 1.5ºC. MPs are likely to question the Minister on Government support for renewable energy, as well as how the UK will meet its emission reduction target. The Committee is also expected to ask about progress made in implementing the Paris

Agreement and the UK's role in UN climate change negotiations post-Brexit. Oral evidence is currently ongoing.

Electric vehicles: developing the market and infrastructure - Inquiry announced 21 September 2017

Inquiry into electric vehicles, the challenges they represent for the energy infrastructure and the actions needed to support the development of this market. This inquiry builds on the written evidence received for the former BEIS Committee's inquiry Electric Vehicles: Developing the Market, which was interrupted by the General Election. This new inquiry brings an added focus to the challenges electric vehicles create for the electricity grid and energy infrastructure and builds on the previous Electric Vehicles: Developing the Market inquiry.

Brexit and the implications for UK business - Inquiry announced 19 September 2017

Inquiry into the effects of leaving the EU on British business composed of five sub-inquiries. The Committee aims to establish how the interests of different sectors should best be pursued both in the negotiating process and post-Brexit and attempts to examine a range of issues relating to market access, non-tariff barriers, regulation, skills, R&D, trade opportunities and transitional arrangements. Sub-inquiries are considering the following sectors:

- Civil Nuclear
- Automotive
- Aerospace
- Processed food and drink
- Pharmaceuticals

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 is an investigative Committee rather than a legislative Committee: it sets its own programme and chooses subjects for inquiries.

The Committee's Chair is Rt Hon. Robert Halfon MP.

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

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 Committee chooses its own subjects of inquiry on environmental, agricultural subjects.

Following the 2017 General Election, Neil Parish MP was re-elected as Chair of the EFRA Committee.

Contact: Environment, Food and Rural Affairs Select Committee House of Commons, London, SW1A 0AA Telephone: 020 7219 7341 Email: efracom@parliament.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. Unlike most select committees, the Committee's remit cuts across government rather than focuses on the work of a particular department.

The Chair of the Environmental Audit Select Committee is Mary Creagh MP.

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

RELEVANT INQUIRIES:

25-Year Environment Plan – Inquiry announced 31 January 2018

The Government published its long-awaited 25-Year Plan for the Environment on 11 January 2018. The Committee's inquiry will examine key decisions around the Plan's overall ambition and approach. The Committee are currently accepting written submissions

The Changing Artic – Inquiry announced 7 March 2018

The Environmental Audit Committee has launched an inquiry into the rapid changes in the Arctic. The Arctic is undergoing profound changes as a result of climate change. It is warming almost twice as fast as the global average. Recent research also suggests microplastic and plastic pollution is an increasing problem. This inquiry will assess the Government's Arctic policy, and whether the UK, as one of the Arctic's nearest neighbours, should be doing more to protect this vulnerable region. The deadline for written submissions is 16 May 2018.

Nitrates - Inquiry announced 08 December 2017

Environmental Audit Committee is calling for evidence on the scale of the nitrate pollution in the UK and the solutions the UK government should implement. The Committee is currently accepting written evidence.

The Future of Chemicals Regulation after the EU Referendum - Inquiry announced 29 September 2017

Environmental Audit Committee is seeking views on the Government's response to the former Committee's report on The Future of Chemicals Regulation after the EU Referendum and the section on chemicals in the Delegated Powers Memorandum

UK progress on reducing F-Gas emissions - Inquiry announced 13 October 2017

Environmental Audit Committee inquiry into the UK's progress on reducing fluorinated gas (F-gas) emissions and the impact leaving the EU will have on progress and reporting on reducing these harmful greenhouse gases in the future

EXITING THE EUROPEAN UNION COMMITTEE

The Exiting the European Union Committee is appointed by the House of Commons to examine the expenditure, administration and

policy of the Department for Exiting the European Union and matters falling within the responsibilities of associated public bodies.

Following nominations and elections among MPs, Hilary Benn was re-elected Chair of the committee for the 2017 Parliament.

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.

Dr Sarah Wollaston has been re-elected as Chair of the Health Committee for the 2017 Parliament.

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

RELEVANT INQUIRY:

Brexit – medicines, medical devices and substances of human origin - Inquiry announced 21 September 2017

Health Committee inquiry into arrangements post-Brexit to guarantee supply of medicines, devices, and products. The report for this Inquiry has been published and the Committee is awaiting the Government's response.

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 "semiautonomous 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.

Norman Lamb MP was elected as Chair of the Science and Technology Committee on 12 July 2017.

Contact: Science and Technology Committee House of Commons, London SW1A 0AA Telephone: 020 7219 2793 Fax: 020 7219 0896 Email: scitechcom@parliament.uk

RELEVANT INQUIRIES:

Energy Drinks – Inquiry announced 8 March 2018

The Science and Technology Committee has launched an inquiry into the consumption of energy drinks. A study conducted by the Centre for Translational Research in Public Health has found that young people in the UK consume more energy drinks than those in other European countries, with consumption in the UK increasing by 185% between 2006 and 2015. A report by the European Food Safety Authority found that 68% of those aged 10-18, and 18% of those aged 3-10, were consumers of energy drinks. Deadline for written submissions is 8 April 2018.

Flu Vaccination Programme - Inquiry announced 1 March 2018

The Science and Technology Committee has examined the planning for the flu vaccination programme, how advice is formulated, and cost-effectiveness issues are addressed, the reasons for different types of vaccines for different groups of the population, the effectiveness and take-up of the vaccination programme, and any plans for adjustments for the next flu season in terms of the vaccines uses and groups targeted.

Impact of social media and screen-use on young people's health - Inquiry launched 21 February 2018

The Science and Technology Committee has launched an inquiry into the impact of social media and screen-use on young people's health. The Committee is welcoming the perspectives and experiences, and details of any initiatives taken, by children, schools and youth organisations. Deadline for submissions 6 April 2018.

Quantum technologies – Inquiry announced 8 February 2018

Quantum technologies have been selected by the Government as one of fourteen 'core industrial challenges' to be tackled through its Industrial Strategy Challenge Fund. The Industrial Strategy itself announced that the quantum technology sector will be allocated £20m of 'pioneer funding' and be the subject of a minister-led review. This follows the establishment of the National Quantum Technologies Programme in 2013, and a Government Office for Science report on quantum technologies in 2016. This inquiry will address the opportunities and challenges for quantum technologies. The deadline for submissions in 29 March 2018.

Biometric Strategy and Forensic Services inquiry – Inquiry announced 6 February 2018

The Committee held a session to hear from the Forensic Science Regulator on developments since the Government's 2016 Forensics Strategy was published, progress on issues raised by the previous Committee's report on that document, and recent developments in the forensics market. The Committee also discussed with the minister the reasons for the delay in producing a Biometrics Strategy, as well as use and retention issues for different types of biometrics, including facial image technology.

Brexit science and innovation Summit – Inquiry announced 4 January 2018

The Science and Technology Committee hosted a Brexit and science summit in February 2018, to identify actions needed now to mitigate risks and exploit opportunities for UK science, research and innovation after Brexit. A report has now been published and can be found on the Committee's webpage. The Committee aims to present the results to Government at the start of phase-II of the Brexit negotiations with the EU.

E-cigarettes – Inquiry announced 25 October 2017

The Science and Technology Committee examine the impact of electronic cigarettes on human health (including their effectiveness as a stop-smoking tool), the suitability of regulations guiding their use, and the financial implications of a growing market on both business and the NHS. The Committee is accepting written evidence to this inquiry.

Evidence-based early-years intervention – Inquiry announced 26 October 2017

The Science and Technology Committee examine the strength of the evidence linking adverse childhood experiences with long-term negative outcomes, the evidence base for related interventions, whether evidence is being used effectively in policy-making, and the support and oversight for research into this area. The Committee is accepting written evidence to this inquiry.

Research integrity – Inquiry announced 13 September 2017

This inquiry looks at trends and developments in fraud, misconduct and mistakes in research and the publication of research results. Research by Parliamentary Office of Science and Technology indicates the trend in misconduct/mistakes in publishing is still upwards. There has also been a so-called 'crisis in reproducibility' of research.

The Committee continues the previous Committee's inquiry, taking forward the evidence it had received before the General Election. The deadline for written submissions has now passed. If you would like to send a late submission please contact the Committee Staff.

Genomics and genome editing in the NHS – Inquiry announced 14 September 2017

Science and Technology Committee inquiry into the mainstreaming of genomic medicine in the NHS. This inquiry examines the Chief Medical Officer's (Dame Sally Davies) call in her latest annual report, 'Generation Genome', for mainstreaming genomic medicine in the NHS within 5 years.

The Committee has invite evidence to include observations on how any barriers to greater integration of genomic therapies in the NHS could be overcome, and how such barriers may differ across the devolved nations. In doing so, the Committee will take forward the interim report from the previous Committee on Genomics and gene-editing and the evidence it had received before the General Election. The deadline for written submissions has now passed. If you would like to send a late submission please contact the Committee Staff.

Algorithms in decision-making –
Inquiry announced 14 September 2017

This inquiry examines the increasing use of algorithms in public and business decision making. It assesses how algorithms are formulated, the scope for error or correction and the impact they may have individuals — and their ability to understand or challenge that decision.

The Committee continues the previous Committee's inquiry, taking forward the evidence it received previously. The deadline for written submissions has now passed. If you would like to send a late submission please contact the Committee Staff.

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.

Lilian Greenwood MP was elected as Chair of the Transport Committee on 12 July 2017.

Contact: Transport Committee, House of Commons, London SW1A 0AA Telephone: 020 7219 3266 Email: transcom@parliament.uk Twitter: @CommonsTrans

JOINT INQUIRY

Improving air quality – Inquiry announced 09 October 2017

The Environment Food and Rural Affairs, Environment Audit, Health and Transport Select Committees are running an inquiry into the health and environmental impacts of air pollution.

MPs from these four select committees have combined forces to relaunch an unprecedented joint inquiry on air quality to scrutinise cross-government plans to tackle pollution hotspots. The report has now been published and can be found on the Committee's websites.

HOUSE OF LORDS SELECT COMMITTEES APRIL 2018

This article provides details of House of Lords Select Committees and their inquiries with relevance to the interests of the Parliamentary and Scientific Committee.

ARTIFICAL INTELLIGENCE COMMITTEE

The Select Committee on Artificial Intelligence was appointed on 29 June 2017 to consider the economic, ethical and social implications of advances in artificial intelligence, and to make recommendations. The Committee was established following the recommendation of the Liaison Committee. Oral evidence to this Inquiry has now concluded and the report is in preparation.

The Committee is Chaired by Lord Clement-Jones.

Contact: Select Committee on Artificial Intelligence, House of Lords, London. SW1A 0PW Telephone: 020 7219 4384 Fax: 020 7219 4931 Email: HLAIAdHoc@parliament.uk

EU ENERGY AND ENVIRONMENT SUB-COMMITTEE

The EU Energy and Environment Sub-committee is a sub-committee of the EU Committee. The Sub-Committee focuses on a range of policy areas related to agriculture, fisheries, environment and energy. Attention is given to agricultural issues, particularly legislation relating to the Common Agricultural Policy (CAP) and animal health and welfare issues. The Common Fisheries Policy (CFP) and wider environmental issues are also examined, as are policies relating to energy and climate change.

The Committee is Chaired by Lord Teverson.

Brexit: plant and animal biosecurity – Inquiry announced 16 March 2018

The EU Energy and Environment Sub-Committee is exploring the impact Brexit could have on the UK's biosecurity in terms of animal and plant health, food safety and invasive species. The Committee is currently accepting written submissions to this inquiry

Brexit: energy security – Inquiry launched 11 July 2017

The EU Energy and Environment Sub-Committee has conducted a short inquiry to examine the implications of Brexit for energy security in the UK. The inquiry aims to highlight the issues the Government will need to consider when developing a new energy relationship with the EU. The report was published on 29 January 2018. The Committee is now awaiting the Government Response and debate.

Contact: EU Energy and Environment Sub-Committee, House of Lords, London SW1A 0PW Telephone: 0207 219 3015, Fax: 0207 219 6715

SCIENCE AND TECHNOLOGY 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 Chair of the Committee is Lord Patel.

Life Sciences and the Industrial Strategy – Inquiry announced 21 July 2017

The Government set out in its Industrial Strategy Green Paper its intention to create a new Life Sciences strategy to make the UK the best place in the world to invest in life sciences. To tackle challenges like cancer and dementia it is important that the UK has a strong life sciences sector. But the sector faces a number of challenges and opportunities, including Brexit and making innovative new treatments available on the NHS.

This inquiry is investigating issues such as whether the Government has the necessary structures in place to support the life sciences sector; how the NHS can use procurement to stimulate innovation in the life sciences; and the content of the new Life Sciences industrial strategy. Oral evidence for this inquiry has concluded and the report is in preparation.

Contact: Science and Technology Select Committee, Committee Office, House of Lords, London SW1A 0PW Telephone: 020 7219 5750 Fax: 020 7219 4931 Email: hlscience@parliament.uk

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

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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.

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Website: www.amps-tradeunion.com

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

We 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.

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AWE plays a crucial role in our nation's defence by providing and maintaining warheads for the UK's nuclear deterrent and delivers advice and guidance on a 24/7 basis to UK government in the area of national security.

We are a centre of scientific, engineering and technological excellence, with some of the most advanced research, design and production facilities in the world. AWE is contracted to the Ministry of Defence (MOD) through a Government-owned-contractor-operated (GOCO) arrangement. While our sites and facilities remain in government ownership, their management, day-to-day operations and maintenance of Britain's nuclear stockpile is contracted to a private company: AWE Management Limited (AWE ML). AWE ML is a consortium comprising three partners: Jacobs Engineering Group, the Lockheed Martin Corporation and Serco Group plc.

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The Biochemical Society works to promote the molecular biosciences; facilitating the sharing of expertise, supporting the advancement of biochemistry and molecular biology and raising awareness of their importance in addressing societal grand challenges. We achieve our mission by :

- bringing together molecular bioscientists;
- supporting the next generation of biochemists;
- promoting and sharing knowledge and
- promoting the importance of our discipline.

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British Antarctic Survey (BAS), an institute of NERC, delivers and enables world-leading interdisciplinary research in the Polar Regions. Its skilled science and support staff based in Cambridge, Antarctica and the Arctic, work together to deliver research that uses the Polar Regions to advance our understanding of Earth as a sustainable planet. Through its extensive logistic capability and know-how BAS facilitates access for the British and international science community to the UK polar research operation. Numerous national and international collaborations, combined with an excellent infrastructure help sustain a world leading position for the UK in Antarctic affairs. For more information visit www.bas.ac.uk @basnews

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The British Ecological Society is an independent, authoritative learned society, and the voice of the UK's ecological community. Working with our members we gather and communicate the best available ecological evidence to inform decision making. We offer a source of unbiased, objective ecological knowledge, and promote an evidence-informed approach to finding the right solutions to environmental questions.

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.

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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

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www.bsac.org.uk | www.antibiotic-action.com
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

UNIVERSITY OF CAMBRIDGE

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

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

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

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

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

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

Chartered Institute of Ergonomics & Human Factors

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Ergonomics, also called Human Factors, sometimes abbreviated 'E/HF' is a science-based discipline about 'designing for people'. E/HF takes into account the physical and mental capabilities, aptitudes and abilities of people acting individually (a pilot, a surgeon or nurse, train driver) or collectively, with or without equipment (a theatre team, air traffic control) in the design of workplaces, equipment and ways of working to deliver the least harmful, safest, most efficient, most elegant possible outcomes'. E/HF uses science to improve the places in which we work, live and relax and the ways in which we interact with people, equipment and systems.

The Cosmetic Toiletry & Perfumery Association | ctpa

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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

Daphne Jackson Trust

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Founded in 1992 in memory of the UK's first female Professor of Physics, the Trust is the UK's leading charity dedicated to realising the potential of scientists and engineers returning to research after career breaks for family, caring and health reasons. Our Fellowship programme, working in partnership with universities, research councils, charities, learned societies and industry, enables individuals to undertake part-time research in universities and research institutes. Fellowships comprise a research project alongside an individually tailored retraining programme, with additional mentoring and support, enabling recipients to re-establish scientific credentials, update skills and redevelop confidence, in a suitably supportive environment.

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

First

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FirstGroup are the leading transport operator in the UK and North America and each day, every one of our 110,000 employees works hard to deliver vitally important services for our passengers. During the last year around 2.2 billion passengers relied on us to get to work, to school or college, to visit family and friends, and much more.

GAMBICA Association Ltd

GAMBICA
AUTOMATION INSTRUMENTATION & CONTROL LABORATORY TECHNOLOGY

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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

serving science, profession & 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.

IBMS Institute of Biomedical Science

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Advancing knowledge and setting standards in biomedical science

With over 20,000 members in over 30 countries, the Institute of Biomedical Science is the leading professional body for biomedical scientists, support staff and students.

For over 100 years we have been dedicated to the promotion, development and delivery of excellence in biomedical science within all aspects of healthcare, and providing the highest standards of service to patients and the public.By supporting our members in their practice of biomedical science we set quality standards for the profession through: training, education, assessments, examinations and continuous professional development.

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.

IKE Institute of Innovation & Knowledge Exchange

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IKE is the UK's professional body for innovators. It accredits and certificates innovation practices. We influence the inter-relationship between education, business, and government through research and collaborative networks. Our Innovation Manifesto highlights our commitment to support the development of innovative people and organisations. IKE runs think-tanks, conducts research, develops new business models and tools and supports organisations to benchmark their innovation capabilities.

Institute of Marine Engineering, Science and Technology (IMarEST)

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

The Institute of Materials Finishing

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The Institute of Materials Finishing is the premier technical organisation representing industry, academia and individual professionals in both the UK's and global surface engineering and materials finishing sector.
We actively promote continual education and knowledge dissemination by providing both distance learning and tutored training courses, as well as a technical support service. We also provide bespoke courses that are tailored to an employer's specific needs. The Institute also publishes *Transactions of the Institute of Materials Finishing* and a bimonthly newsletter (*IMFormation*), as well as holding regular regional and international technical meetings, symposia and conferences.

Institute of Measurement and Control

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Reg Charity number: 269815

The Institute of Measurement and Control is a professional engineering institution and learned society dedicated to the science and application of measurement and control technology for the public benefit. The InstMC has a comprehensive range of membership grades for individuals engaged in both technical and non-technical occupations. Also, it is licensed by the Engineering Council to assess and register individuals as Chartered Engineers (CEng), Incorporated Engineers (IEng) and Engineering Technicians (EngTech).

The InstMC works to develop the knowledge and skills of individual engineers, fostering communication and advancing the science and practices within the industry.

IOP Institute of Physics

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The Institute of Physics is a leading scientific membership society working to advance physics for the benefit of all. We have a worldwide membership from enthusiastic amateurs to those at the top of their fields in academia, business, education and government. Our purpose is to gather, inspire, guide, represent and celebrate all who share a passion for physics. And, in our role as a charity, we're here to ensure that physics delivers on its exceptional potential to benefit society.

Alongside professional support for our members, we engage with policymakers and the public to increase awareness and understanding of the value that physics holds for all of us. Our subsidiary company, IOP Publishing, is a world leader in scientific communications, publishing journals, ebooks, magazines and websites globally.

IPEM Institute of Physics and Engineering in Medicine

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IPEM is a registered, incorporated charity for the advancement, in the public interest, of physics and engineering applied to medicine and biology. 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 Advancing Chemical Engineering Worldwide

The Institution of Chemical Engineers

With over 44,000 members in 120 countries, IChemE is the global membership organisation for chemical engineers. A not for profit organisation, we serve the public interest by building and sustaining an active professional community and promoting the development, understanding and application of chemical engineering worldwide.

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Institution of Civil Engineers

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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 product design. Charterships and other professional registrations available for engineers, product designers and environmentalists. Members of the IED include experts on a wide range of all engineering and product design disciplines, all of whom practice, manage or educate in design.

IET

The Institution of Engineering and Technology

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The IET is a world leading professional organisation, sharing and advancing knowledge to promote science, engineering and technology across the world. Dating back to 1871, the IET has 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

London School of Hygiene & Tropical Medicine

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The London School of Hygiene & Tropical Medicine is a world-leading centre for research and postgraduate education in public and global health, with over 4,000 students and more than 1,000 staff working in over 100 countries across the world. Our depth and breadth of expertise encompasses many disciplines, and we are one of the highest-rated research institutions in the UK.

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

The Marine Biological Association
Est. 1884
Incorporated by Royal Charter 2013

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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.

SCIENCE DIRECTORY

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.

NPL National Physical Laboratory

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

NATURAL HISTORY MUSEUM

Advancing the science of nature

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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

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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

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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.

QUADRUM INSTITUTE

Quadram Institute
Science • Health • Food • Innovation

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Opening fully in mid-2018, the Quadram Institute will be an interdisciplinary research centre capitalising on the academic excellence and clinical expertise of the Norwich Research Park. Its mission is to understand how food and the gut microbiota link to the promotion of health and preventing diet and age related diseases. The Quadram Institute brings together fundamental and translational science with a clinical research facility for human trials and one of Europe's largest gastrointestinal endoscopy units. This will synergise interactions between basic and clinical research, delivering a step change in the understanding of the role of food in health.

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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.

Kew
ROYAL BOTANIC GARDENS

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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.

Ri The Royal Institution
Science Lives Here

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

THE ROYAL SOCIETY

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The Royal Society is the academy of science in the UK and the Commonwealth comprising 1400 outstanding individuals representing the sciences, engineering and medicine. The Society has played a part in some of the most fundamental, significant and life-changing discoveries in scientific history and Royal Society scientists continue to make outstanding contributions to science across the wide breadth of research areas. 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, supporting excellence in science and encouraging the development and use of science for the benefit of humanity.

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.

sfam society for applied microbiology

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*Sf*AM 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, *Sf*AM publishes five internationally acclaimed journals. Value for money and a modern, innovative and progressive outlook are its core principles. A friendly society, *Sf*AM values integrity, honesty, and respect, and seeks to promote excellence and professionalism and to inspire young microbiologists.

Society for Underwater Technology

SUT 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.

Society of Chemical Industry

SCI: where science meets business

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Established by Royal Charter in 1881, SCI is a unique multi-disciplinary community. Set up by a prominent group of forward thinking scientists, inventors and entrepreneurs, SCI continues to be a multi-science and industry network based around chemistry and related sciences. Our charitable objective is to promote links between science and industry for the benefit of society. Our passion is invention and creation.

We deliver our charitable objective by:

- Supporting the commercial application of science into industry
- Tackling global challenges across Agrifood, Energy, Environment, Health and Materials

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 (SMI) 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 and gas, maritime security and safety, marine science and technology, maritime autonomous systems and marine renewable energy.

UK Innovation & Science Seed Fund

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The **UK Innovation & Science Seed Fund** is a leading patient capital investor with more than £330 million private investment leveraged to date. The Fund works to build technology companies from the earliest stage by working closely with its partners led by STFC, BBSRC, NERC and Dstl, with the National Research and Innovation Campuses they support, and with entrepreneurial science-led teams. UK Innovation & Science Seed Fund is also closely aligned with the Catapults and InnovateUK, helping to commercialise key technological advances in industrial biotech, agricultural technology, healthcare, medicine, clean energy, materials, artificial intelligence, software and space.

Understanding Animal Research

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Understanding Animal Research is a not-for-profit organisation that explains why animals are used in medical, veterinary, environmental and other scientific research. We aim to achieve a broad understanding of the humane use of animals in medical, veterinary, scientific and environmental research in the UK. We work closely with policymakers to ensure regulation is effective and are a trusted source of information for the national and international media. We are funded by our members who include universities, professional societies, trade unions, industry and charities.

University of Essex

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Established in 1964, the University of Essex is ranked as one of the Top 20 universities in the Research Excellence Framework and is awarded Gold in the Teaching Excellence Framework. It is home to world-leading expertise in analytics and data science, with research peaks spanning the social sciences, sciences, and humanities. Pioneers of quantitative methods and artificial intelligence techniques, Essex is also in the UK top 10 for Knowledge Transfer Partnerships, and works with businesses to embed innovation into operations, through KTPs, knowledge exchange and contract research.

Universities Federation for Animal Welfare

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Website: www.ufaw.org.uk
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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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Monday 23 April 5:30pm
Discussion Meeting in partnership with Natural and Environment Research Council
Into the deep – discovering our oceans
Boothroyd Room, Portcullis House

ROYAL SOCIETY OF BIOLOGY

25 April 2018 19:00-22:00 | Royal Society of Biology Accreditation Award Ceremony

Terrace Pavilion, House of Commons, Houses of Parliament SW1A 0AA

26 June 2018 10:00-12:30
Parliamentary Links Day
The Attlee Suite, Portcullis House, Houses of Parliament, London SW1A 2LW

10 October
Biology Week Reception
Churchill Room, House of Commons, Houses of Parliament SW1A 0AA

5 December
Christmas Parliamentary Reception
Churchill Room, House of Commons, Houses of Parliament SW1A 0AA

Please contact Karen Patel and Stephen Benn 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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Natural History Museum London

National Space Centre Leicester

Oxford University Museum of Natural History Oxford

The Observatory Science Centre Herstmonceux

Thinktank Birmingham

W5 Belfast

Meet-the-expert sessions, hands-on activities, experiments and public shows

operationearth.co.uk

NERC science and researchers local to each centre are involved. You can speak to the people working on environmental science in your local area on topics such as clean air, zero plastic waste and polar science.

NERC SCIENCE OF THE ENVIRONMENT

Rt Hon Norman Lamb MP and Stephen Metcalfe MP

Carol Monaghan MP and Chi Onwurah MP

invite you to attend

Parliamentary Links Day 2018

Tuesday 26 June 2018 10:00 - 12:30

The Attlee Suite, Portcullis House, Houses of Parliament, London SW1A 2LW

RSVP to: **www.rsb.org.uk/linksday**

BRITISH PHARMACOLOGICAL SOCIETY

ROYAL SOCIETY OF CHEMISTRY

Royal Society of Biology

The Council for the Mathematical Sciences

SEB SOCIETY FOR EXPERIMENTAL BIOLOGY

BIOCHEMICAL SOCIETY

The Geological Society

100 YEARS the geneticssociety 1919 - 2019

RSE The Royal Society of Edinburgh KNOWLEDGE MADE USEFUL

BRITISH ECOLOGICAL SOCIETY

The Physiological Society

IOP Institute of Physics

THE NUTRITION SOCIETY Advancing Nutritional Science

sfam society for applied microbiology