

Parliamentary and Scientific Committee

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Stephen Metcalfe MP, Chairman, Parliamentary and Scientific Committee

Welcome to the Spring 2019 edition of Science in Parliament.

As you will see from the contents section below, this edition contains a bumper crop of interesting articles; ranging from research on lunar rocks, quantum technologies, polar science, novel vaccine technology, marine microbiology. These show why UK researchers and their endeavours are so highly regarded internationally.

Ian Taylor, one of my outstanding predecessors as Chairman of the Parliamentary and Scientific Committee, writes about the vitally important topic of how to convert this world class research into outstanding innovation. This is not easy, but UK must do better if it is to remain globally competitive. Keeping up with international competition, so we remain world- leading in the research that will drive future innovation, is why there is cross party support to increasing overall R&D expenditure to at least 2.4% of GDP, whether it is done in universities, research institutes or by business. The steps to deliver this are described in another article based on a report by AIRTO launched at a Parliamentary reception in January.

A Parliamentary event by POST and the British Antarctic Survey also provides the basis for two articles on science diplomacy. These show how science can be used to establish and maintain better international relations in a troubled world. That event featured Sir David Attenborough, an ambassador for science par excellence. Another article describes how we are developing international partnerships that will help ensure UK scientists continue to play an important part in tackling major global challenges.

Of course, the dominating political issue continues to be BREXIT. In March 2017, when I also chaired the House of Commons Select Committee on Science and Technology, I produced a briefing paper on Science Priorities for BREXIT. http://www.sciencein parliament.org.uk/wp-content/ uploads/ 2012/09/Science Priorities-for-Brexit-Final.pdf This was prescient.

Although terms of Withdrawal and an outline of the Future Relationship were agreed in November between the UK Government and the EU Council of Ministers and the Commission, and these would maintain much continuity in the relationship with EU over research, other completely different aspects of 'the deal' are causing well-known difficulties. Writing this piece at the end of February, it is impossible to know exactly how this will end, but whatever happens, Science will still be one of the most important endeavours we can undertake and the P&SC will continue to push the Government to ensure its interests are strongly represented.

I remain grateful to Dr William Duncan and all the P&SC staff for their continued support for the Committee and the guidance that they provide in a somewhat turbulent world!



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:

- 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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# DIAMOND SHINES ITS LIGHT ON MOON ROCKS FROM APOLLO MISSIONS



Lorna Campbell Communications Consultant Diamond Light Source Harwell Science & Innovation Campus, Didcot

#### Nearly 50 years after our first steps on the Moon, rock samples from the Apollo missions still have a lot to tell us about lunar formation, and Earth's volcanoes.

An international collaboration involving scientists in Tenerife, the US and the UK, are using Diamond, the UK's national synchrotron light source, to investigate Moon rocks recovered during the Apollo Missions in a brand new way.

Nearly 50 years after the first humans landed on the Moon, there is still a lot we don't know about how the Moon formed, and the nature of lunar volcanic activity. We know that, on Earth, volcanic eruptions can be triggered (or ended) by changes in magma (molten rock) in or beneath the planet's crust. The cause of these changes is often thought to be a result of the mixing of different batches of magma in the 'plumbing system' below the volcanoes.

Volcanologists are working on detecting and understanding these changes, by examining volcanic rock samples, with the aim of being able to accurately forecast future eruptions.

"Using a new imaging technique developed at Diamond, we can apply the same techniques to lunar rock samples which will provide new insights into how the Moon was formed, and its volcanic history." explains Dr Matt Pankhurst of Instituto Volcanológico de Canarias and NASA lunar principal investigator.

Dr. Pankhurst continues; "We are using a new imaging

technique developed at Diamond to carry out 3D mapping of olivine – a common green mineral found in the Earth's sub-surface and in these Moon rock samples. These maps will be used to improve understanding of the Moon's ancient volcanic systems, and help to understand active geological processes here on Earth. With this new technique, our team may be able to recover from these Moon rock samples information such as what the patterns of magma flow within

mineral as the magma cools. Accurate 3D images of the iron distribution within olivine in the Moon rock samples will 'unlock' information about the volcanic processes in which they formed.

On Earth, scientists study the inner workings of volcanoes by analysing the minerals contained in the fine-grained rock that is formed from the rapid cooling of magnesium-rich and iron-rich lava; basalt. More than 90 percent of all volcanic rock on Earth is basalt.



Dr Matt Pankhurst Lunar PI with one of the moon rock samples from the Apollo 12 & 15 missions at Diamond Light Source

the volcanic system were, what the magma storage duration was like, and potentially even identify eruption triggers."

In magma, the ratio of iron to magnesium in olivine changes over timeframes ranging from hours to months, and these changes are 'locked in' to the So when early astronomers looked at the Moon, they mistakenly thought that the darker areas they could see were seas, and named them Mare, the Latin for sea. However, we now know that the 16% of the lunar surface which is covered in this dark material, is basalt, a volcanic rock. Before the Apollo missions, we believed that these areas meant that they were young rocks, but when the rock samples were brought back from the Moon, they were shown to be ancient. In fact, the youngest volcanic Moon rock sample is nearly 3 billion years old.

However, age alone was not going to provide an understanding of the Moon's primordial volcanic systems. So,



Dr Hongchang Wang, Dr Matt Pankhurst, Dr Ryan Zeigler and the team at Diamond studied moon rock samples like these for their olivine content at Diamond

in addition to rock dating, the researchers wanted to use the novel X-ray speckle imaging technique developed at Diamond Light Source.

Olivine in magma is mainly made up of magnesium and iron and as the magma cools, the ratio of these two elements changes over timeframes ranging from hours to months. These changes are 'locked in' to the mineral but using the technique to shine X-rays on the common green mineral – olivine – found in the Moon rock samples this information is 'unlocked'. High quality 3D images are produced and then data is analysed and mapped using state-of-the art diffusion modelling to reveal the history of individual crystals of olivine. This enables the researchers to study



Image Courtesy of Nasa Image Library

the moon rocks in more detail than has ever been possible before.

This new research is a longtime coming, because although NASA has had the rocks for nearly half a century now, preserving them has taken priority over analysing them with techniques usually reserved for Earth rocks; that are not only more plentiful, but are a lot easier to reach. These Moon rock samples on the other hand are so precious they are normally kept in a clean environment in a special building called the Lunar Sample Laboratory Facility at the agency's Johnson Space Center (JSC) in Houston and do not often see the light of day.

Nonetheless, NASA has approved the use of 18 lunar samples to be analysed at the synchrotron facility in the UK, the results of which will not only help reveal the history of the Moon, but can also help to understand active geological processes here on Earth.

The team have examined samples from the Apollo 12 and 15 missions, using an advanced X-ray speckle imaging technique developed on Beamline B16 at Diamond Light Source. As Dr. Hongchang Wang, Senior Optics Scientist, explains: "Combined with the recently developed fast fly-scan tomography and novel white beam camera, the X-ray speckle imaging technique has allowed us to swiftly and effectively collect 3D information of olivine inside the lunar rock in much more detail than ever before." This new technique does not damage the lunar samples.

NASA has approved the use of 18 lunar samples for these experiments, and similar, wellcharacterised terrestrial samples have also been scanned, and used to verify the chemical composition of olivine. Samples are loaned to scientists who wish to study them, a process overseen by NASA's Apollo sample curator, Ryan Zeigler. As a scientist who understands the trade-off between studying the samples and preserving them, he says that a balance must be struck in experiment design but adds these decisions are becoming easier as more powerful, non-destructive techniques are being developed



This photograph was taken during the Apollo 15 mission on the lunar surface. Astronaut David R. Scott waits in the Lunar Roving Vehicle (LRV) for astronaut James Irwin for the return trip to the Lunar Module, Falcon, with rocks and soil collected near the Hadley-Apernine landing site.

and used at Diamond. He comments:

"The researchers are now using state-of-the-art diffusion modelling to establish the history of individual crystals of olivine from 3D images. These techniques will be applied to the new data gathered during this beamtime. The results will add to our understanding of lunar and planetary formation, topics which have been continually debated since the samples were first returned to Earth."

Prof Andrew Harrison, CEO at Diamond Light Source concludes: "A successful demonstration of the new technique at B16 will pave the way, we hope, for extended collaboration with NASA and



Moon rock sample from Dr Ryan Zeigler of NASA, studied at Diamond's B16 Beamline

maybe No 10 Downing Street\* and the Natural History Museum might now be interested in loaning us their own samples of Moon rock ... Diamond has a huge amount of experience of investigating priceless heritage items, and gaining new insights from them. Using these techniques, we could study the UK's Moon rock samples in new ways, and these fresh images would give them more meaning and inspire the next generation of scientists and engineers."

\*The UK's Moon rock gift was presented to Prime Minister Harold Wilson by President Richard Nixon in 1970. It went on a tour of museums around the country, starting at the Science Museum in London, returning to Downing Street in 1973. In 1979 an aide to Margaret Thatcher revealed to her that the Moon rocks had been languishing in a cupboard for several years! Since then they have been on display in Downing Street and the Natural History Museum.

### WHO WERE THE ASTRONAUTS BEHIND THE MOON ROCK SAMPLES?



Image of sample collection from Apollo 12, the second manned lunar mission. Image Courtesy of Nasa Image Libr.

Everyone can name the first two people to step on the Moon, but the Moonwalkers from the later Apollo missions are less well known. During Apollo 12, Mission commander Charles "Pete" Conrad and Lunar Module Pilot Alan L. Bean collected 35kg of samples in an Image Courtesy of Nasa Image Library area of the Ocean of Storms

area of the Ocean of Storms (Oceanus Procellarum) that had previously been visited by several unmanned missions, and was therefore named Mare Cognitum (Known Sea). For Apollo 15, Commander David Scott and Lunar Module Pilot James Irwin spent three days near Hadley Rille, in an area of the Mare Imbrium called Palus Putredinus (Marsh of Decay). They used the first lunar rover to travel much further, and collected 77kg of samples.

These rock samples are so precious that they are kept in a special building, the Lunar Sample Laboratory Facility at NASA 's Johnson Space Center (JSC) in Houston. They have been housed in a clean environment for nearly 50 years. Not all Apollo samples are still in Houston, however. From the 48lbs (nearly 22kg) of rocks that Neil Armstrong and Buzz Aldrin brought back from their Apollo 11 Moon landing, plaques were prepared with four pieces weighing 50 milligrams. The White House presented these as goodwill gifts to the leaders of 135 countries, including the UK, the United Nations and all 50 American states.



Image Courtesy of Nasa Image Library

# THE UK IS ON THE PATH TO BECOMING A WORLD LEADER IN QUANTUM TECHNOLOGIES. WE NEED TO KEEP THE MOMENTUM



Dr Rhys Lewis, Quantum Metrology Institute Director, National Physical Laboratory\*

\*Rhys Lewis is Director of the Quantum Metrology Institute at The National Physical Laboratory, the UK's national measurement institute. He is responsible for NPL's strategic direction in quantum and for NPL involvement in the UK National Quantum Technologies Programme. The UK National Quantum Technologies Showcase held at the QEII centre, Westminster in November 2018 demonstrated just how far the UK has come since the launch of the UK National Quantum Technologies Programme five years ago.

The first Showcase in 2015 had 200 delegates and a handful of exhibitors. In 2018, there were 900 delegates and over 80 exhibitors, many with close-to-market technologies. Industry participation has grown considerably since 2014, outstripping original predictions. The government's Industrial Strategy Challenge Fund (ISCF) Pioneer quantum fund was oversubscribed earlier this year. The UK is now a serious player in the emerging global quantum industry.

The foresight of the government in 2013 to invest in quantum has given us a strong advantage. This foresight was not just to recognise the value of supporting quantum technology innovators in the UK, but of how to build the right links that would maximise the chance of their success. Doing so required a fine balance of interaction between government, industry and academia. Whilst businesses will ultimately commercialise quantum technologies, the science expertise that underpins them exists largely in national and university labs. The success of the programme so far has been in providing a strategic direction for this expertise, continually driving it towards commercial applications, and

supporting processes to develop commercial products – through collaborations, licensing and the formation of new companies. Wider coordination under strong executive leadership would further benefit the national programme in the future.

The National Quantum Technologies Programme is delivered principally through the EPSRC research council funding universities, and Innovate UK helping support businesses. Other partner organisations include Defence Science and Technology (Dstl), the National Cyber Security Centre (NCSC) and the National Physical Laboratory (NPL). The programme has been a great success so far, and funding has been secured for phase 2 starting in 2019 when the first programme ends. The recent report from the House of Commons Science and Technology Committee on quantum technologies supports a forward view of the programme and its organisation. Now is a good time to look at the achievements of the UK quantum industry, what has led to these successes, and what still needs to be done.



Single-electron current source mounted in high-frequency chip carrier

#### QUANTUM INNOVATIONS IN THE UK

Quantum technologies harness the surprising properties of single atoms, electrons and photons, and how they interact. The behaviour of quantum systems gives rise to many extraordinary properties which don't appear at a larger scale in everyday objects. Our growing ability to detect, measure and manipulate these properties is about to create a new wave of innovations.

The National Ouantum Technologies Programme includes the creation of four university-led hubs which broadly represent four areas of innovation: Sensors, Imaging, Communications and Information Technologies. Through these hubs, we have seen the emergence of many innovations at various stages of development, which will have a great impact on many industries, from computing and electronics, to oil and gas, to defence, to civil engineering.

In addition to the universitybased programmes, technology development is also happening in government laboratories, in particular at our own Quantum Metrology Institute of the National Physical Laboratory which houses over 100 quantum scientists working across the full range of quantum technologies.

An exciting area of sensor research at NPL's Quantum Metrology Institute is atomic magnetometers. We create clouds of atoms, and measure how changes in magnetism affect their quantum state – leaving a 'fingerprint 'on the atoms. A promising application is detecting corrosion in pipes and other metal materials, where the disruption to a metal's surface by the corrosion alters its magnetic pattern. The same concept could also be used to detect signs of heart and brain disease, and potentially in applications of navigation and communication. Development of some of these applications is also underway in university groups, for example at UCL, Nottingham, Birmingham, Strathclyde and Sussex.

Imaging and sensors have wide-ranging applications. Quantum technologies are being used to look beneath the earth's surface, with considerable interest from mining, oil and gas and subsea exploration. A



Optical reference cavity in mounted frame

collaboration between the Glasgow-led Quantic hub and Thales has developed a quantum camera that can see round corners. A laser beam is fired into a room and the backscattered light is detected at the lowest possible level, allowing detailed imaging of outof-sight people and objects. This could ultimately be used by firefighters and soldiers to detect if there is a person in a building before entering it. It is also a candidate technology for the remote detection of hazards for driverless cars.

Whereas sensing involves detecting the effects that physical processes have on a particle's quantum state; quantum communications involves deliberately manipulating the quantum state, sending it from a transmitter to a receiver and detecting any change at the other end. The quantum communications hub is led by York University with partners Bristol, Cambridge and others. NPL delivers testing capability and supports the development of standards. NCSC and NPL are working with the hub to develop assurance methods for quantum communications technologies.

Quantum key distribution (QKD) is one of the most commercially-advanced quantum communication technologies. It enables a secret key to be encoded into a series of photons, which can be used to encrypt and decrypt messages. Since observing a quantum system changes its state, any third party intercepting the photons, will change them. If the key arrives unchanged, parties can start sending encrypted messages with confidence that the code is secure. This could create an ultra-secure communications method.

superposition of these states, i.e. a mixture of both 1 and 0. This creates the potential for quantum computers to store orders of magnitude more information than in ordinary computers, and potentially to simplify the processing of what are now highly complex problems. The upshot will be unprecedented data processing speeds, which will be invaluable for R&D in pharma and chemical industries and many applications which require the manipulation of large amounts of data.

The growing interest in both QKD and quantum computing has spurred a raft of innovators and researchers in the UK creating new technologies capable of confining, manipulating, transmitting and detecting at the quantum scale.

#### WHY HAS IT WORKED

The success so far of The UK National Quantum Technologies Programme lies in how it has brought together industry and academia to progress key areas



#### Chip-scale ion microtrap

Many quantum systems rely on 'qubits', the quantum equivalent of bits which represent the 1s and 0s in digital communication. Qubits can exist in multiple states; for example a photon can be created in two different states which can represent either a 1 or a 0, or in a quantum of quantum technology. Each hub is led from a single University (Birmingham, Glasgow, Oxford, or York) but includes input from over 30 other universities as well as organisations like NPL, and includes active engagement with industry.

Quantum Computing is probably the furthest from commercialisation but potentially the most disruptive. The Networked Quantum Information Technologies Hub (NQIT) at Oxford is working towards a networked approach to quantum information processing. NQIT focus their development activities mainly on the ion trap, a system which can hold one or a small number of atomic gubits. Different ion trap designs are being developed for example at Oxford and Sussex universities and at NPL.

Also covered by NQIT is superconducting qubits, the main technology used in operating small-scale quantum computer demonstrators around the world which operate close to absolute zero in temperature. A recent NPL report (Opportunities for superconducting quantum technology in the UK) describes a strong UK capability in these technologies. The recently announced National Centre for Quantum Computing is likely initially to explore both hardware approaches as well as developing the necessary software to drive a quantum computer when one is available.

Other hubs are supporting development and commercialisation of quantum technologies in the short to medium term. The Ouantum Communications Hub, for example, is creating the UK's first quantum communications network, which will connect multi-node fibre networks in Bristol and Cambridge, and BT Labs near Ipswich. NPL is supporting this network by developing methods to test and demonstrate new quantum communications technologies such as QKD. The Quantum Sensors hub at Birmingham is developing sensors for gravity and working with potential end users in civil engineering. NPL is

developing new atomic clock technology which is being commercialised by UK industry. Many of these developments are being delivered with the support of Innovate UK and the Industrial Strategy Challenge Fund.

Through the National Programme, universities and national laboratories have established quantum labs to support development and testing of new innovations. NPL will soon open its Advanced Quantum Metrology Laboratory which will house state-of-the-art quantum measurement capabilities under highly controlled conditions, allowing industry and researchers to test and validate new quantum systems.

It is this combination of scientific expertise and technology development for controlling and detecting quantum states, an expanding commercial sector, and a growing infrastructure for test and validation, that has allowed the industry to progress rapidly in a way that is far greater than the sum of its parts.

#### WHERE DO WE GO FROM HERE?

The second phase of the National Quantum Technologies Programme was allocated £315m in the 2018 Budget. The details of the programme are being finalised but it will include continuation of the university programme with refreshed objectives, the establishment of a national centre for quantum computing, and an industry-led collaborative programme towards technology commercialisation.

In February 2018, Sir Mark Walport, Chief Executive of the UK Research and Innovation (UKRI), asked NPL to explore how to incentivise major companies to invest in Quantum Technologies. The resulting report identified the need to help different industries appreciate the game changing potential of Quantum Technologies to their business. In doing so, it recognised that they will only invest in new products when they identify "Proof of Value" rather than "Proof of Concept".

This is hard for all new industries, but quantum has a particular challenge. Quantum technologies are complex and there are significant perceived technical and market risks from customers. From the innovators NCSC, aims to deliver the test and validation capability required by industry to build confidence in these new technologies.

Finally, the issue of skills must be addressed more comprehensively to build the future workforce which industry will need. There are well-funded programmes to train new scientists and engineers to PhD level. What is needed in addition is training for apprenticeships, technicians, and practising operational teams already in industry.



Ultra-High –Q Whispering Gallery Microresonators

perspective, target markets are often poorly defined, and in some cases, technologies are so disruptive that new markets will need to be created before they see uptake.

We must therefore develop trustable standards, means of validation, and places to offer real-world demonstrations. This allows us to show both that new quantum technologies work, and that they deliver value over existing technologies for specific applications. It is not reasonable to expect buyers in IT, energy, or automotive manufacture to fully understand the complexities of applied quantum mechanics. Buyers need to see the new products working and have independent validation of their capabilities. NPL, working with other organisations such as

Also important in the longer term for quantum, as for many other industries, is that STEM skills are promoted in schools.

Quantum technologies are advancing at pace. But we still need to do more to clearly map out the potential to end-users of quantum technologies; and to increase the engagement between these end-users and innovators, researchers and government laboratories. This is essential to ensuring that emerging technologies meet their needs, and that they understand them well enough to deploy them in their organisations.

http://www.npl.co.uk/quantummetrology-institute/

# **CONVERTING WORLD-CLASS RESEARCH INTO OUTSTANDING INNOVATION**



Ian Taylor, Chair, UK Innovation and Science Seed Fund (UKI2S)

The UK is good at research, not so good at innovation. There is no doubt the UK is punching above its weight when it comes to scientific research. Even though the country is home to just one percent of the world's population, and receives just three percent of the global spend on research funding, we claim twelve percent of all citations and have sixteen percent of the most highly cited articles. Yet the UK's research output in terms of innovation figures are not really impressive.

As outlined by the Global Innovation Index, the UK's Innovation Efficiency Ratio (IER) in fact ranks at 21st out of 127 countries, only rising to 14th at its peak over the last five years. This suggests that there is a missing link between the awesome science and the discoveries being made in the UK and how we turn them into commercial opportunities for the benefit of our economy and society.

The Government's Industrial Strategy highlights the need to make the UK the "most innovative nation by 2030" and the Chancellor's Budget last autumn indicated £1.6 billion further investment in order to help boost innovation. All in order to meet the Government's four 'Grand Challenges': the growing need to harness our artificial intelligence and data capabilities; supporting cleaner growth; and preparing for the ageing population; as well as enabling people to move around more freely.

If we are to reach these goals

and prepare for these societal challenges and opportunities, it is important that the infrastructure is in place to turn scientific research into innovations with commercial value.

Improving the resource available in the UK for R&D is no doubt the first step in achieving greater innovation output. The Government is aiming to increase R&D investment to 2.4% GDP by 2027 (from the current 1.7%, less than half of which is currently government spend) and aspires to eventually rise to 3%. Reaching this target will require a disproportionate increase in private sector R&D. The UK needs to attract business investment to succeed.

That said, as the Minister of State for Universities, Science, Research and Innovation, Chris Skidmore MP, highlighted recently, OECD statistics suggest that for every pound put in from public R&D funding in the UK, the private sector funds approximately £2.60 . As the Minister goes onto say, this looks good when compared to countries like Germany and Finland, but when you consider other countries, like Canada, it become clear that more needs to be done to meet the target. We need to recognise the sheer volume of investment in the US where it is reported that more than a half-trillion dollars was spent on R&D in 2018, with government agencies spending \$144 billion and industry \$368 billion.

Gaining increased attention of international businesses should not be hard as long as there is an attractive inward investment climate (otherwise other countries will seize on opportunities to attract research). The UK has the highest proportion of international subsidiaries (11.7% of the total) of R&D intensive foreign multinationals.

Maintaining access to skills, as well as allowing for collaboration and the transfer for information across borders will be critical. As we are currently one of the largest

lan Taylor was an MP 1987-2010. He is a former Science Minister and an ex Chair of the Parliamentary & Scientific Committee recipients of research funding in the European Union, international and domestic businesses will be watching the impact of Brexit on science in the UK closely. For example, ensuring scientists based in the UK can continue to be part of the shared European research endeavour and have the best possible access to international funds and the collaborations they support will be important.

To invest, businesses need to be confident that they can find the right talent when required, including specialist R&D knowledge. It is clear that universities are an extremely important asset here, but so too is accessing our base of public sector research establishments (PSRE).

Supported by public investment from Government, the science and innovation campuses in the UK play a key role in the commercialisation of science. Hosting the perfect environment for organisations of all sizes to be part of everchanging communities of innovators, enjoying ready access to the latest expertise and equipment they need in order to succeed. There is a lot to gain from this base. In Germany, for example, there are four large, internationally renowned research institutions sitting outside of the university base - the Max Planck Society, Fraunhofer-Gesellschaft, Helmholtz Association and Leibniz Association. These, alongside smaller research institutions such as archives and specialist information centres contribute about € 12.5 billion annually to the country's R&D.

We have a similar network of institutions in the UK, in the

form of the Catapult Network. For this to lead to greater contributions to the UK economy, the publicly funded research needs to meet private sector R&D.

There are a variety of challenges that can get in the way of building this route towards innovation however. This investment is a high-risk venture, making it harder to secure private investment to get these projects off the ground. Particularly if the innovation is one that will disrupt a traditional market; meaning that there will be no similar companies or investments to compare the potential outcomes or returns.

In addition to this, the researchers behind new ideas may not be commercially minded or even supported with an experienced commercial team; making the investment appear to be an even higherrisk endeavour. Specialist mentoring is key in order to help fledgling companies to secure investment, and then grow and scale successfully.



Supported by the UK Innovation and Seed Fund (UKI2S) the PSREs have been able to use public spending to leverage further private investment, which will in turn accelerate the innovation process and establish a flourishing innovation infrastructure in the UK.

Once a company starts to scale, the UK can benefit from increased R&D investment, the retention of scientific expertise, the creation of high-value jobs across the country and the wider contribution of the company itself to the economy. Particularly as this research can go onto fulfil an unmet commercial need. As such, it is vital that we begin to close the gap.

UKI2S is focused on investing in the earliest, highest risk stages of innovative companies, emerging from the UK's publicly funded science base, the £27 million seed fund is provided by core public sector research partners from across the UK research councils and PSREs. Independent analysis shows that every £1 invested by UKI2S has yielded £6.6 gross added value. Its investments have led to £440 million of private sector investment, £150 million of exports, and the creation of more than 300 high-value tech jobs. It has also leveraged 30 times its investment from the private sector.

To date the Fund has invested approximately £14.4 million at a steady rate in over 50 start-up companies, validating the science, providing strategic advice and mentoring support in addition to patient equity capital. The focus of this work naturally aligns with Government ambitions to ensure innovation thrives in the UK, including the Industrial Strategy, and the companies in which we invest in can be tracked back to supporting the Four Grand Challenges that Government has set.

This is also helping to build up the profile of research emerging from the UK's public research campuses. All too often the focus can move towards Universities when some of the country's greatest discoveries, ripe for commercialisation come from places like the Defence Science and Technology Laboratory (DSTL) and the National Physical Laboratory (NPL).

The bridge between publicly funded research and the innovative commercial opportunities can be a risky one to cross, but it is none-theless critical, creating an extremely valuable path to gain from the UK's privileged access to world-leading research.

The effectiveness of research funding is being carefully considered by the House of Commons Science and Technology Select Committee (to which UKI2S submitted evidence). This must also be a priority area for Ministerial attention.

Only if we get this mix right can we ensure that the UK does not miss opportunities to retain and enhance its excellent science status, keeping top expertise here and creating high-value jobs for the UK economy. This innovation can also make waves into solving some of the world's greatest societal and economic challenges.

# DIPLOMACY MEETS SCIENCE AT POST'S ANNUAL RECEPTION



Dr Sarah Bunn Senior Scientific Adviser, Parliamentary Office of Science and Technology

Science diplomacy and polar science were the focus of the Parliamentary Office of Science and Technology's 2019 Annual Reception, held on 29 January in Parliament. In the first event during POST's 30th anniversary year, Parliamentarians and invited guests from academia, foreign Embassies, Government and scientific organisations attended a seminar discussing science diplomacy. This was followed by an exhibition of polar science with keynote addresses by Sir David Attenborough and Professor Dame Jane Francis, Director of the British Antarctic Survey.



Professor Dame Jane Francis (Director of the British Antarctic Survey) and Sir David Attenborough (Credit Jessica Taylor/UK Parliament)

#### SCIENCE DIPLOMACY AND SOFT POWER

Science has long been used as a tool to leverage soft power, with connections between researchers and policymakers a feature of the intersection between science, international relations and foreign policy for decades. Described more recently as *science diplomacy*, this is an emerging area in both research and policy worlds and was the subject of a briefing by POST published in 2018.<sup>1</sup> Science diplomacy refers both to the role that scientific research activities can play in fostering positive international relations and to the use of diplomacy to support international science. A distinguished international panel of speakers explored these themes in a lively discussion chaired by The Rt Hon the Baroness Anelay of St Johns.

**Professor Carole Mundell**, Chief Scientific Adviser at the Foreign and Commonwealth Office (FCO) described the UK's network of science attachés in

47 countries and highlighted recent work. In 2016, David Cameron and Argentinian President Mauricio Macri agreed to embark on a new chapter of relations – including a communiqué on science collaboration as a pillar for future activities, underpinned by a new FCO Science and Innovation post in Buenos Aires. In the Middle East, examining challenges on food and water security from a scientific perspective was a route through which to build relations in

challenging diplomatic spaces.

Carole highlighted key features through which science diplomacy operates, namely people and infrastructure. Some research – such as space science – requires significant infrastructure beyond the means of one nation, and strategic funding mechanisms can overcome geographical barriers and create a culture that facilitates collaboration.

#### "There are whole mechanisms of the science ecosystem, and there are tools that we can use to influence how and where and what those diplomatic borders are, depending on the outcomes that we want."

Reflecting on the critical role of complex international agreements and relationships, Carole highlighted how multilateral discussions in diplomatic spaces (such as G20 and UN meetings) are informed by science, and multilateral decisions subsequently underpin scientific work.

**Professor Nicole Grobert** (University of Oxford) shared her experiences of engaging in science policy, initially through establishing the Young Academy of Europe, to give younger researchers a voice in European science policy, and more recently as a member of the European Commission's Group of Chief Scientific Advisors (CSA). Nicole reflected on science as an international enterprise and how global challenges require scientists to collaborate. Within this, Nicole affirmed the importance of communication and listening as key skills.

Scientists share a language in that the laws of nature are fixed, and this common ground gives researchers a perfect tool with which to overcome borders, and from which they can work together to find solutions to global problems. From the

perspective of an academic running a busy research group, science diplomacy takes place every single day in the lab, to enable projects and via interactions between people from different cultural backgrounds. From her perspective as a CSA, Nicole explained their key task of providing scientific evidence to policy making – drawing on collaboration with numerous national science academies. Nicole explained that while the CSA group is not tasked with science diplomacy per se, Commissioner Carlos Moedas said in 2015:

"I believe science diplomacy is the torch that can light the way, Challenges' EU-wide study, which seeks to measure and define success in science diplomacy; with the aim of informing the development of training for diplomats. Staff based in Science Ministries who were placed in Embassies reported a lack of knowledge and experience in diplomacy, while career diplomats said that they were conscious that they lacked understanding of the scientific world.

#### Professor Klaus Dodds,

(Royal Holloway, University of London) recounted the importance of where science diplomacy takes place – research facilities and field sites – with illuminating examples from the archives; informal politically controversial that no amount of science diplomacy can save a particular country's commitment to agreements. Social science diplomatic initiatives are vulnerable to sudden cancellation because topics appear too sensitive.

Klaus outlined successes in polar science diplomacy. The UK must work collaboratively with Canada, Norway and Russia to carry out meaningful Arctic science. The NERC Arctic Office – working with the FCO Science and Innovation Network – has been very successful in working with international partners; most recently to facilitate reciprocal benefits for UK and Russian scientists.



#### Science Diplomacy Panel

where other kinds of politics and diplomacy have failed."

As an example of such recent collaborations, Nicole stated that the EC CSA group is working with Canada on microplastics and will attend a G7 meeting in Washington to discuss this.

Dr Tim Flink (Humboldt University, Berlin) reflected on his research examining science diplomacy and commented that discourse has tended to overstate what it can achieve. He highlighted different national approaches in using it as a soft power tool, how it operates in foreign ministries and the role for international science and technology agreements and funding programmes. Tim shared findings from the S4D4C 'Using Science for Diplomacy for Addressing Global

social spaces (notably bars, hot tubs, saunas) were important loci for dialogue between US and Soviet scientists in the 1970s. Klaus highlighted that the intersectional qualities of science diplomacy have in the past been dominated by men; shaping the where of science diplomacy. He went on to describe the who and what in science diplomacy, outlining the important role of early career researchers and science attachés, particularly in situations where international relations need to be restored. However the spectre of undiplomatic science looms personality clashes, visa obstacles, funding disputes, and frustration with access to labs and field sites (often resulting from wider political relations). Some topics can be so

Science diplomacy is applied in Antarctica to support geopolitical interests in the region, delivered through the activities of the British Antarctic Survey which works skilfully in British Antarctic Territory and beyond, with numerous international partners. The UK uses assets such as HMS Protector and the new polar vessel, the RRS Sir David Attenborough, to conduct mobile science diplomacy. The ship is an object of and for science diplomacy.

**Baroness Anelay** closed the session by highlighting the importance of trusted advice on science and invited speakers to reflect on the future. Summary points from the panel highlighted that while science diplomacy is a strong concept that brings people together, it is not a magic bullet and as a concept, needs refining. Academics are a trusted group in a position to give good advice, which can underpin policy development and shape diplomacy, but scientists and politicians need to find efficient ways to communicate with each other. The projection of shared values is particularly important, with work in the polar regions providing exemplars of success.

### A WARM WELCOME FOR POLAR SCIENCE

Adam Afriyie MP welcomed guests to the second part of the event, a reception on polar science, and introduced keynote speakers Sir David Attenborough and Professor Dame Jane Francis. Sir David recounted the history of scientific exploration in Antarctica, highlighting pioneering expeditions to this most hostile of environments by Cook, Scott and Shackleton. Cook's expedition of 1772 sought to answer the question of whether there was a great Southern Continent but came up against great walls of ice, concluding that there was probably land beyond. Bransfield and Smith first sighted land in 1820 and established the presence of a continent, but the first person to land on rock was Shackleton in 1907. Scott's subsequent expedition in 1912 had a scientific purpose, and although beaten to the South Pole by Amundsen, he collected geological specimens of huge scientific value. The later historic crossing of Antarctica in 1957 by Hillary and Fuchs (a member of the British Antarctic Survey), marked the beginning of international efforts to examine the geophysical characteristics of this vast land mass. Sir David went on to describe the development of international agreements to collaborate on scientific research in the region,

ultimately resulting in the Antarctic Treaty in 1959 to preserve the area as a natural reserve devoted to peace and science, remarking, "Would that there were international treaties like that elsewhere on this planet...sadly not so far."

Professor Dame Jane Francis shared news about the British Antarctic Survey's latest research, highlighted the challenges of working in this extraordinary environment, and the value of international collaboration. A pressing scientific question is whether ice shelves are melting due to climate change. Several projects are underway to find out, including one where a team of scientists and engineers have begun the incredibly complex coal, the atmospheric carbon dioxide in those bubbles was never higher than 300 parts per million (ppm), but since then, we have added an additional 109 ppm into the atmosphere.

A major study is the International Thwaites Glacier Collaboration, funded by the Natural Environment Research Council and the US National Science Foundation. Involving some of the most remote and complex fieldwork ever undertaken, scientists will investigate whether the Thwaites glacier may collapse in the future and how this will affect global sea-level rise. Other collaborations involve partners in Chile, Argentina, Australia, New Zealand and Korea. Looking

the legal aspects of the Treaty and environmental protection. Jane noted

"Fifity-three nations that sit round a table can agree to keep working together in this continent for peace and science. Let's hope the Antarctic Treaty continues to be as strong as it is at the moment."

James Gray MP, Chair of the APPG for the Polar Regions, opened the polar science exhibition, with guests exploring exhibition stands hosted by the British Antarctic Survey; the Natural Environment Research Council's Arctic Office; the Scientific Committee on Antarctic Research; the Centre for Polar Observation and



Left to Right: Dr Grant Hill-Cawthorne (Head of POST), Adam Afriyie MP, Baroness Anelay of St Johns. (Credit Lef Apostolakis POST/UK Parliament)

task of drilling two kilometres into the ice sheet in West Antarctica, in order to understand how the region will respond to a warming climate. Ice holds the history of previous climate, so BAS researchers seek to understand what happened in the past by examining samples of ancient ice. Scientists can analyse tiny bubbles of air trapped within the ice and measure the composition of the atmosphere as it was hundreds of thousands of years ago. For the last 800,000 years until the 1700s, when we started burning forward, Jane updated the audience on the RRS Sir David Attenborough, a state-of-the-art polar research ship commissioned by the Natural Environment Research Council and built by Cammell Laird.

Jane concluded by highlighting how BAS's research contributes to international policy development and is part of the UK's commitment to the Antarctic Treaty, which has its 60th anniversary this year. Fiftythree nations work in Antarctica, with annual meetings to discuss Modelling; the International Network for Terrestrial Research and Monitoring in the Arctic and the Siberian Environmental Change Network.

#### Reference

1 Dr Sarah Bunn & Emmeline Ledgerwood, Science Diplomacy, POSTnote 568, February 2018, Parliamentary Office of Science and Technology

POST looks forward to welcoming parliamentarians to future events, details of which are available on www.parliament.uk/post

# **'BREAKING THE ICE' –** DELIVERING SCIENCE DIPLOMACY IN AN ERA OF NEW TENSIONS



Henry Burgess, Head of the Natural Environment Research Council Arctic Office. ©Brendan O'Hara

The Arctic is special in many ways, not least in its wildlife, scenery and its people. And of course in its crucial role in helping to regulate the Earth's climate, a role that we now know is being stressed beyond its abilities to cope, with very serious consequences for us all.

Another prominent feature of the Arctic is its popularity as a conference theme. Just in the last 12 months Tromsø, London, Ottawa, Berlin, Reykjavik, Helsinki and Davos have all played host to significant international Arctic meetings, looking at science, business or policy, and often all three.

The refrain at these events is admirably consistent – the need for more effective international dialogue; the respectful and honest engagement with local communities; the importance of long-term, joined-up monitoring that reflects the realities of the Arctic, rather than political or funding boundaries; and new international partnerships to tackle the biggest scientific questions.

Which is all true. And in our role in the Natural Environment Research Council Arctic Office, we aim to make those aspirations a reality for researchers based here in the UK. Put simply, to support and promote their Arctic work; provide advice to policy and decision-makers; and connect them up to new national and international initiatives.

But when you wake up on an early morning in March 2018 and the first thing you hear is the terrible news from Salisbury and you remember that you are partway through an exchange programme for UK and Russian early career researchers, abstract thoughts of science diplomacy and how to keep it going suddenly move from being buzz words at conferences, to very solid and very real problems.

To set the scene, it's important to know that the UK is good at Arctic science. Very good. We're only behind the US, Canada and Russia when it comes to the number of scientific publications. Researchers here in the UK are more regular co-authors than almost any others. Spread over

at least 70 universities and research centres the network is nimble, outward-facing and highly skilled. With icestrengthened research vessels, such as the RRS James Clark Ross and the new RRS Sir David Attenborough; sampling aircraft; and the NERC Arctic Research Station in Ny-Alesund (Svalbard, Norway) and an extensive suite of autonomous underwater vehicles such as Auto-Sub Long Range (Boaty McBoatface to you and I...), the UK is effectively a full-spectrum player.



The RRS *Sir David Attenborough* – a state-of-the-art polar research vessel for Britain ©Rolls Royce

It's easy to see what this means in reality, with the current Arctic strategic research programme, funded by the Natural Environment Research Council (£20m over five years together with our German partners) – the Changing Arctic Ocean Programme – bringing together over 200 scientists across 16 projects and working with partners in 15 other countries. Looking at what the changes in the Arctic Ocean including the 'Atlantification' of the Arctic - mean for those ecosystems.

When the framework and the funding support is right, then the partnerships that UK-based scientists can build and the ships, stations and other assets they can mutually exchange with colleagues go together to build projects with real impact and of huge scientific value.

The role of the NERC Arctic Office is not to duplicate these large scale efforts, but to build on their successes to find the additional ways in which we can connect up the community, and especially in ways and in places that might otherwise not happen.

Which brings us back to Russia. The largest country in the Arctic, with the enormous areas of permafrost, numerous rivers draining into the Arctic Ocean and which is already seeing the impact of regional climate change. What happens in the Russian Arctic is of critical importance in understanding the changes to the Arctic as a whole, and so the planet. Russian Arctic science is strong and successful, but issues of language, funding and geography mean that there are not as many international connections as everyone would like to see. An issue recognised by the International Arctic Science Committee (IASC), which is taking active steps,



UK-Russia Early Career Arctic Research Workshop, Lomonosov Moscow State University, March 2018 ©UK Science and Innovation Network

through its new Five Year Strategic Plan to strengthen connections.

So over the last 18 months with our partners in the UK Science and Innovation Network (a joint BEIS and FCO initiative) in the British Embassy in Moscow, as well as the central team in Whitehall, we have been focused on a range of activity to build up links and create new international opportunities for UK-based researchers – especially early career researchers - to connect with Russian colleagues.

What does this mean in practice? Well, it is the researchers themselves who need to decide the priorities to mean that they can really make it live.

The NERC Arctic Office held a large open meeting on the Russian Arctic in Cambridge in late 2017 to work this through. And from this has developed three key themes: building earlycareer links, facilitating access to Arctic research excellence and research facilities; and strengthening institutional connections between prominent universities and research centres.

Engaging with the UK Polar Network and APECS Russia, the two organisations that support early career polar researchers has been crucial. Through the support of their Presidents and Committees we have had fantastic teams which have taken much of the heavy lifting of organising activities. The first practical event was in Moscow in early March 2018 and was a real success, bringing together over 25 researchers from across the UK and Russia, including Arctic Russia, to find common research interests and identify avenues for future cooperation.

And that was why, on that March morning in 2018, as I thought about the potential pressures on the programme and the challenges ahead, I was confident that the personal connections we had already built up, the trust that we had created between universities and other institutions, together with all the hard work of the people involved in the programme, would mean that the work would continue.

And continue it has, with a successful follow-up meeting and a bilateral statement of collaboration released by the two national APECS committees at the POLAR2018 conference in Davos, joint events at large Arctic fora in Moscow and St Petersburg, and a trilateral science session between the UK, Norway and Russia at the Arctic Frontiers conference in Tromsø, Norway. All of which is leading to significant practical results, with a new Interdisciplinary Russian Arctic Field Course for 30 students from across the UK and Russia, with teaching staff from both countries, supported by the FCO's Global Britain Fund. As well as commitments to host information on the NERC Arctic Office website www.arctic.ac.uk - about how to access Russian Arctic science stations and partner with Russian

It was a pleasure to be able to showcase this work, together with the much wider work of the

scientists.

NERC Arctic Office and our partners, at the POST Annual Reception event on 29 January, which had the theme of science diplomacy.

The communications element of our work is crucial and gives a platform to promote new opportunities and highlight the strengths of the community in close cooperation with researchers themselves. So the NERC Arctic Office, together with Whitehall partners in the UK Science and Innovation Network,

The Expedition

MOSAIC



NERC Arctic Office stand at POST event

have developed a digital campaign around the #UKinArctic hashtag to do just that. Now regularly used by researchers, and being namechecked in the Government's

ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR UND MEERESFORSCHUNG



Arctic Policy Framework Beyond the Ice (2018), the campaign has been referenced by both BEIS and FCO Ministers in their Twitter posts.

Looking forward, this year will see the start of the € 100m MOSAiC Arctic drift expedition, in which the German icebreaker RV Polarstern will be frozen in to the Arctic Ocean in September, acting as a drifting ice station and laboratory, until she comes out of the ice a year later somewhere between Greenland and Svalbard. 17 nations will have their scientists joining the vessel in a truly unique undertaking. Thanks to support from BEIS and NERC, the UK will have six teams there.

At the political level, I hope that the implementation of the Agreement on Enhancing International Arctic Science Cooperation, ratified by the eight Arctic States in 2018, will begin in earnest. Offering the potential for easing the practical barriers on visas, customs, moving samples and equipment, facilitating exchanges and secondments all offers further hope that science and diplomacy can move forward together, to benefit everyone.

In the NERC Arctic Office we are committed to supporting these approaches wherever we can. The excellent science must always come first. So the focus with our partners is always on ensuring that the diplomacy enables the science. But where better relations between scientists and funding bodies helps the wider diplomatic landscape that is always a welcome extra benefit.

Henry Burgess is the Head of the Natural Environment Research Council Arctic Office, hosted by the British Antarctic Survey in Cambridge. www.arctic.ac.uk

## VACCINE INNOVATION LOWER COSTS, MORE APPLICATIONS, AND NATIONAL PRODUCTION WITH 'PROTEIN GLYCAN COUPLING TECHNOLOGY'



Professor Brendan Wren Professor of Microbial Pathogenesis Dean of Faculty of Infectious and Tropical Diseases London School of Hygiene & Tropical Medicine

Vaccines are one of the most effective weapons we have to combat infectious diseases in both humans and animals. Those considered the most successful are ones that evoke longlasting protective immunity with minimal side effects.

One of the most effective types are 'glycoconjugate' vaccines. These have the potential to be low cost, mass produced, transferable to other health issues like parasites and cancer... and are being developed here in the UK. Glycoconjugates vaccines are a combination of a protein and a sugar. Because there are two separate components, the vaccine can trigger responses across the immune system. Their success stems from their suitability for most of the human population, including the most vulnerable - infants and the elderly. To date, glycoconjugate vaccines have been licensed for protection against bacterial pneumonia and meningitis.

The development and use of these efficient, long-lasting vaccines has been one of the great success stories of modern medicine. With over a billion doses administered annually, glycoconjugate vaccines have directly caused a significant reduction in the global occurrence of human bacterial meningitis and pneumonia. Unfortunately, the traditional method of producing these vaccines by chemical synthesis requires over 300 quality control steps and are currently very expensive and here in the UK, there are no vaccine manufacturers whatsoever.

Combined with Brexit, where any scenario will bring uncertainty on the ease of access and import and trade costs, the future/effective use of glycoconjugates may seem uncertain.

However, novel technology is being developed in the heart of London, which could ensure the sustainability of these life-saving vaccines.

The London School of Hygiene & Tropical Medicine (LSHTM) has a 120-year history of innovation in healthcare, from first making the link between smoking and lung cancer, to using a novel 'ring vaccination' approach in a highly successful Ebola vaccine trial during the West African epidemic. Researchers at LSHTM are now using their expertise in vaccines to develop an innovative technique called 'glycoengineering'.

In harmless strains of *E. coli,* cells are tricked into acting as mini factories for the production of an inexhaustible and readily renewable supply of pure vaccine product. The process, formally known as *Protein Glycan Coupling Technology* (*PCGT*), is easily scaled up with existing modern systems, as *E. coli* cells are already grown in large volume bioreactors for the production of other pharmaceutical products. It is also an incredibly low-cost production option, with the inbuilt flexibility of adding different glycan/protein combinations for other custom-made vaccines.

For the past two decades, LSHTM scientists have been developing and using this technology for a number of other bacterial vaccines in three categories: (i) improving existing vaccines, (ii) new vaccines and (iii) animal vaccines. LSHTM is in the final stages of spinning out a new company ArcVax to exploit the new technology as a platform for vaccine discovery and production.

### IMPROVING EXISTING VACCINES

The most common cause of pneumonia is *Streptococcus pneumonia*, which was



Farm manager and chickens in Uganda.

©LSHTM

responsible for almost 20% of all childhood deaths in 2005. It still affects over a million infants across the world every year, killing many. Existing glycoconjugate vaccines are effective, but currently too costly for low-income countries, where they are needed most for vulnerable children.

using PGCT. Examples include bioterrorist threat agents for which no vaccines are currently available. For example, PGCT has been used to produce Francisella tularensis and Burkholderia pseudomallei vaccines which have been shown to be highly protective in models of infection.

vaccine. This 'trojan horse' approach is very attractive, as it can match current manufacturing costs while providing protection against additional diseases. At LSHTM, low cost single dose vaccines have already been produced in this way to protect against multiple diseases in poultry and pigs.



Given the continued threat of antimicrobial resistance and the potential peril of bioterrorist agents, the production of these novel vaccines against old and new bacterial foes is particularly timely. Scaled up production is now set to take place in the UK's first ever-dedicated Vaccines Manufacturing Innovation Centre, a £66m investment by UKRI as part of the Government's Industrial Strategy Challenge Fund Medicines Manufacturing portfolio. LSHTM is a key partner in this purposebuilt facility, which will pave the way for the rapid manufacture of vaccines in the event of a pandemic affecting the UK. As glycan-based vaccine formulations continue to be improved through the efforts of the experts there and elsewhere in the UK, so too will their potential use beyond bacteria into vaccines to protect against viruses and parasites, and even cancer.

Read more about the VMIC here: lshtm.ac.uk/newsevents/ news/2018/lshtm-partner-uksfirst-ever-dedicated-vaccines-ma nufacturing-innovation, and more information on PGCT: lshtm.ac.uk/research/researchaction/features/search-better-vac cines-creating-route-endingdisease

Learn how LSHTM is marking the 120th anniversary of its foundation throughout 2019 by celebrating health innovation: lshtm.ac.uk/120

## **Glycoprotein Conjugate Vaccine** Production Process

![](_page_18_Figure_8.jpeg)

Glycoconjugate vaccine infographic

In response, LSHTM has been working with this novel approach to produce the vaccines at low cost and demonstrating their efficacy compared to commercial vaccines at the same time. The scientific results of this research, recently published in Nature Vaccine, highlight how low cost, widely applicable, and effective recombinant pneumococcal vaccines can be produced.

#### **NEW VACCINES**

For many bacterial diseases, there are no current vaccines. To address this unmet medical need, we have constructed tailor made glycoconjugate vaccines against a range of pathogens

#### **ANIMAL VACCINES**

Given the cost savings from using vaccines made this way, there could be substantial benefit in using them for livestock, where lower costs are a major driving force for farmers. Apart from protecting animals against disease and the many associated economic benefits of that, vaccines against animal pathogens that also infect humans will directly benefit human health and reduce the need for antibiotics to be given to animals. Some concepts being explored include creating vaccines that are still 'living' (live attenuated), which deliver a payload of a glycoconjugate

![](_page_18_Picture_15.jpeg)

©LSHTM

#### Vaccine-vial

#### FUTURE PERSPECTIVES

Infections caused by bacterial pathogens, especially antibiotic resistant ones, are an everincreasing public health threat in the UK and worldwide. Glycoconjugate vaccines are

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# MICROBIOLOGY IN THE HIGH SEAS: INTRODUCING THE MARINE MICROBIOME

![](_page_19_Picture_1.jpeg)

Dr Christopher Brown, Policy and Public Affairs Manager Society for Applied Microbiology

Public attention on the future health of our oceans is at an alltime high, spurred on by reports of dying coral reefs, plastic pollution and overfishing. Meanwhile, the notion of sustainably exploiting ocean resources is drawing the attention of industry and policymakers, due to advances in science and technology. Through all this noise, it is important that there is a voice for the ocean's silent majority – marine microorganisms.

The impacts of climate change and pollution on ocean biodiversity have become a significant concern for policymakers, as indicated within the Government Office for Science's 2018 Foresight report *Future of the Sea* and the Environmental Audit Committee's inquiry into sustainable seas. While these factors endanger aquatic organisms, including plant life and fish, the enormous array of microscopic life in marine environments will also be affected. Microbiology research is steadily revealing the microorganisms that live in our oceans - collectively known as the marine microbiome. Microbiologists are also gradually unpicking the impacts of human activity on marine microorganisms, as well as their potential industrial uses. In November 2018, the Society for Applied Microbiology produced a briefing that introduces marine microbiome research to policymakers and the public.

### WHAT IS THE MARINE MICROBIOME?

Microorganisms are ubiquitous throughout our seas: up to a million microbes can be found in a drop of seawater,<sup>1</sup> and microbial communities are estimated to make up around 90% of total ocean biomass.<sup>2</sup> The term 'marine microbiome' is used to describe the collective of all the microorganisms within marine environments. It is also used to refer to the smaller, localised communities of microbes that live in specific ecosystems including marine creatures, coral reefs and hydrothermal vents.

Marine microbes carry out many of the basic functions that support life in the oceans and beyond. Phytoplankton for example are particularly important as they produce an

![](_page_19_Figure_10.jpeg)

estimated 50 80%,<sup>3,4</sup> of all global oxygen (rainforests are estimated to provide around 28%).<sup>5</sup> In simplified terms, that means every second breath we take contains oxygen made from marine microorganisms. That is why it is crucial to understand circumstances toxic algal blooms pose a threat to aquatic life and can harm local fishing economies.

Warmer waters may also see more exotic diseases arrive in northern climes. For example, rising sea surface temperatures can wreak havoc. Plastic waste introduces harmful bacteria to coral reefs, contributing to the increased likelihood of coral disease from 4% to 89%.<sup>8</sup>

Industrial activities in the ocean are set to increase as new technologies facilitate the

![](_page_20_Picture_5.jpeg)

#### Algal bloom

how marine microbiomes are affected by external factors such as climate change and pollution. These impacts can be more difficult to assess as microbiomes are invisible to the naked eye and can contain many millions of individual organisms. However, advances in genomics and other technologies are providing vital tools to enable the work of marine microbiologists.

### WHAT ARE THE IMPACTS OF CLIMATE CHANGE?

Increasing carbon dioxide (CO<sub>2</sub>) emissions are causing global ocean temperatures and acidity to rise, changing the environment around marine microorganisms. As a result, we may see more frequent 'algal bloom' events, where microorganisms grow rapidly in large quantities. In certain in the North Atlantic over the past 50 years have been linked to an increase of human disease caused by *Vibrio* bacteria (e.g. *Vibrio vulnificus*).<sup>6</sup> Continued research will be needed to assess other potential threats to public health, fish farms and our coastal wildlife.

#### HOW IS POLLUTION AFFECTING MARINE MICROBIOMES?

Whilst the harm caused by pollution in the oceans is well documented, the impact on microorganisms is not as widely known, despite the potential for severe knock-on effects. Looking at the popular example of plastic pollution, specific bacterial species have been identified on ocean plastics that are not usually found in the surrounding water.<sup>7</sup> In heavily polluted regions, these foreign bacteria extraction of key oil and mineral reserves. Understanding the impact of industrial pollution on marine microbiomes is key to preserving ocean biodiversity, but much knowledge remains unknown. For instance, the longterm effects of catastrophes such as the 2010 Deepwater Horizon oil spill are still under debate. Similarly, the impact of deep-sea mining activities on marine microbiomes is currently an active area of scientific research.

#### HOW CAN MARINE MICROBES BE USED?

Beyond informing sustainable industry practices, microbiome studies may also reveal new discoveries with economic potential. Research on pollutioneating bacteria, for instance, may inform new strategies for bioremediation, a process where microorganisms are exploited to reduce or eliminate the adverse effects of pollutants in the environment.

Marine microbes have evolved to survive in extreme conditions, gifting them with unique genetic material (e.g. DNA) that can potentially be exploited to yield high-value products including biofuels and medicines.<sup>9</sup> The international PharmaSea project, for example, analyses microorganisms in deep sea trenches for new antibiotics, previously identifying 2 drug leads from over 1000 different strains of bacteria.<sup>10</sup>

In 2016, a report published by the Commonwealth Secretariat estimated the global marine biotechnology market to be worth US\$6.7 – 29 billion.<sup>11</sup> This economic potential is reflected by a recent analysis which revealed that private companies own 84% of all patents related to marine genetic resources.<sup>12</sup> Three countries in particular dominate this area: Germany (49%), the United States (13%), and Japan (12%). These figures suggest that the UK's strong marine biotechnology research base may not currently be utilised to its full potential. HM Government should investigate how the UK marine biotechnology sector can best be supported to help deliver the goals set out in the Industrial Strategy.

#### INTERNATIONAL CONSIDERATIONS – A POTENTIAL SEA-CHANGE ON THE HORIZON

The momentum of research and development (R&D) on ocean resources is increasing, and efforts to conserve and protect biodiversity must keep apace. Indeed, future international regulations may change how UK scientists access and utilise *marine genetic*  resources (e.g. the DNA of marine bacteria, plants and sea creatures) for R&D.

Unlike for ocean mineral deposits, there are currently no international rules on R&D using genetic material from Areas Beyond Natural Jurisdiction (ABNJ), such as the high seas. Nevertheless, in September 2018 the first meeting of the 'Intergovernmental Conference (IGC) on Marine Biodiversity of Areas Beyond National Jurisdiction' took place.<sup>13</sup> These discussions are aimed at developing a legally binding instrument, under the UN

community, including Open Science and international development. However, caution is needed to ensure that regulations don't slow down research efforts. The needs of the global scientific community must be heard.

The second and third IGC meetings will be convened throughout March and August 2019, respectively. In the lead up to these meetings, many actors will be making their voices 4 Walker, J.C.G. (1980) The oxygen cycle heard, including the perspectives of trade associations, blocs of nations and the academic sector.

#### References

- 1 Zehr, J.P. et al. (2017) How microbes survive in the open ocean. Science, 357(6352), p646-647. https://doi.org/10.1126/science.aan57 64
- 2 Life in the World's Oceans: Diversity, Distribution, and Abundance. Edited by Alasdair McIntyre. (2010) Wiley-Blackwell, Chapter 12. http://comlmaps.org/mcintyre/ch12
- 3 https://www.newscientist.com/ article/dn27578-oceans-microbiomehas-incredible-diversity-and-humanlikeness/
- in the natural environment and the biogeochemical cycles, Springer-Verlag, Berlin, Federal Republic of Germany (DEU) https://www.springer.com /gb/book/9783662229880

- 9 Royal Society (2017) Future ocean resources: Metal-rich minerals and genetics - evidence pack. https://royalsociety.org/future-oceanresources
- 10 http://www.pharma-sea.eu/ pharmasea/
- 11 Day, J., Hughes, A., Greenhill, L. and Stanley, M.S. (2016) Blue Biotechnology, Commonwealth Blue Economy Report Series, No. 5. Commonwealth Secretariat: London http://thecommonwealth.org/sites/def ault/files/inline/Blue%2BBiotechnolog y\_UPDF.pdf
- 12 Blasiak, R. et al. (2018) Corporate control and global governance of marine genetic resources. Science Advances, 4(6): eaar5237. https://doi.org/10.1126/sciadv.aar523

![](_page_21_Picture_13.jpeg)

#### Oil Spill

Convention on the Law of the Sea (UNCLOS), that will ensure marine biodiversity is conserved and used sustainably - including how marine genetic resources are used.

In practical terms, such an agreement could change how scientists conduct research in the high seas, including how new discoveries are documented and how developing nations might benefit from such research. The principles behind these discussions are laudable and shared by many in the scientific

Through all this noise, it is important that there is a voice for the ocean's silent majority.

To access a full copy of our briefing on the marine microbiome, please visit https://sfam.org.uk/resources/ policy-briefing-marinemicrobiome.html For further information, please contact Chris at christopher@ sfam.org.uk.

- 5 https://www.nationalgeographic.org/ activity/save-the-plankton-breathefreely/
- 6 Vezzulli, L. et al. (2016) Climate influence on Vibrio and associated human diseases during the past halfcentury in the coastal North Atlantic. PNAS, 113(34), E5062-E5071. https://doi.org/10.1073/pnas.160915 7113
- 7 https://www.newscientist.com/ article/dn23794-plastisphere-microbesgo-to-sea-on-flotsam-fragments/
- 8 https://www.nature.com/articles/ d41586-018-01239-3

13 For a summary of this meeting, please see http://enb.iisd.org/vol25/ enb25179e.html

# PARTNERSHIPS AT HEART OF PIONEERING NEW APPROACH TO TACKLE GLOBAL CHALLENGES

![](_page_22_Picture_1.jpeg)

Professor Helen Fletcher, UKRI Director of International Development and GCRF Challenge Leader in Global Health.

Now more than ever the world is facing challenges that need a collective response. We are living on a globally interconnected planet where everything from climate change, pandemics and employment, to conflict, water security and mass migration are linked and impact us all.

The UK is renowned for the excellence of its research base. It is also regarded as one of the world leaders in the delivery of effective humanitarian and development programmes – (official development assistance (ODA). And these two strengths come together to underpin the Global Challenges Research Fund (GCRF).

GCRF explicitly recognises the crucial role of research in promoting the economic development and welfare of developing countries and the inception of the fund has seen a step-change in international development research.

Impacts are already emerging from UKRI's early investment in 37 GCRF research projects announced in 2017 from the training of hundreds of researchers across diverse areas including health in conflict and circular water economy, to on the ground solutions such as real-time modelling of a Diphtheria outbreak among Rohingya refugees. By generating reliable and timely forecasting, the project enabled humanitarian organisations to make better decisions on the ground.

In January UKRI announced a pioneering new to approach to problem solving on a global scale with 12 GCRF Interdisciplinary Research Hubs. These are built on a foundation of fair and equitable partnerships, with UK expertise working with businesses, researchers, community groups, universities, NGOs and charities across 85 countries. Those directly affected by the issues will inform research into the solutions and there will be ongoing opportunities to transfer knowledge and showcase both UK and international expertise.

Professor Andrew Thompson, UKRI International Champion and Executive Chair of the Arts and Humanities Research Council, says: "The sheer scale and ambition of these Hubs is what makes them so exciting. They enable us to deliver a coordinated global response and each Hub has the potential to transform the quality of life for many people throughout the world and safeguard our planet for future generations."

The Hubs are a five-year programme with a £200m investment from the UK government boosted with funding and in-kind support from industry and other organisations. Informed by the United Nations Sustainable Development Goals (SDGs), they are tackling headon a wide range of challenges from improving human health and promoting gender equality and social justice to fortifying ecological systems and biodiversity on land and sea, generating agricultural sustainability and fostering greater resilience to natural disasters. The aim is to increase global security and prosperity while stimulating innovation and future business opportunities

#### **12 GCRF HUB SUMMARIES**

#### ACCELERATING ACHIEVEMENT FOR AFRICA'S ADOLESCENTS HUB

By 2050, Africa will be home to half a billion teenagers. Despite their incredible creativity and potential, many of these young people will be trapped in a cycle of poverty, violence, low education and poor health. This Hub works with policy makers, NGOs and adolescents themselves to discover which combinations of services can most efficiently and cost-effectively help adolescents achieve their potential. By testing different combinations such as malaria prevention, business skills and violence prevention, this Hub will identify 'accelerator' packages to boost nutrition, health, schooling, employment, gender equality and safety for teenagers across Africa.

Lead organisation: University of Oxford, Geographical focus: Africa

#### ACCOUNTABILITY FOR INFORMAL URBAN EQUITY HUB

Over half of the world's population live in cities and one in three of these live in informal settlements in low and middle-income countries. But inadequate access to services and limited opportunities to shape their environment lead to a wide range of physical and mental health risks. This Hub will support marginalised people to claim their health rights and helps build government accountability and capacity through evidence-based research to inform policy change at all levels. Lead organisation: Liverpool School of Tropical Medicine

Geographical focus: East Africa, West Africa and South-Central Asia

continued

#### ACTION AGAINST STUNTING HUB

Progress against the global goal to reduce child stunting by 40 per cent by 2030 has stalled. To accelerate gains and help millions of children reach their potential, there is an urgent need to change the 'frame' to better understand the factors, synergies and relationships that cause stunting. Our Hub will harness world leading researchers to the communities themselves to build up a comprehensive research picture of the 'whole child', enabling joined-up, child-centred interventions.

Lead organisation: London International Development Centre and London School of Hygiene and Tropical Medicine

Geographical focus: West Africa, South-Central Asia and South-East Asia

![](_page_23_Picture_4.jpeg)

The children are from the Keonjhar district, Odisha, India –  $\ensuremath{\mathbb{C}}$ Sneha Krishnan

Progress against the global goal to reduce stunting by 40% by 2030 has stalled, the Action Against Stunting Hub will build up a comprehensive picture of the whole child, from their gut micro biome to their eating habits to deliver joined-up, child-centred interventions.

#### **GENDER, JUSTICE AND SECURITY HUB**

Conflict and gender-based violence have devastating, long-term consequences on individuals, families and communities. They also severely hamper the successful delivery of development goals internationally. This Hub seeks to advance sustainable peace by developing an evidence-base around gender, justice and inclusive security in conflict-affected societies. Working with international partners, it will expand research capacity and interdisciplinary research and connect with leading ambassadors for gender justice to translate insights into ongoing actions that improve lives.

Lead organisation: London School of Economics and Political Science

Geographical focus: South America, West Africa, East Africa, Middle East, South-Central Asia and South-East Asia

#### LIVING DELTAS HUB

River deltas comprise just one per cent of global landscapes yet support over half a billion people. Deltas are vital social-ecological systems and global food-baskets, but the terrain and the livelihoods of those who rely on them are under threat from human exploitation, environmental degradation and climate change. Focusing on three deltas in Asia, this Hub will operate on a model of equitable partnership with the delta-dwellers and the research community working together to develop new knowledge and policies. The aim is to safeguard delta futures through more resilient communities and sustainable development.

Lead organisation: Newcastle University Geographical focus: South and South-East Asia

#### **ONE HEALTH POULTRY HUB**

Population growth is driving global demand for safe, low-cost poultry meat and eggs but rapid intensification creates conditions for diseases. This Hub explores how to meet rising demand while minimising the risk to public health. It will study how intensification increases risk of infectious disease and antimicrobial resistance, why certain processes and behaviours are risky and establish when and where to test interventions for disease control. Working with strong networks of local, regional and global stakeholders, the evidence generated will be put to immediate use.

Lead organisation: Royal Veterinary College Geographical focus: South Central Asia and South-East Asia

![](_page_23_Picture_17.jpeg)

Trader in a live bird market in Bangladesh – @AO ECTAD Bangladesh With demand for poultry meat growing across the globe, the One Poultry Hub will look at issues created by the intensification of poultry and implement solutions for reducing disease.

#### **ONE OCEAN HUB**

We are entirely reliant upon the ocean but over-exploitation, competing uses, pollution and climate change are pushing ocean ecosystems towards a tipping point. This Hub will bridge current disconnects across law, science and policy to empower local communities, women and youth to co-develop research and solutions. The aim is to predict, harness and share equitably environmental, socioeconomic and cultural benefits from ocean conservation and sustainable use. The Hub will also identify hidden trade-offs between more easily monetized fishing or mining activities and less-understood values of the ocean's deep cultural role, function in the carbon cycle, and potential in medical innovation.

Lead organisation: University of Strathclyde Geographical focus: East Africa, West Africa, Southern Africa, Oceania and the Caribbean

![](_page_24_Picture_2.jpeg)

Fishermen sorting their catch in India - Cristina Mittermeier for SeaLegacy 2018 - The One Ocean Hub will be working with local communities across Africa, Oceania and the Caribbean to bridge current disconnects across law, science and policy to empower communities and lead to more sustainable and equitable Oceans for the future.

#### SOUTH ASIAN NITROGEN HUB

Humans have massively altered flows of nitrogen on our planet, leading to both benefits for food production and multiple threats to the environment. The result is a web of interlinked problems, as nitrogen losses from agriculture and fossil fuel combustion cause air and water pollution. This Hub will develop a more coherent picture of the nitrogen cycle. It will quantify nitrogen flows and impacts and explore how to improve nitrogen management in agriculture and reduce the need for synthetic fertilizers by making better use of manure, urine and natural nitrogen fixation processes.

Lead organisation: NERC Centre for Ecology and Hydrology, Geographical focus: South-Central Asia

### SOUTH-SOUTH MIGRATION, INEQUALITY AND DEVELOPMENT HUB

Migration between the countries of the Global South accounts for nearly half of all international migration, 70 per cent in some places, potentially contributing to delivery of the Sustainable Developmental Goals by creating opportunities for work and for the transfer of resources, knowledge and skills between developing countries. The developmental benefits of migration are undermined by inequalities in access to the opportunities that South-South migration can bring and by limited and unequal access to rights for migrants and their families. This Hub will work with academics, artists, community organisers, international organisations and policy makers to develop approaches which reduce inequalities associated with South-South migration.

#### Lead organisation: Coventry University

Geographical focus: South America, Caribbean, Africa, Middle East and East, South-East and South-Central Asia

#### TRADE, DEVELOPMENT AND THE ENVIRONMENT HUB

Thousands of species are threatened globally with extinction, there has been a swift decline in biodiversity and ecosystem resilience and people are being kept in poverty as trade in wildlife and agricultural commodities from low and middleincome countries has rapidly increased. This Hub includes economists, trade modellers, political scientists, ecologists, development scientists, large companies, UN bodies and NGOs who will work together across supply chains to influence trade related policy and practice. It will also produce research to help ensure that trade becomes a driver of positive change in the world, with biodiversity loss halted and people permanently lifted out of poverty.

Lead organisation: UN Environment World Conservation Monitoring Centre

Geographical focus: South America, Central, East and West Africa and East and South-East Asia

![](_page_24_Picture_15.jpeg)

The golden dried fish of Winneba - fish used to be the "gold" of West Africa coast line. Picture taken in the West African village of Winneba, Ghana, where storage of fish is difficult caused lack of ability to preserve their catch of the fish. ©Cristina Mittermeier for SeaLegacy 2018. [The One Ocean Hub will be working with local communities across Africa, Oceania and the Caribbean to bridge current disconnects across law, science and policy to empower communities and lead to more sustainable and equitable Oceans for the future.]

#### **URBAN DISASTER RISK HUB**

Rapid urbanisation presents a time-limited global opportunity to embed disaster risk management in urban development especially when you consider 60 per cent of the area expected to be urban by 2030 is yet to be built. This Hub will work with international agencies to bring disaster risk management to the centre of global urban policy and practice, strengthening the voice and capacity of the urban poor. Bringing together leading researchers with inspiring community and government leaders the Hub will work at an unprecedented scale to deliver real impact through interdisciplinary research.

Lead organisation: University of Edinburgh Geographical focus: South America, East Africa, Middle East and South-Central Asia

continued

#### WATER SECURITY AND SUSTAINABLE DEVELOPMENT HUB

Eighty per cent of the world's population live in areas threatened by water security yet efforts to resolve this are repeatedly thwarted by pressures such as pollution, extreme weather, urbanisation, over-abstraction of groundwater and land degradation. This Hub takes a broad view of water systems to explore the challenges and barriers to water security from the impact of different social, cultural and environmental values of water through to the consequences of fragmented water governance. It will tackle these barriers by providing a forum, open to all stakeholders, to jointly question, discuss, and construct new ideas to resolve water security issues.

Lead organisation: Newcastle University

Geographical focus: South America, East Africa and South-Central Asia and South-East Asia

https://www.ukri.org/files/news/ukri-gcrf-global-interdisciplinary-research-hubs/

**UKRI GCRF KEY FACTS** 

12 GLOBAL INTERDISCIPLINARY RESEARCH HUBS

**85 COUNTRIES** 

**550 RESEARCHERS** 

**400 UNIQUE PARTNER ORGANISATIONS** 

£200M INVESTMENT FROM UK GOVERNMENT WITH ADDITIONAL FUNDING BEING PROVIDED BY ALL INTERNATIONAL PARTNERS

16 UN SUSTAINABLE DEVELOPMENT GOALS BEING ADDRESSED ACROSS THE HUBS

The UK government announced the Global Challenges Research Fund (GCRF) in 2015 to strengthen the UK's capacity for international development research. It forms part of the UK's Official Development Assistance (ODA) commitment and is overseen by the Department for Business, Energy and Industrial Strategy (BEIS). It is delivered through UK Research and Innovation, Scottish Funding Council, Higher Education Funding Council for Wales, Higher Education Division Northern Ireland, Academy of Medical Sciences, Royal Society, British Academy, Royal Academy of Engineering and UK Space Agency.

# **GEARING UP TO 2.4%:** GROWING THE UK'S R&D ACTIVITY TO MEET THE 2.4% GDP TARGET

![](_page_25_Picture_14.jpeg)

Steve Yianni FREng (non-Executive Director) AIRTO

![](_page_25_Picture_16.jpeg)

Professor Richard Brook OBE FREng (President) AIRTO

The UK has a thriving Innovation, Research and Technology (IRT) sector, offering people with the right skills and expertise, and substantial resources, to deliver the UK's Industrial Strategy. The sector plays a critical independent role in helping industry cope with and share the costs and risks of innovation. By utilising this worldclass asset to its full capacity in playing a central part in achieving the government's 2.4% target, we stand to gain global competitive advantage by improving the scope and productivity of UK industry. On Monday 28 January 2019, AIRTO launched its new position statement at a reception in the Palace of Westminster hosted by Heidi Allen, the Member of Parliament for South Cambridgeshire. We were delighted to be joined by our members, parliamentarians, representatives from government, industry and allied organisations to network and discuss the role of the UK's Innovation, Research & Technology (IRT) sector in delivering the Modern Industrial Strategy.

![](_page_26_Picture_1.jpeg)

![](_page_26_Picture_2.jpeg)

Heidi Allen MP

The United Kingdom's departure from the European Union in 2019 marks a monumental event, and a move to transform the way that our country trades with our closest partners in Europe, and beyond.

Since the end of World War II our economy has harnessed the global technological revolution, and has led the way in sectors which are heavily reliant on scientific and engineering expertise for innovation, such as medicine, aerospace, automotive and information technology and telecommunications, to name but a few.

As we leave the European Union, the government's commitment to cultivating our national scientific and engineering capabilities through the Industrial Strategy has been welcomed widely. Measuring

Read our fuil position statemen

the level of R&D activity in the UK (both public and private) is a useful way of gauging how well the UK compares to competitor nations in fostering a supportive environment for innovation, Innovation will be fundamental to our national economic prosperity and quality of life for decades to come.

There is general consensus that in order to achieve the 2.4% R&D intensity target, both public and private sectors need to increase their respective activity. The current achieved level is 1.7% of GDP (evidenced by OECD Science, Technology & R&D Statistics), albeit there are some debates about whether this figure represents a truly accurate baseline measure. Based on other countries' experiences, the proportion of public to private investment needed to achieve this is approximately

1:2, i.e. ~one third from government sources and ~two thirds from private sources including industry. In the UK, government figures show that this ratio is currently estimated to be 1:2.6, indicating that UK private investment leverage is already at an above average level. To reach 2.4% of GDP from the current 1.7% position, therefore, needs a commensurate uplift in public sector investment (41%), coupled with either: i). a continuing level of above average investment from private sources; or, ii). a greater and dis-proportionate commitment of private funding for R&D. Ideally, a combination of both

As such, much of the debate in our discussions with stakeholders has centred on what levers government could deploy to attract more industry

will ensue.

investment in R&D in the UK and to create an appropriate and optimal environment for increased UK R&D activity.

AIRTO notes however that going for more R&D for its own sake should not be seen as an end in itself. To drive towards the goals of the Industrial Strategy and to obtain a return on the increased investment, the additional R&D undertaken needs to be targeted with a strong focus on delivering more to the market and supplemented with translational research that will deliver successful practical outcomes (i.e. leading to increased scope for higher productivity, leading to more return on investment, profit, jobs, & prosperity). Industry will need to be persuaded that there will be a commercial return from the R&D investment made. Strategic use of government levers is essential to achieving this. In addition, government needs to be seen as a more confident customer for increased R&D and its outcomes, to instil confidence in industry and commerce.

#### AIRTO proposes six levers for government to consider, as follows:

### 1. Incentives for business R&D

The largest investors in R&D will be industrial companies and private investors. Decisions to invest will be driven not only by competitive trends and market forces but by practical risk sharing incentives such as R&D tax credits and grants, as well as by human behavioural factors, all of which need to be taken into account and deployed to maximum effect in support of increasing the R&D undertaken in the UK.

#### 2. Public procurement and early adoption of novel products and services

Government procurement is potentially a powerful stimulant for innovation, and hence R&D in the UK, particularly for SMEs. To fully realise this potential, government must support innovation across the whole of the technology readiness spectrum, including through increased use of initiatives like the Small Business Research Initiative (SBRI).

#### 3. Skills for the future

Capitalising on the UK's world class higher education system and modern apprenticeships to provide more science, technology, engineering and mathematics (STEM) qualified people is pivotal to the UK's capacity to grow R&D to 2.4% of GDP and beyond. Many training schemes including apprenticeships and spanning future leader fellowships to post-graduate level programmes with universities are supported by the IRT sector. However, there is a critical need for more multidisciplinary people skilled in the four key areas of finance, industry, government and academia, which the IRT sector is well positioned to deliver with the right support in place, e.g. via new types of appropriately resourced Innovation Management Fellowships.

### 4. Physical infrastructure for R&D

There is an imbalance of capitalisation in the IRT sector, which needs to be addressed if the UK is going to have the optimal facilities and the capacity to grow and apply its R&D services for industry in the decades to come. The Industrial Strategy Challenge Fund (ISCF) will need to resource broader programmes of work at higher Technology Readiness Level (TRL), such as technology demonstrators and preproduction prototyping and performance proving projects. In addition, having a clear national vision and mission for National Laboratories and RTOs (including the Catapult Centres), which comprise an essential core within a joined-up IRT sector in the UK, would increase the chances of the sector rising to the 2.4% challenge. This challenge will mean a significant expansion in

these organisations if the UK is to have the necessary resource for translational research and R&D commercialisation.

#### 5. Regulation

Appropriate regulation is an important element of an attractive UK R&D environment within which to develop new products and services, compared to other nations. Codes of practice and standards also underpin confidence to enter new markets for such innovative products and services. To remain internationally competitive in lower risk sectors, the UK should adopt light touch regulation, to create a favourable environment for experimentation and

demonstration. In sectors requiring necessarily higher safety thresholds, such as pharmaceuticals, a more stringent regulatory framework is required. In achieving the right balance, the public needs to be engaged to ensure that trust, and the confidence that risks are being properly managed, are retained.

#### 6. International R&D exports

The international footprint of the UK-based IRT sector is strong, and can provide for further growth potential in offering R&D services to overseas industrial and other clients, including those considering locating operations in the UK. As such, the IRT sector represents a significant

#### CALL TO ACTION – PHYSICAL INFRASTRUCTURE FOR R&D

Review the return on investments for R&D tax credits across key sectors; Continue the commitment to public funding for research and innovation; Deploy IRT organisations to help technology based SMEs improve productivity.

#### CALL TO ACTION – SUPPORT PUBLIC PROCUREMENT & SERVICES

Make it easier for the Small Business Research Initiative (SBRI) to apply to larger firms to stimulate research and innovation via private businesses;

Pilot models of procurement with National labs and government agencies acting as intelligent clients for technology procurement.

#### CALL TO ACTION – SKILLS FOR THE FUTURE

Trial schemes that translate academic learning to the 'shop floor' and market place, across apprentice, Masters and PhD levels;

Create fellowships for developing applied skills;

Grow the number of industry prepared graduates for the workplace via sandwich degrees.

#### CALL TO ACTION – PHYSICAL INFRASTRUCTURE FOR R&D

Address imbalances between research and innovation activities by deploying schemes such as the industrial strategy challenge fund;

Invest in an 'RTO+' programme to improve capitalisation of existing organisations, rather than creating 'shiny' new centres to open!

Reduce 'red tape' for existing IRT organisations.

#### **CALL TO ACTION – REGULATION**

Regulation needs to exist to give confidence of market opportunities; Appropriate regulation can give UK competitive advantage.

#### **CALL TO ACTION – INTERNATIONAL REACH**

Set out a co-ordinated and aligned national plan around specific sector strengths.

leverage opportunity for UK as it enters the post-Brexit world in years to come. By succeeding in R&D investment in the UK, there are follow-on benefits in terms of the UK being a favoured nation for overseas based entities to trade with and invest in). Developing a coordinated and aligned national plan around specific IRT sector strengths is needed; where there are 'sector deals' for example, joined-up plans across the Department for International Trade and other Departments of Government will be critical to stimulating and growing R&D exports.

Further consideration of each of these six levers is contained within AIRTO's document detailing its discussions with stakeholders. However, given the large number of organisations with a variety of interests in how to deliver the 2.4% target, AIRTO is particularly seeking to highlight those elements which it considers to be most pertinent to the IRT sector and the need to translate R&D investment as rapidly and efficiently as possible into returns to the UK economy and society. These highlighted points are that:

1. The IRT sector is a national asset, which needs to be resourced to an increased capacity if it is to successfully deliver against the 2.4% target. There is an imbalance in the capitalisation of the sector, which prevents it from being able to fully realise the national ambitions to lift R&D activity to 2.4% of GDP and to ensure that the outcomes reach productive application in the economy. Industry demand for development and preproduction work frequently

exceeds capacity, with many independent IRT sector organisations having limited working capital to build resources to match this demand.

2. The National Laboratories and Research & Technology Organisations (RTOs) that make up the IRT sector are independent, and this independence plays a critical role in helping industry to share the costs and risks of innovation and to raise its productivity. These organisations are well placed to develop codes and standards for industry sectors, which can provide for industry efficiency, scale, and export potential.

3. The IRT sector offers people with the right mix of skills and expertise to work effectively and collaboratively across academia, government, industry and finance - a fertile training ground for upskilling UK plc for the future. The UK is world leading in each of these four areas, but there is little cross-fertilisation of people and no common vernacular. People with experience and credibility at communicating in each of these four areas provide the multidisciplinary breadth of capability necessary for successfully translating R&D into commercial success, being able to blend expertise across these four domains.

Throughout AIRTO's consultation with stakeholders during 2018, we have sought to consider and develop understanding on some key issues which are central to R&D activities, including:

• What things are working well to support R&D activities which the government should continue to support?

- What barriers exist to doing R&D in the UK?
- What actions are needed for the UK to successfully stimulate R&D activities?

We conclude that to succeed in lifting R&D activity to 2.4% of GDP over the coming eight years, the government needs to 'gear up to 2.4%' to accelerate investment in the IRT sector as a critical resource for UK plc.

![](_page_28_Picture_11.jpeg)

Left to right: William Duncan (Parliamentary and Scientific Committee), Carol Monaghan MP, Simon Andrews (Fraunhofer Research UK), Alison Thewliss MP.

#### **ABOUT AIRTO**

AIRTO is the Association of Innovation, Research and Technology Organisations. Its membership comprises approximately sixty of the principal organisations operating in the UK's Innovation, Research and Technology (IRT) sector. The IRT sector has a combined turnover of £6.9 billion. employing over 57,000 scientific and technical staff (equivalent to the academic staffing of the Russell Group of universities) and, for comparison, it is significantly larger than the network of Fraunhofer Institutes in Germany both in size and its scope of activities. The sector contributes £34 billion to UK GDP. AIRTO's members work at the interface between academia and industry, for both private and public sector clients. Members include independent Research and Technology Organisations, Catapult Centres, Public Sector Research Establishments, National Laboratories, some

university Technology Transfer Offices and some privately held innovation companies.

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# FLOUR POWER????

![](_page_29_Picture_1.jpeg)

Alan Malcolm Former Executive Secretary of Parliamentary and Scientific Committee

During the past 20 years or so, several hundred babies have been born, unnecessarily, with neural tube defects, such as spina bifida, which government action could have prevented.

The cost to the health service, and support services, has been a few hundreds of millions of pounds. The distress to families and individuals can only be guessed at.

![](_page_29_Picture_5.jpeg)

### HOW COULD THIS HAPPEN?

In the 1960's and 1970's, anecdotal evidence suggested that women with a low level of folic acid (aka folate, a vitamin) in their blood might be at higher risk of having a baby with a neural tube defect, of which spina bifida was the most obvious and the most common.

The UK taxpayer helped to set up an international research project to establish whether this was the case. The results were so overwhelmingly clear that the trial had to be stopped in order to deliver folate supplements to women at higher risk.

The question then was what to do with such findings.

The Medical Research Council had no brief for implementing health policy.

And so a committee, under Dame June Lloyd, was set up. In 1991 it reported with ten recommendations. Not one was implemented.

One was that a campaign be mounted to educate women about the benefits of taking folate supplements in advance of pregnancy. This needed to be taken prior to conception, and continued during the first few weeks following impregnation.

This raised several issues involving human behaviour. Many pregnancies even within what used to be called matrimony are not planned. Teenage pregnancies are often even less planned.

In fact no campaign was initiated, although every year or so a lady journalist in a women's magazine would cover the topic.

#### The question therefore was how to deliver folate to the vulnerable population.

A second, recognizing that the first would fail, was that bread flour (and related products such as breakfast cereals) should be supplemented with folate. Such a strategy had proved outstandingly successful 40 years earlier in the run up to WW2. Bread flour had been supplemented with several vitamins, including B1. Not a single case of beri beri had been reported since. Not a single protest about the addition of "chemicals" to food had been received by any government department.

But life had moved on, and the anti fluoridation campaign still occupied the in tray of many MPs

# Why did government refuse to implement any of the recommendations.

The obvious answer is a lack of "joined up government" Each department who could have been targeted for action ran for cover. MAFF (now known as DEFRA) thought that its responsibility for food stopped at the farm gate.

The Department of Education was sure that the French subjunctive was within its remit, but telling people what to eat definitely was not.

The Health Education Council (since abolished) had spent all its budget on anti smoking. All now rested with those who actually made bread. The industry indicated that it was willing to help, provided two conditions were met. One was that it was made compulsory by law (as was the B1 case), so that rivals could not cut costs by omitting folate. The second was that they could explain to consumers why another chemical was being added to bread and breakfast cereals which was safe, and made bread even more healthy. The government did however act. It set up committees every three years each of which came to the same conclusion – fortifying bread flour would be a good idea.

COMA recommended in 2000 that 240 micrograms of folate per 100g of flour would deliver positive benefits while reducing any significant risk of side effects (eg to elderly males, who were unlikely to fall pregnant)

![](_page_30_Picture_12.jpeg)

![](_page_30_Picture_13.jpeg)

![](_page_30_Picture_14.jpeg)

No way said the government's lawyers. You cannot tell people that eating folate reduces the risk of spina bifida. We know it is true, but it is illegal in UK law. Greengrocers cannot tell shoppers that eating oranges reduces the risk of contracting scurvy, even though a British sailor proved this to be true 250 years ago.

The government could have changed the law to allow it be legal to tell the truth, but did nothing. The Scientific Advisory Committee on Nutrition (SACN) reviewed this topic in 2006, 2009 and 2017 and came to the same conclusion, all to no avail. The government was deaf.

# Not all governments have ignored science with quite the insouciance of the UK.

France, Canada, Australia and even the USA have all implemented a campaign of fortification. It was therefore with delight and relief that the scientific and medical professions greeted Steve Brine's announcement in October 2018 that the government would now set up its seventh committee to review the evidence on mandatory fortification of flour.

Let us hope that his intention is to follow its recommendations - unlike all his predecessors.

![](_page_31_Picture_0.jpeg)

### HOUSE OF COMMONS SELECT COMMITTEES

Current work and Inquiries

#### **SCIENCE & TECHNOLOGY COMMITTEE**

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

#### **CURRENT INQUIRIES** include

#### • My Science Inquiry

*Inquiry announced 09 November 2018* Call for ideas from the public. Report published on 27 February

• Japanese Knotweed and the built environment Inquiry announced 23 October 2017

Oral evidence session on 22 January. No further public meetings scheduled

Digital Government

Inquiry announced 25 July 2018

Oral evidence session on 8 January. No further public meetings scheduled

• Work of the Science Minister and Government Chief Scientific Adviser

*Inquiry announced 11 December 2018* Oral evidence session on 30 January. No further public meetings scheduled

• The work of the biometrics commissioner and the forensic science regulator

*Inquiry announced 12 February 2019* Oral evidence session on 19 March

- Work of the Centre for Data Ethics and Innovation Inquiry announced 31 January 2019 Oral evidence session on 5 February. No further public meetings scheduled
- Brexit, Science and Innovation: Preparations for 'No-Deal'
  preparedness

Inquiry announced 19 December 2018

Oral evidence session on 30 January. No further public meetings scheduled

• Technologies for meeting Clean Growth emissions reduction targets

*Inquiry announced 23 October 2017* Oral evidence session on 26 February

• Balance and effectiveness of research and innovation spending

*Inquiry announced 20 July 2018* Oral evidence session on 18 December. No further public meetings scheduled

#### **RECENTLY CONCLUDED INQUIRIES** include

• Energy drinks

*Inquiry announced 08 March 2018* Report published on 4 December. *Awaiting Government response.* 

Quantum technologies

*Inquiry announced 08 February 2018* Report published on 6 December 2018. *Government response awaited* 

- Evidence-based early-years intervention Inquiry announced 26 October 2017 Report published on 8 February. Government response awaited.
- Research integrity

Inquiry announced 13 September 2017 Reports published

• Impact of social media and screen-use on young people's health

Inquiry announced 21 February 2018 Report published on 31 January. Awaiting Government response.

Flu vaccination programme

*Inquiry announced 1 March 2018* into 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.

Report published 16 October. Government response published on 10 January 2019

• E-cigarettes

*Inquiry announced 25 October 2017* into the health impacts and role of e-cigarettes as a smoking cessation tool. Report published on 17 August 2018. *Government response published on 10 December 2018* 

#### **BUSINESS, ENERGY AND INDUSTRIAL STRATEGY**

This Select 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 OAA Telephone: 020 7219 5777 Email: beiscom@parliament.uk

#### Inquiries

#### **CURRENT WORK** includes

- Carbon capture, usage and storage (CCUS) Oral evidence on 17 January
- Clean Growth Strategy inquiry Oral evidence concluded
- Energy efficiency Oral evidence session on 26 February
- •Gas storage No further public meetings scheduled
- Rolling out smart meters Oral evidence 9 January. No further public meetings scheduled

#### **RECENTLY CONCLUDED INQUIRIES** include

• Electric vehicles: developing the market and infrastructure Report published 16 October 2018 *Government response published 9 January 2019* 

#### **ENVIRONMENTAL AUDIT COMMITTEE**

The remit of the Environmental Audit Select 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 OAA Telephone: 020 7219 5776 Email: eacom@parliament.uk

#### Inquiries

#### **CURRENT WORK** includes

- Chemicals Regulation after the UK has left the EU Oral evidence 4 December 2018. Currently no further public meetings scheduled.
- Planetary Health Inquiry announced 23 November 2018. Oral evidence session on 12 March
- National Audit Office's report on packaging recycling obligations

*Oral evidence session on 12 September 2018.* No further public meetings scheduled.

• Draft Environment (Principles and Governance) Bill Inquiry launched on 20 December 2018. Oral evidence on 27 February 2019.

- Toxic Chemicals in Everyday Life Inquiry launched on 12 February 2019.
- Chinese Waste Import Ban Inquiry launched on 12 January 2019. Oral evidence session on

31 January 2019

#### **RECENTLY CONCLUDED WORK** includes

• The Changing Arctic

*Report published on 6 November 2018.* Awaiting Government response

Hand car washes

*Report published on 15 November.* Government response published 22 January

Nitrates

Report published on 22 November 2018. *Government response* on 24 January 2019

Sustainable seas

Report published on 8 January. Awaiting Government response

- Sustainable Development Goals in the UK follow-up Report published on 10 January 2019
- Sustainability of the Fashion Industry Inquiry launched 22 June 2018. Report published 19 February

#### **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

#### **RECENTLY CONCLUDED WORK** includes

Antimicrobial resistance

Inquiry into the significant and increasing threat to public health in the UK and globally from antimicrobial resistance Report published on Monday 22 October 2018. *Government Response published in January 2019.* 

#### **CURRENT WORK** includes

Drugs policy

*Inquiry announced 04 February 2019* Accepting written submissions; the closing date is Monday 18 March 2019.

- Suicide prevention: follow-up Inquiry announced 10 December 2018 One-off evidence session held on Tuesday 22 January 2019
- Drugs policy: medicinal cannabis Inquiry announced 07 December 2018 Health and Social Care Committee inquiry into Drugs policy: medicinal cannabis

#### • Availability of Orkambi on the NHS

*Inquiry announced 30 November 2018* Accepting written submissions; the deadline is Monday 25 February 2019

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### HOUSE OF LORDS SELECT COMMITTEES

#### 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.

#### WORK IN PROGRESS

#### Forensic science

Inquiry announced 23 July 2018 into what new research programmes are needed in forensic science; the level of understanding within the criminal justice system and what routes are available to improve understanding; the performance of the market for forensic services in the UK; and the detection, recovery, integrity, storage and interpretation of evidence from digital devices and networks.

The deadline for written submissions has passed. Oral evidence sessions taking place.

#### **RECENT REPORTS ISSUED** include

#### Off-site manufacture for construction

Report published 19 July 2018. This states that the construction sector as it currently operates cannot meet the UK's need for housing and may struggle to meet the need for infrastructure. Given that the UK already lags behind other countries in construction productivity, and is facing a labour shortage, the Government and the construction sector must urgently find solutions. Government Response published 9 October 2018. Report debated on 12 December 2018

#### EU ENERGY AND ENVIRONMENT SUB-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.

#### **CURRENT WORK** includes

- Post-Brexit enforcement of environmental law Oral evidence session on 6 February 2019
- Implementation and enforcement of the EU landing obligation Report published on 8 February 2019.

Despite the long lead-in time, when the Committee examined the issue in November and December 2018 they found little evidence of the landing obligation being followed to date and an almost unanimous view that the UK was not ready for full implementation. Without being able to discard fish, fishers may reach their quotas much earlier in the year – particularly in 'mixed fisheries' where it will be hard to avoid catching a species for which there may be a very low quota. The Committee heard that fishers could hit their quota for some species in some areas within a few weeks of the landing obligation coming into force, forcing them to choose between not fishing for the rest of the year (which would have serious financial implications for them) and breaking the law by continuing to fish for other species and discarding anything caught over quota

Awaiting Government Response and Debate.

#### No deal preparations

Oral evidence concluded. Ministerial correspondence on-going.

• Food safety risk management post-Brexit Oral evidence on-going.

#### REACH regulations

Report published 7 November 2018.

The report warns that the Government's preparations for regulating chemicals after Brexit are not progressing quickly enough, risking human and environmental health and with potentially severe consequences for the chemicals sector. Government response published 16 January 2019. Awaiting debate.

#### · Brexit: plant and animal biosecurity

Report published on 24 October 2018.

The report finds that the UK's biosecurity could be at risk after Brexit if it loses access to vital EU alerts on animal and plant pest and disease threats.

Government response published 16 January 2019. Awaiting debate

- Office of Nuclear Regulation's Brexit preparedness Inquiry announced 05 July 2018 into the Brexit preparedness of the Office of Nuclear Regulation.Response from Minister on 1 December 2018.
- Air quality

Inquiry announced 08 June 2018 into the implementation of the EU air quality directive Oral evidence concluded. Response from Minister received 11 October 2018.

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## PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

POST is the academic unit within Parliament that bridges research and policy to ensure that the best available research evidence is brought to bear on the legislative process and scrutiny of Government. It is an office of both Houses of Parliament, overseen by a Board of MPs, Peers and external experts.

POST delivers a number of key services for Parliament:

#### **1. PARTERNING WITH RESEARCH PRODUCERS**

POST runs the Knowledge Exchange Unit, which supports the exchange of information and expertise between researchers and UK Parliament. This includes connecting parliamentarians and parliamentary staff with research producers in academia and industry, providing training for academics on how to engage with Parliament and running @UKParl\_Research, a one-stop shop for all opportunities for researchers to engage with Parliament.

#### 2. INTERNAL KNOWLEDGE EXCHANGE

POST trains staff and Members of both Houses in the effective use and appraisal of research evidence for scrutiny.

#### **3. HORIZON SCANNING**

POST provides proactive assessment and appraisal of future topics that may impact policy. It produces 4-page POSTnotes on emerging topics by interviewing key stakeholders and summarising the body of knowledge in an accessible format.

#### 4. SYNTHESISING RESEARCH EVIDENCE

POST works with the Select Committees and Libraries of both Houses, producing rapid strategic evidence syntheses of the published body of research evidence to support inquiries and Members. These syntheses may be either published as POSTbriefs, or organised into private roundtable events or public seminars.

#### **5. TRAINING**

POST runs PhD Fellowships to allow PhD students gain a firsthand experience of working in a policy environment. Students come to POST for 3 months and either work on a Select Committee Inquiry, with a Library section or produce their own POSTnote.

POST is also developing a Parliamentary Academic Fellowship scheme to allow postdoctoral academics to join Parliament for specific knowledge exchange activities. **POSTnotes** are four-page summaries of public policy issues based on reviews of the research literature and interviews with stakeholders from across academia, industry, government and the third sector. They are peer reviewed by external experts. POSTnotes are produced proactively, so that parliamentarians have advance knowledge of key issues before they reach the top of the political agenda. Those produced recently are:

#### 2019

- 595: Reservoirs of Antimicrobial Resistance
- 594: Limiting Global Warming to 1.5°C
- 593: Cyber Security of Consumer Devices

#### 2018

- 592: Stalking and Harassment
- 591: Robotics in Social Care
- 590: EU Environmental Principles
- 589: Trends in Agriculture
- 588: Reducing UK Use of Antibiotics in Animals
- 587: Flexible Electricity Systems
- 586: Shift Work, Sleep and Health
- 585: Sleep and Health
- 584: Security of UK Telecommunications
- 583: Developing Non-Academic Skills
- 582: Unpaid Care
- 581: Antimicrobial Resistance and Immunisation
- 580: Small Modular Nuclear Reactors
- 579: Persistent Chemical Pollutants
- 578: Biometric Technologies
- 577: Age of Criminal Responsibility
- 576: Relationships and Sex Education
- 575: Fire Safety of Construction Products
- 574: The Microbiome and Human Health
- 573: Health in Private-Rented Housing
- 572: UK Fisheries Management
- 571: The Ageing Process and Health
- 570: Parental Alcohol Misuse
- 569: Overseas Electricity Interconnection

POSTbriefs are reactive briefings that strategically synthesis the primary and secondary scientific literature for the use of Select Committees and Libraries.

#### 2018

- 30: Carbon Capture and Usage
- 29: Sleep and Long-Term Health
- 28: Distributed Ledger Technology
- 27: Topics of Interest 2018

#### **PLANNED WORK**

POST carries out horizon-scanning to anticipate issues of science and technology that are likely to impact on policy.

#### **BIOLOGY AND HEALTH**

#### In production:

- Advances in cancer treatment
- Causes of obesity
- Climate change and vector-borne disease
- Outward medical tourism

#### Scheduled:

- Alternatives to plastic food packaging
- Blockchain technology in the food chain
- Industry influence on public health policy
- researching gambling

#### **ENERGY AND ENVIRONMENT**

#### In production:

- Adaptation and mitigation in agriculture
- Assessing and restoring soil microbiomes
- Climate change and fisheries
- Climate change and wildfire frequency
- Developments in wind power
- Environmental gain
- Food waste
- Natural hazard risk assessment

#### Scheduled:

• Insect population decline

#### PHYSICAL SCIENCES AND ICT

#### In production:

- Chemical weapon
- Integrating health and social care
- Key EU space programmes
- Online safety education for young people

#### Scheduled:

• Civilian drones

#### **SOCIAL SCIENCES**

#### In production:

- Approaches to reducing violent crime, focusing on early interventions
- Behaviour change in health and social care
- Research glossary

#### Scheduled:

• Improving eyewitness testimony

#### PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

Houses of Parliament Westminster London SW1A OAA Telephone: +44 (0) 20 7219 2840 Fax: +44 (0) 20 7219 2849 Email: post@parliament.uk

#### Head of POST

• Dr Grant Hill-Cawthorne: 020 7219 2952

#### Scientific Advisers

- Dr Peter Border (Biology and Health): 020 7219 2876
- Dr Sarah Bunn (Biology and Health): 020 7219 1860
- Dr Lydia Harriss (Physical Sciences and ICT): 020 7219 8380
- Dr Lorna Christie (Physical Sciences and ICT): 020 7219 5829
- Dr Jonny Wentworth (Environment and Energy): 020 7219 2161
- Jack Miller (Environment and Energy): 020 7219 1159
- Dr Abbi Hobbs (Social Sciences): 020 7219 2841
- Dr Rowena Bermingham (Social Sciences): 020 7219 1729

#### Science communication, publications, and events

• Lef Apostolakis (Science Communication Manager): 020 7219 8973

#### Knowledge Exchange

- Dr Sarah Foxen (Knowledge Exchange Manager): 020 7219 2382
- Naomi Saint (Knowledge Exchange Manager): 020 7219 2840

#### Office administration

• Yasmin McNeil (Team Manager): 020 7219 284

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## **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 What if there's no Brexit deal? http://researchbriefings.files.parliament.uk/ documents/CBP-8397/CBP-8397.pdf This has a section on Higher education, science and research

We have recently also published, and continue to update, briefings on issues such as

• Civilian drones Published Monday, February 11, 2019 This paper outlines current regulations for the use of recreational and commercial drones in the UK. It also presents recent policy development in the UK and internationally, as well as emerging technological and regulatory issues related to drone integration into domestic airspace.

• New Nuclear Power Published Thursday, January 17, 2019 This paper summarises current progress on nuclear power, including conventional reactors, advanced designs, waste disposal and nuclear research.

• Mobile Coverage in the UK Published Tuesday, January 15, 2019 A Briefing Paper on mobile coverage in the UK. It provides mobile coverage statistics and information about recent reforms and proposals aimed at improving mobile coverage in rural areas.

#### • Climate change conference (COP24): Katowice, Poland

Published Wednesday, January 9, 2019 This short Briefing Paper provides a brief overview of the twentyfourth UN conference on climate change, held in December 2018, including information on the Paris Agreement, the Talanoa Dialogue and the People's Seat.

#### • Research and development spending

Published Friday, December 21, 2018 R&D spending in the UK. Including analysis of R&D by region and industry, and international comparisons of R&D.

#### • UK funding from the EU

Published Wednesday, November 28, 2018 This briefing looks at the funding received by the UK from EU institutions and considers the implications of Brexit on the EU as a source of funding for regional development, agriculture support, research and innovation and other areas.

#### • Full-fibre networks in the UK

Published Tuesday, November 13, 2018 A briefing on the Government's policy for building a UK-wide fullfibre broadband network by 2033. It covers what is full-fibre broadband compared to superfast broadband and the Government's strategy for promoting full-fibre set out in its Future Telecoms Infrastructure Review (FTIR), published in July 2018

#### • Superfast Broadband in the UK

Published Tuesday, November 13, 2018 A Briefing on the Government's superfast broadband policy for the UK. It sets out the current situation for superfast broadband access and coverage in all four nations of the UK, and how the roll-out of superfast broadband is being managed and funded. Data and maps on superfast broadband connectivity and speeds are also included.

#### • Brexit: energy and climate change

Published Friday, November 9, 2018 A Briefing Paper discussing key energy and climate change policy in the UK, the status of related Brexit negotiations and the possible impact of Brexit on these policy areas, including in relation to a no deal scenario.

#### Previous reports cover

- New Nuclear Power
- Shale gas and fracking
- Brexit: energy and climate change
- Full-fibre networks in the UK
- Automated and Electric Vehicles Act 2018
- Distributed Ledger Technology
- In Vitro Fertilisation: 40th Anniversary
- NHS and Healthcare Data
- Security of UK Telecommunications
- Animal Sentience and Brexit
- Leaving the EU: Antimicrobial Resistance
- Antimicrobial Resistance and Immunisation
- Small Modular Nuclear Reactors
- Biometric Technologies

We would be pleased to hear from anyone who wants to know more about how the Library works or how we can help with Parliamentary duties. Please contact Ed Potton (pottone@parliament.uk) in the first instance. If you want to keep up to date with what we are up to, you can follow us @CommonsLibrary or visit www.commonslibrary.parliament.uk.

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Operating across the whole of the UK with a combined budget of more than £6 billion, UK Research and Innovation brings together the seven Research Councils, Innovate UK and Research England.

We are an independent organisation with a strong voice for research and innovation, both to government and internationally, we are supported and challenged by an independent chair and board. We are principally funded through the Science Budget by the Department for Business, Energy and Industrial Strategy (BEIS).

Our mission is to be a trusted partner and to ensure research and innovation continues to flourish in the UK. We will support and help connect the best researchers and innovators with customers, users and the public. We will invest every pound of taxpayers' money wisely in a way that maximises impact for citizens, in the UK and across the world.

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Arts & Humanities Research Council

Contact: Mike Collins Head of Communications AHRC, Polaris House, Swindon, SN2 1EU Tel: 01793 416083 E-mail: m.collins@ahrc.ukri.org Website: www.ahrc.ukri.org

AHRC funds world-class, independent researchers in a wide range of subjects. Their research provides social and cultural benefits and contributes to the economic success of the UK but also to the culture and welfare of societies around the globe.

### EPSRC

Engineering and Physical Sciences Research Council

Contact: Ciara McLoone Communications Manager for Government and Parliament EPSRC, Polaris House, Swindon, SN2 1ET Tel: 01793 444 080 E-mail: Ciara.mcloone@epsrc.ukri.org Website: www.epsrc.ukri.org

EPSRC funds engineering and physical sciences research, covering fields from healthcare technologies to structural engineering, manufacturing to mathematics, advanced materials to chemistry.

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Contact: Sarah Miles External Affairs Manager NERC, Polaris House, Swindon, SN2 1EU Tel: 01793 442 505 E-mail: Sarah.Miles@nerc.ukri.org Website: www.nerc.ukri.org

NERC is the driving force of investment in environmental science. Their leading research, skills and infrastructure help solve major issues and bring benefits to the UK, such as affordable clean energy, air pollution, and resilience of our infrastructure.

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Contact: Dr Kate Turton Head of Engagement and Insight BBSRC, Polaris House, North Star Avenue, Swindon SN2 1UH Tel: 01793 413355 E-mail: kate.turton@bbsrc.ukri.org Website: www.bbsrc.ukri.org

BBSRC invests in world-class bioscience research and training. Their research is helping society to meet major challenges, including food security, green energy and healthier, longer lives and underpinning important UK economic sectors.

### Innovate UK

Contact: Nick Spickernell

Government & Parliamentary Analyst Innovate UK, Polaris House, Swindon, SN2 1ET Tel: 07767 272711

E-mail: Nick.spickernell@innovateuk.ukri.org Website:

www.gov.uk/government/organisations/innovate-uk

Innovate UK works with people, companies and partner organisations to find and drive the science and technology innovations that will grow the UK economy. They drive growth by working with companies to de-risk, enable and support innovation.

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Contact: Ben Johnson Associate Director, Insight and Engagement Research England, Nicholson House, Lime Kiln Close, Stoke Gifford, Bristol, BS34 8SR Tel: 0117 931 7038 E-mail: Ben.Johnson@re.ukri.org Website: re.ukri.org

Research England is a new council within UK Research and Innovation. Taking forward the England-only responsibilities of HEFCE in relation to research and knowledge exchange, Research England will create and sustain the conditions for a healthy and dynamic research and knowledge exchange system in English universities.

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Contact: Susie Watts External Affairs Strategy Lead ESRC, Polaris House, Swindon, SN2 1EU Tel: 01793 413119 E-mail: Susie.watts@esrc.ukri.org Website: www.esrc.ukri.org

ESRC is the UK's largest funder of research on the social and economic questions facing us today. Their research shapes public policy and contributes to making the economy more competitive, as well as giving people a better understanding of 21st century society.

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Contact: Darren O'Keefe Public Affairs and Policy Manager Tel: 0207 395 2297 E-mail: Darren.O'Keefe@mrc.ukri.org Website: www.mrc.ukri.org

MRC is at the forefront of scientific discovery to improve human health. Their scientists tackle some of the greatest health problems facing humanity in the 21st century, from the rising tide of chronic diseases associated with ageing to the threats posed by rapidly mutating micro-organisms.

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Contact: Natalie Bealing MCIPR Head of Stakeholder Engagement Tel: 01235 445484 E-mail: natalie.bealing@stfc.ukri.org Website: www.stfc.ukri.org

STFC is a world-leading multi-disciplinary science organisation. Their research seeks to understand the Universe from the largest astronomical scales to the tiniest constituents of matter, yet creates impact on a very tangible, human scale.

#### Association of the British Pharmaceutical Industry

Contact: Audrey Yvernault Head of Policy and Public Affairs 7th Floor, Southside, 105 Victoria Street, London SW1E 6QT Tel: 020 7747 7136 Email: AYvernault@abpi.org.uk Website: www.abpi.org.uk

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

Contact:

Vaccines, biosimilars, small and large molecules, cell therapy and regenerative medicine

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Colin Danson Distinguished Scientist & Head of Profession for Physics and Mathematics AWE Aldermaston, Reading RG7 4PR Email: Colin.Danson@awe.co.uk www.awe.co.uk Tel: 0118 98 56901 AWF plavs a crucial role in our nation's defence by providing

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 Governmentowned-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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Contact: Ben Connor, Policy Manager British Ecological Society 12 Roger Street, London WC1N 2JU Email: ben@britishecologicalsociety.org Tel: 020 7685 2510 Website: www.BritishEcologicalSociety.org Twitter: @BESPolicy

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 evidenceinformed approach to finding the right solutions to environmental questions.

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Contact: Dr Jane Gate, Executive Director AIRTO Ltd: Association of Innovation Research & Technology Organisations Ltd c/o National Physical Laboratory Hampton Road, Teddington Middlesex TW11 0LW Tel: 020 8943 6600 E-mail: enquiries@airto.co.uk Twitter: @airtoinnovation Website: www.airto.co.uk

AIRTO, the Association of Innovation, Research and Technology Organisations, comprises approximately sixty principal organisations operating in the UK's Innovation, Research and Technology (IRT) sector. The IRT sector has a combined turnover of £6.9Bn, employs over 57,000 people and contributes £34Bn to UK GVA. AIRTO's members work at the interface between academia and industry, for both private and public sector clients. Members include independent Research and Technology Organisations, Catapult Centres, Public Sector Research Establishments, National Laboratories, some university Technology Transfer Offices and some privately held innovation companies.

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Contact: Hannah Russell Director of Society Programmes Biochemical Society Charles Darwin House, 12, Roger Street, London WC1N 2JU Tel: +44 (0)20 7685 2439 Email: Hannah.russell@biochemistry.org Website: www.biochemistry.org

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.

#### British In Vitro Diagnostics Association (BIVDA)

Contact: Doris-Ann Williams MBE Chief Executive British In Vitro Diagnostics Association 299 Oxford Street, London W1C 2DZ Tel: 0845 6188224 Email: doris-ann@bivda.co.uk

www.bivda.org.uk

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. AMPS Management and Professional Staffs

Contact: Tony Harding 07895 162 896 for all queries whether for membership or assistance. Branch Office Address: Merchant Quay, Salford Quays, Salford M50 3SG.

#### Website: www.amps-tradeunion.com

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

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

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

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Contact: Linda Capper, MBE, MCIPR Head of Communications British Antarctic Survey High Cross Madingley Road Cambridge CB3 0ET Email LMCA@bas.ac.uk Tel: +44 (0)1223 221448 Mobile: 07714 233744

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 uf Antarctic affairs. For more information visit www.bas.ac.uk @basnews

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Contact: Jonathan Brüün Chief Executive British Pharmacological Society The Schild Plot, 16 Angel Gate, City Road, London EC1V 2PT Tel: : 020 7239 0171 Fax: 020 7417 0114 Email: jonathan.bruun@bps.ac.uk Website: www.bps.ac.uk

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.

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Tracey Guise, Chief Executive Officer British Society for Antimicrobial Chemotherapy (BSAC) 53 Regent Place, Birmingham B1 3NJ +44 (0)121 236 1988

tguise@bsac.org.uk www.bsac.org.uk

BSAC is a learned society whose members are among the world's leading infectious disease physicians, pharmacists, microbiologists, and nurses.

With more than 45 years of leadership in antibiotic research and education, BSAC is dedicated to saving lives by fighting infection. It does this by supporting a global network of experts via workshops, conferences, evidence-based guidelines, e-learning courses, and its own high-impact international journal.

BSAC also provides national surveillance and susceptibility testing programmes, an outpatient parenteral antimicrobial therapy (OPAT) initiative, research and development grants, and the secretariat for the All-Party Parliamentary Group on Antibiotics.

 $\mathsf{BSAC}$  has members in 40 nations and active learners in more than 135 countries.

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Contact: Geoff Rodgers Brunel University London Kingston Lane Uxbridge UB8 3PH Tel: 01895 265609 Fax: 01895 265740 E-mail: g.j.rodgers@brunel.ac.uk Website: www.brunel.ac.uk

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

Institute of Energy Futures: Led by Professor Sawas 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 Joblina leads this pioneering research institute whose themes are Health

Initiate of Environment, Health and Societies: Professor Luc virobel. Institute of Environment, Health and Societies: Professor Susar Jobling leads this pioneering research institute whose themes are Health and Environment, Healthy Ageing, Health Economics Synthetic Biology, Biomedical Engineering and Healthcare Technologies, and Socia Sciences and Health.

Swerness and retail... 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.

![](_page_39_Picture_15.jpeg)

Contact: Dr Christopher Flower Josaron House 5-7 John Princes Street London W1G 0JN Tel: 020 7491 8891 E-mail: info@ctpa.org.uk Website: www.ctpa.org.uk & www.thefactsabout.co.uk

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

Contact Dr Doug Brown, CEO British Society for Immunology 34 Red Lion Square Holborn London WC1R 4SG Tel: 020 3019 5901 E-mail: bis@immunology.org Website: www.immunology.org

The British Society for Immunology's mission is to promote excellence in immunological research, scholarship and clinical practice in order to improve human and animal health. We are the leading UK membership organisation working with scientists and clinicians from academia and industry to forward immunology research and application around the world. Our friendly, accessible community of over 3,500 immunologists gives us a powerful voice to advocate for immunological science and health for the benefit of society.

## Cavendish Laboratory

Contact: Departmental Administrator,

The Cavendish Laboratory, J J Thomson Avenue, Cambridge CB3 0HE, UK. E-mail: glw33@cam.ac.uk http://www.phy.cam.ac.uk

nttp://www.pny.cam.ac.u

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

![](_page_39_Picture_32.jpeg)

Contact: Dr Eric Albone MBE Clifton Scientific Trust 49 Northumberland Road, Bristol BS6 7BA Tel: 0117 924 7664 Fax: 0117 924 7664 E-mail: eric.albone@clifton-scientific.org Website: www.clifton-scientific.org

#### Science for Real- Science for Life-Science for Citizenship and Employability

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

- encountering science as a creative, questioning, collaborative human activity
- bringing school science added meaning and motivation, from primary to post-16
- locally, nationally, internationally (our UK-Japan Young Scientist Workshop Programme in since 2001)

Clifton Scientific Trust Ltd is registered charity 1086933

![](_page_39_Picture_40.jpeg)

Contact: Ian Brown Building 42a Cranfield University Cranfield Bedfordshire United Kingdom

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.

Nowadays BSSS is an established international membership organisation and charity committed to the study of soil in its widest aspects. The Society acts as a forum for the exchange of ideas and provides a framework for representing the views of soil scientists to other organisations and decision making bodies. It promotes research by organising several conferences each year and by the publication of its two scientific journals, the European Journal of Soil Science, and Soil Use and Management.

![](_page_39_Picture_44.jpeg)

Stephen Barraclough Chief Executive s.barraclough@ergonomics.org.uk +44 7736 89 33 44 www.ergonomics.org.uk

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.

![](_page_39_Picture_47.jpeg)

Contact: Lindsay Walsh De Morgan House 57-58 Russell Square London WC1B 4HS Tel: 020 7637 3686 Fax: 020 7323 3655 Email: cms@lms.ac.uk Website: www.cms.ac.uk

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

![](_page_40_Picture_1.jpeg)

Contact: Dr Katie Perry Chief Executive The Daphne Jackson Trust Department of Physics University of Surrey, Guildford GU2 7XH Tel: 01483 689166 Email: Katie.perry@surrey.ac.uk Website: www.daphnejackson.org

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.

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Contact: Director of Science Fera Science Ltd. (Fera) Sand Hutton, York, YO41 1LZ Tel: 01904 462000 E-mail: chiefscientistoffice@fera.co.uk Website: www.fera.co.uk

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 agriinformatics services ensure that our customers have access to leading edge science, technology and expertise.

![](_page_40_Picture_8.jpeg)

serving science, profession & society

Contact: Florence Bullough Head of Policy and Engagement Burlington House Piccadilly London W1J 0BG Tel: 020 7434 9944 Fax: 020 7439 8975 E-mail: florence.bullough@geolsoc.org.uk Website: www.geolsoc.org.uk

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.

![](_page_40_Picture_12.jpeg)

Contact: Louise Kingham OBE FEI Chief Executive 61 New Cavendish Street London W1G 7AR Tel: 020 7467 7100 Email: info@energyinst.org Website: www.energyinst.org

The Energy Institute (EI) is the chartered professional membership body bringing global energy expertise together. Our ambition is that energy, and its critical role in our world, is better understood, managed and valued. We're a unique network with insight spanning the world of energy, from conventional oil and gas to the most innovative renewable and energy efficient technologies. We gather and share essential knowledge about energy, the skills that are helping us all use it more wisely, and the good practice needed to keep it safe and secure. We articulate the voice of energy experts, taking the knowhow of around 20,000 members and 250 companies from 120 countries to the heart of the public debate. And we're an independent, not-for-profit, safe space for evidence-based collaboration, an honest broker between industry, academia and policy makers.

![](_page_40_Picture_15.jpeg)

Contact: Mac Andrade Director Infrastructure First Group 4th Floor, Capital House 25 Chapel Street London NW1 5DH E-mail: mac.andrade@firstgroup.com

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.

![](_page_40_Picture_18.jpeg)

Contact: Lynda Rigby, Executive Head of Marketing and Membership Institute of Biomedical Science, 12 Coldbath Square, London, EC1R 5HL Tel: 020 7713 0214 Email: mc@ibms.org Twitter: @IBMScience Website: www.ibms.org

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.

![](_page_40_Picture_23.jpeg)

Gemma Wood Head of Public Affairs EngineeringUK 5th Floor, Woolgate Exchange Basinghall Street London EC2V 5HA Tel: 0203 206 0441 Mob: 07734 768 242 www.EngineeringUK.com

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.

![](_page_40_Picture_26.jpeg)

Contact: Steven Brambley Rotherwick House 3 Thomas More Street London, E1W 1YZ Tel: 020 7642 8080 E-mail: info@gambica.org.uk Website : www.gambica.org.uk

GAMBICA is the voice of the laboratory technology, instrumentation, control and automation industries, providing influence, knowledge and community. We offer members a common platform for voicing their opinions and representing their common interests to a range of stakeholders. GAMBICA seeks to spread best-practice and be thought leaders in our sectors.

![](_page_40_Picture_29.jpeg)

Contact: Delia Mertoiu 5 Cambridge Court 210 Shepherds Bush Road London W6 7NJ Tel: 020 7603 6316 E-mail: info@ifst.org Website: www.ifst.org

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.

![](_page_41_Picture_1.jpeg)

Contact: Michelle Medhat Institute of Innovation & Knowledge Exchange **Rex House** 4 – 12 Regent Street London SW1Y 4PE www. InnovationInstitute.org.uk

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 Measurement and Control

Contact: Dr. Patrick A Finlay Chief Executive Officer The Institute of Measurement and Control 87 Gower Street, London WC1E 6AF Tel: +44 (0) 20 73874949 E-mail: ceo@instmc.org Website: www.instmc.org 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 Technician (EnaTech).

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

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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.

Alana Collis, Technical policy manager +44 (0) 1788 534459 acollis@icheme.org www.icheme.ora

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

![](_page_41_Picture_14.jpeg)

Contact: Bev Mackenzie Institute of Marine Engineering, Science and Technology (IMarEST), Aldgate House, 33 Aldgate High Street, London, EC3N 1EN

Tel: +44(0) 20 7382 2600 Fax: +44(0) 20 7382 2667 E-mail: technical@imarest.org Website: www.imarest.org

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.

### **IOP** Institute of Physics

Contact: Alex Connor 76 Portland Place, London W1B 1NT Tel: 020 7470 4819 E-mail: alex.connor@iop.org Website: www.iop.org

The Institute of Physics is the professional body for physics in the UK and Ireland, inspiring people to develop their understanding and enjoyment of physics. We are a world-leading science publisher and proud to be a trusted voice for the physics community.

Our work includes supporting the teaching of physics, encouraging innovation in business and providing evidence-based advice to Government. Our members are from across the physics community - in academia, the classroom, and industry - and our reach extends to all who have an interest in physics and its contribution our culture, society and economy.

#### Institution of Civil Engineers

![](_page_41_Picture_23.jpeg)

Contact: Alex Green-Wilkes, Public Affairs Manager, One Great George Street, Westminster, London SW1P 3AA, UK Tel: 020 7665 2109 E-mail: alex.green-wilkes@ice.org.uk Website: www.ice.org.uk

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.

#### The Institute of Materials Finishing

Contact: Dr Trevor Crichton FIMF; MInstCorr; MRSC; CChem. Email : exeterhouse@materialsfinishing.org Tel : 0121 622 7387

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.

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#### Institute of **Physics and** Engineering in Medicine

Contact: Rosemary Cook CBE (CEO) Fairmount House, 230 Tadcaster Road, York, YO24 1ES Tel: 01904 610821 Fax: 01904 612279 E-mail: rosemary.cook@ipem.ac.uk Website: www.ipem.ac.uk

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 bioengineers, 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.

![](_page_41_Picture_34.jpeg)

Contact: Joanna Cox IFT Michael Faraday House Six Hills Way Stevenage SG1 2AY Tel: +44(0)1438 765690 Email: policy@theiet.org Web: www.theiet.org

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.

![](_page_42_Picture_0.jpeg)

![](_page_42_Picture_1.jpeg)

Contact: Dr Julian Braybrook Queens Road, Teddington Middlesex, TW11 0LY Tel: +44 (0)20 8943 7000 Fax: +44 (0)20 8943 2767 E-mail: info@lgcgroup.com Website: www.lgcgroup.com

LGC is an international leader in the extended life sciences sector, providing reference materials, genomics reagents and instrumentation, as well as research and measurement services, 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 measurement for matters of policy, standards and regulation. LGC is also the UK's National Measurement Laboratory for chemical and bio-measurement.

With headquarters in Teddington, South West London, LGC has 46 laboratories and centres across Europe and at sites in China, Brazil, India, South Africa and the US.

![](_page_42_Picture_6.jpeg)

London School of Hygiene & Tropical Medicine Contact: Professor Peter Piot, Director Keppel Street, London, WC1E 7HT Tel: 020 7636 8636 Email: director@lshtm.ac.uk www.lshtm.ac.uk

The London School of Hygiene & Tropical Medicine (LSHTM) is a world-leading centre for research and postgraduate education in public and global health with over 4,000 students and more than 1,300 staff working in over 100 countries across the world – including at two MRC Units in The Gambia and Uganda which joined LSHTM in 2018. Our depth and breadth of expertise encompasses many disciplines, and we are one of the highest-rated research institutions in the UK.

![](_page_42_Picture_9.jpeg)

Contact: Kirsty McBeath Met Office, Fitzroy Road, Exeter, EX1 3PB Email: kirsty.mcbeath@metoffice.gov.uk Website: www.metoffice.gov.uk

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.

![](_page_42_Picture_12.jpeg)

Contact: Steve Shiel Director of Scientific, Regulatory and Corporate Affairs, L'Oréal UK & Ireland 255 Hammersmith Road, London W6 8AZ Tel: +44(0)20-8762-4489 E-mail: Steve.SHIEL@loreal.com Website: www.loreal.co.uk

L'Oréal employs more than 3,800 researchers world-wide and dedicates over €877 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

Contact: Dr Matthew Frost Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, PL1 2PB Tel: 07848028388 Fax: 01752 633102 E-mail: matfr@mba.ac.uk Website: mba.ac.uk

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.

![](_page_42_Picture_18.jpeg)

Contact: Policy Officer Microbiology Society Charles Darwin House 12 Roger Street London WC1N 2JU Tel: 020 7685 2400 E-mail: policy@microbiologysociety.org Website: www.microbiologysociety.org

The Microbiology Society is a membership charity for scientists interested in microbes, their effects and their practical uses. It is one of the largest microbiology societies in Europe with a worldwide membership based in universities, industry, hospitals, research institutes and schools.

Our principal goal is to develop, expand and strengthen the networks available to our members so that they can generate new knowledge about microbes and ensure that it is shared with other communities. The impacts from this will drive us towards a world in which the science of microbiology provides maximum benefit to society.

![](_page_42_Picture_22.jpeg)

Contact: Dr Elizabeth Rollinson, Executive Secretary The Linnean Society of London Burlington House, Piccadilly, London W1J 0BF Tel: 020 7434 4479 ext 212 E-mail: elizabeth@linnean.org Website: www.linnean.org

As the world's oldest active biological society, the Linnean Society is an essential forum and meeting point for those interested in the natural world. The Society holds regular public lectures and events, publishes three peer-reviewed journals, and promotes the study of the natural world with several educational initiatives. The Society 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

#### Institution of MECHANICAL ENGINEERS

Contact: Paul Haines Head of Content & Communications 1 Birdcage Walk London SW1H 9JJ Tel: +44 (0)20 7304 6833 E-mail: P\_haines@imeche.org Website: www.imeche.org

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.

![](_page_42_Picture_29.jpeg)

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

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

![](_page_43_Picture_1.jpeg)

Contact: John Jackson

Head of Science Policy and Communication Natural History Museum Cromwell Road, London SW7 5BD Tel: +44 (0)20 7942 5257 E-mail: j.jackson@nhm.ac.uk Website: www.nhm.ac.uk

We challenge the way people think about the natural world  $- \ensuremath{\text{its}}$  past, present and future

We use our unique collection and unrivalled expertise to tackle the biggest challenges facing the world today. We are leaders in the scientific understanding of the origin of our planet, life on it and can predict the impact of future

of our planet, life on it and can predict the impact of future change. We study the diversity of life and the delicate balance of

ecosystems to ensure the survival of our planet. We help enable food security, eradicate disease and manage

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

![](_page_43_Picture_9.jpeg)

Contact: Mark Hollingsworth Chief Executive Officer The Nutrition Society 10 Cambridge Court, 210 Shepherds Bush Road, London, W6 7NJ, UK Email: office@nutritionsociety.org Tel: +44 (0)20 7602 0228 www.nutritionsociety.org

The Nutrition Society is a not for profit, membership organisation which is dedicated to delivering its mission of advancing the scientific study of nutrition and its application to the maintenance of human and animal health. Highly regarded by the scientific community, the Society is one of the largest learned societies for nutrition in the world and anyone with a genuine interest in the science of human or animal nutrition can become a member.

### QUADRUM INSTITUTE

![](_page_43_Picture_13.jpeg)

Contact: Laura Knight Head of Corporate Affairs Quadram Institute Bioscience, Norwich Research Park, NR4 7UA Tel: 01603 255000/5310 Email: laura.knight@quadram.ac.uk Website: www.quadram.ac.uk

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.

![](_page_43_Picture_16.jpeg)

Contact: Nick Allen Executive Officer Boughton Green Road, Northampton, NN2 7AL Tel: 01604 735500 Fax: 01604 716502 E-mail: nick.allen@northampton.ac.uk Website: www.northampton.ac.uk

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.

![](_page_43_Picture_19.jpeg)

Contact: Henry Lovett Policy & Public Affairs Officer Hodgkin Huxley House 30 Farringdon Lane London EC1R 3AW Tel: +44 (0) 20 7269 5722 E-mail: hlovett@physoc.org Website: www.physoc.org

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.

![](_page_43_Picture_23.jpeg)

Contact: Juniour Blake External Relations Manager Royal Academy of Engineering 3 Carlton House Terrace London SW1Y 5DG Tel: 020 7766 0600 E-mail: juniour.blake@raeng.org.uk Website: www.raeng.org.uk

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.

# The University of Nottingham

UNITED KINGDOM · CHINA · MALAYSIA

Contact: Alex Miles Deputy Director, External Relations (Public Affairs) University Park, Nottingham, NG7 2RD E-mail: alex.miles@nottingham.ac.uk Mobile: 07917115197 Twitter: @AlextoMiles www.nottingham.ac.uk

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.

![](_page_43_Picture_30.jpeg)

Contact: Sue Ferns, Director of Communications and Research, New Prospect House 8 Leake St, London SE1 7NN Tel: 020 7902 6639 Fax: 020 7902 6637 E-mail: sue.ferns@prospect.org.uk www.prospect.org.uk

Prospect is an independent, thriving and forwardlooking 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.

![](_page_43_Picture_34.jpeg)

Contact: Office of the Science Directorate Royal Botanic Gardens, Kew Richmond, Surrey, TW9 3AB Tel: 020 8332 5050/5248 Email: scienceadmin@kew.org Website: www.kew.org

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.
- 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

Contact: Dr Gail Cardew Director of Science and Education The Royal Institution 21 Albemarle Street, London W1S 4BS Tel: 020 7409 2992 Fax: 020 7670 2920 E-mail: gcardew@ri.ac.uk Websites: www.rigb.org, www.richannel.org Twitter: ri\_science

The Royal Institution (Ri) has been at the forefront of public engagement with science for over 200 years and our purpose is to encourage people to think further about the wonders of science. We run public events and the famous CHRISTMAS LECTURES<sup>®</sup>, 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.

![](_page_44_Picture_4.jpeg)

Contact: Matt Davies Parliamentary Affairs Manager Policy and Campaigns Royal Society of Chemistry, Thomas Graham House (290), Science Park, Milton Road, Cambridge, CB4 0WF Tel 020 7440 2267 Email vineyc@rsc.org Website: www.rsc.org

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 notfor-profit organisation with 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

#### Society of Chemical Industry

SCI: where science meets business

Contact: Sharon Todd SCI 14-15 Belgrave Square London SW1X 8PS Tel: 020 7598 1500 E-mail: sharon.todd@soci.org Website www.soci.org

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

![](_page_44_Picture_14.jpeg)

Contact: Becky Purvis Head of Public Affairs The Royal Society, 6-9 Carlton House Terrace London SW1Y 5AG. Tel: 020 7451 2261 Email: becky.purvis@royalsociety.org Website: www.royalsociety.org

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.

![](_page_44_Picture_18.jpeg)

Contact: Dr Christopher Brown, Policy Officer Charles Darwin House, 12 Roger Street, London, WC1N 2JU Christopher@sfam.org.uk +44 (0)207 685 2596

SfAM is a UK organization, serving microbiologists internationally. It works to advance, for the benefit of the public, the science of microbiology in its application to the environment, human and animal health, agriculture, and industry. With Wiley-Blackwell, SfAM publishes five internationally acclaimed journals. Value for money and a modern, innovative and progressive outlook are its core principles. A friendly society, SfAM values integrity, honesty, and respect, and seeks to promote excellence and professionalism and to inspire young microbiologists.

#### Society of Cosmetic Scientists

Contact: Gem Bektas, Secretary General Society of Cosmetic Scientists Suite 109 Christchurch House 40 Upper George Street Luton Bedfordshire LU1 2RS Tel: 01582 726661 Fax: 01582 405217 E-mail: secretariat@scs.org.uk Website: www.scs.org.uk

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

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

![](_page_44_Picture_25.jpeg)

Contact: Dr Stephen Benn Director of Parliamentary Affairs Royal Society of Biology Charles Darwin House 12 Roger Street London WC1N 2JU Tel: 020 7685 2400 E-mail: stephen.benn@rsb.org.uk Website: www.rsb.org.uk

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 evidencebased 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.

#### Society for Underwater Technology

![](_page_44_Picture_29.jpeg)

Society for Underwater Technology Contact: David Liddle, Business Development Executive 1 Fetter Lane, London EC4A 1 BR Tel: 020 3440 5535 Fax: 020 3440 5980 E-mail: info@sut.org Website: www.sut.org

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.

![](_page_44_Picture_32.jpeg)

Contact: John Murray Society of Maritime Industries 28-29 Threadneedle Street, London EC2R 8AY Tel: 020 7628 2555 Fax: 020 7638 4376 E-mail: info@maritimeindustries.org Website: www.maritimeindustries.org

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.

![](_page_45_Picture_1.jpeg)

Contact: Dr Andrew Muir c/o STFC Innovations Ltd Harwell Campus Oxford OX11 0QX Tel: 0121 710 1990 E-mail: Andrew.muir@midven.co.uk Website: https://ukinnovationscience seedfund.co.uk/

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.

#### Universities Federation for Animal Welfare

Contact: Dr Robert Hubrecht OBE Chief Executive and Scientific Director The Old School, Brewhouse Hill Wheathampstead, Herts. AL4 8AN. Tel: 01582 831818. Fax: 01582 831414. Email: ufaw@ufaw.org.uk Website: www.ufaw.org.uk Registered in England Charity No: 207996

UFAW, 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.

Contact: Chris Magee Head of Policy and Media Understanding Animal Research Hodgkin Huxley House 30 Farringdon Lane, London EC1R 3AW direct tel: 020 3675 1234 email: cmagee@UAR.ORG.UK http://www.understandinganimalresearch.org. uk/

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.

![](_page_45_Picture_14.jpeg)

Contact: Chris Eady The Welding Institute, Granta Park, Great Abington, Cambridge, CB21 6AL

Tel: 01223 899614 Fax:01223 894219 E-mail: chris.eady@twi.co.uk Website: www.twi-global.com

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.

![](_page_45_Picture_21.jpeg)

Contact: Dr Rob Singh Deputy Director, Enterprise Wivenhoe Park Colchester CO4 3SQ T 01206 874278 E rjsingh@essex.ac.uk W www.essex.ac.uk/business

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.

# SCIENCE DIARY

#### PARLIAMENTARY AND SCIENTIFIC Further discussion meetings being arranged COMMITTEE

Tel: 020 7222 7085 Email: office@scienceinparliament.org.uk www.scienceinparliament.org.uk follow us on Twitter @ParlSciCom

Evening Discussion Meetings followed by dinner

#### Monday 25 March at 5.30pm -Nutritional Challenges for a growing and ageing population

This joint meeting with the Nutritional Society will bring together leading researchers in nutritional science to discuss the evidence of ageing and nutrition from biochemistry/mechanisms through to the importance of conditions associated with both ageing and nutrition. This will then lead to a discussion on the resultant public health and social care implications and challenges of poor nutrition and ageing. Speakers will include:

- · Professor Ilaria Bellantuono, University of Sheffield: General physical and functional decline with ageing - the health & social costs.
- · Professor Emma Stevenson, University of Newcastle: The role of nutrition and activity in healthy musculoskeletal ageing.
- · Professor Philip C. Calder, University of Southampton: Micronutrient intervention to prevent age-related immune decline.

(subject to confirmation) are expected to include:

- Monday 20 May at 5.30pm: Throwaway Waste and Disposable Fashion
- Monday 17 June at 5.30pm: Fake News
- Monday 8 July at 5.30pm: STEM and Diversity
- Monday 9 September at 5.30pm: AI and Health
- Monday 14 October at 5.30pm: Climate Change – is there a Plan B?
- Monday 11 November at 5.30pm: Extinctions
- Monday 2 December at 5.30pm: Noise

Annual Lunch - Tuesday 19 November at 12.30

#### **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.

#### **ROYAL SOCIETY OF BIOLOGY** 12 March from 08.00 - 12.00: Voice of the Future 2019 in the Boothroyd Room, Portcullis House.

Young scientists and engineers will question MPs and Ministers about the issues that matter to them.

#### 24 March at 19.00: **Degree Accreditation Awards Ceremony** on the Terrace Pavilion.

The annual Degree Accreditation Awards Ceremony celebrates biosciences in higher education, both in the UK and internationally, and will showcase top projects by graduates at accredited higher education institutions.

#### Tuesday 25 June at 10.00: Parliamentary Links Day in the Attlee Suite, Portcullis House

Details of all events can be found on www.rsb.org.uk/events

#### SCIENCE LECTURE – HOSTED BY MR SPEAKER

#### Wednesday 15 May at 18.30: Speaker's **State Apartments**

Lecture by Dame Nancy Rothwell, DBE DL FRS FMedSci Co-Chair of the Prime Minister's Council for Science and Technology; President and Vice-Chancellor of the University of Manchester

Attendance strictly by invitation.

Contact Dr Stephen Benn, Director of Parliamentary Affairs, Royal Society of Biology. stephen.benn@rsb.org.uk

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#### **OFFICERS OF THE PARLIAMENTARY & SCIENTIFIC COMMITTEE**

President The Lord Oxburgh Chairman Deputy Chairman: Hon Treasurer: Hon Secretary Vice-Presidents:

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