The Journal of the Parliamentary and Scientific Committee

SCIENCE IN PARLIAMENT sip

SPRING 2106

www.scienceinparliament.org.uk

Stephen Metcalfe MP, Chairman, Parliamentary and Scientific Committee

The Treasury's recent announcement about the introduction of a sugar tax has received a mixed response. The new levy on the soft drinks industry is welcomed by health campaigners, reflecting a bold and important move towards reducing childhood obesity. The £520m a year it is expected to raise will be used to boost sport in schools and fund breakfast clubs at 1,600 schools in England. If the money raised is used wisely, initiatives such as these will undoubtedly be beneficial to encouraging healthier lifestyles from a young age.

Naturally, those that condemn the decision are from the UK soft drinks industry which is reported to be worth £15.7 billion. Speaking from my own experience, the closure of the Britvic factory in Chelmsford in 2014 was a sad day for the area with many in my constituency losing their jobs. It will be interesting to see the impact of the tax on small independent drinks companies.

The tax will be exclusively on soft drinks, which leads me to question, where does this leave the fruit juices, smoothies and milkshakes which are also high in sugar? Many are unaware of the specific foods and drinks that are naturally high in sugar. This is an important point that Dr Alison Tedstone illustrates in her article. Perhaps technology is the answer? Public Health England is leading the way with their sugar smart app which helps families keep track of how much sugar is in certain foods.

Some interesting alternative solutions have been proposed to help tackle the issue of obesity. Shirley Cramer, chief executive of the Royal Society for Public Health, calls for "activity labelling" on pre-packaged foods as she argues that the current "traffic light" food labelling system is not promoting positive changes in public health.

Amidst the debate over sugar consumption, one voice which has largely ignored in the debate is the sugar beet farmer. Sugar beet growers are already faced with a challenging outlook, and they are now concerned about the impact of the sugar tax on the crop's economics. With the sugar tax not due till 2018, there is plenty of time for the soft drinks manufacturers and beet farmers to prepare for solutions that will cause minimal impact to the industry.

SCIENCE IN PARLIAMENT
sip

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

Science in Parliament has two main objectives:

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

CONTENTS

SEVEN WAYS TO SAVE OUR SOILS

Helen Browning

Franklin D. Roosevelt stated in 1936 that 'The history of every nation is eventually written in the way in which it cares for its soil'. Certainly many great civilisations have crumbled alongside their soils,[1] degraded through years of cultivation to the point where food production was not viable.

Sadly – despite all our modern technology and scientific know-how, we are at risk of repeating ancient mistakes. Soil degradation is happening at a global and UK scale, and the impacts of this in the long-term, if left unaddressed, would be catastrophic for our climate and our food production.

The UN designated 2015 to be the International Year of Soil to raise awareness of this issue. What happened in the UK? Soils really have upped the environmental and agricultural agenda; at most conferences, I hear soil actually mentioned – and repeatedly too.

BUT IN TERMS OF REAL, DEFINITIVE ACTION?

The main issue to solve here is a farming culture where agro-chemicals are seen as the main source of fertility and pest/disease control. This is combined with short-term leases and the pressure to compete with other global suppliers with lower overhead costs. The result? Short-term and quick-fix management decisions, resulting in high value but soil damaging simple rotational crop systems with quick returns. Unintended consequences are overlooked and soil health is often forgotten within decision making. This has led to declining UK food diversity, weeds which we can no longer control and soils which are being stripped of their nutrients and organic matter.

Not enough is happening to solve this. The upgraded GAECs (Good Agriculture and Environment Conditions) in England will not prevent all damaging operations, let alone promote widespread positive management. And while soil should be given the same level of protection as water and air, an EU Soil Directive is still not on the table.

We have therefore been working on a report to detail how we can save UK soils. We will be presenting not just to farmers, but also to policy makers and advisors. Here is a quick summary:

COMMIT TO OUR TARGET: INCREASE SOIL ORGANIC MATTER LEVELS BY 20% IN 20 YEARS

This is the main target of the Soil Association's Soils Campaign. In other words, we want to see arable and horticultural soil organic matter levels raised by 1% on existing levels, every year. Currently – levels are actually declining[2]. We know this target is entirely possible – it is based on what organic farmers frequently achieve, as found by a meta-analysis of comparative studies between organic and non-organic farms.

Seven ways to save our soils, with some examples of how to do this:

1. **Increase animal and plant matter going back onto fields**

   Reversing declines and achieving good levels of organic matter is the key to soil health. This means ensuring that farms are recycling more plant and animal matter back into soils.

   Farmers: Learn about the additional benefits of animal manure and composts and bring livestock onto arable farm

   Government: Commit to our SOM target. Stop subsidising damaging practices. Increase farmer awareness.

2. **Improve soil health monitoring across the UK**

   Analysing soils is an essential first step to support effective decision making on soil health, but some farmers neglect to do this routinely.

   Farmers: Routinely analyse your soils, including organic matter. Test and monitor soil health – especially if you are arable.

   Government: Using cross-compliance, ensure farmers monitor soil health and SOM levels on a representative area of their farms.

3. **Encourage soil organisms**

   The current focus on chemical inputs began at a time when we did not yet understand the importance of soil life to need to crop productivity, pests and disease and the ability to cope with extreme weather. This needs to change.

   Farmers: Think about soil life before making decisions. Be innovative and get involved with farm trials, on your own farm or in a network such as the Soil Association's Innovative Farmers.

   Government: Invest in R&D on the role of soil biology in yields and carbon/water storage. Address regulatory gaps to ensure new pesticides do not damage soil life.

4. **Cover up bare soil with continuous plant cover**

   You can't see healthy soil – it is covered by plants. Plant roots hold soils together and encourage healthier soil communities through plant-fungal interactions. Benefits spread beyond the farm in terms of biodiversity, carbon storage, flood and drought control, and water quality.

   Farmers: Use cover crops, green manures, longer grass leys and under-sown crops. Utilise agri-environment schemes to bring back permanent grassland where appropriate.

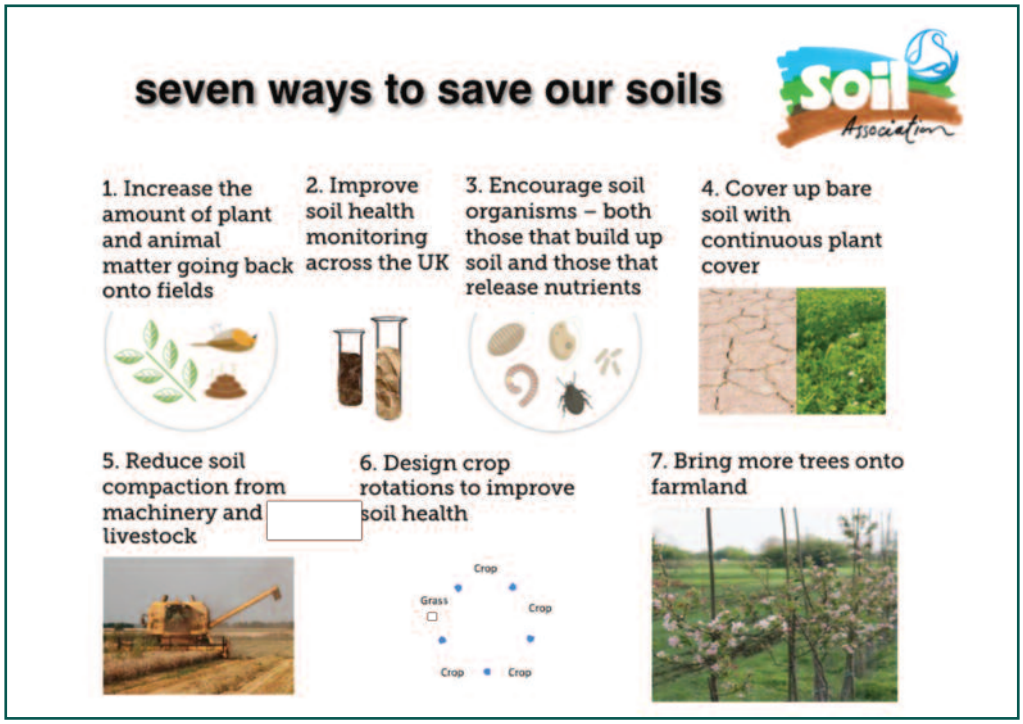
   Government: Introduce stricter cross-compliance measures. Support research to help farmers choose the right cover crops and ensure knowledge exchange.

5. **Bring more trees onto farmland**

   Trees reduce erosion, can help draw up nutrients and hold soils together. But they can be valuable assets to farmers in their own right.

Farmers: Learn about the value of farmland trees from the Woodland Trust. Plant/encourage trees on vulnerable soils and rough grazing.

Government: Create confidence in agroforestry through research and financial support.



6. Reduce soil compaction from machinery and livestock

Soil compaction is a major problem in the UK[3] – it can lead to increased surface run-off as well as drought stress, fewer grazing days, poor root growth and reduced yields overall.

Farmers: Routinely assess your soils visually and use the wealth of alleviation practices that can reduce compaction

Government: Raise awareness on the impact of compaction on crop and livestock performance. Have a GAEC standard specifically on compaction.

7. Design crop rotations to improve soil health

It is vital we ensure farmers are able to design diverse, long-term crop rotations that our soils need.

Farmers: Design longer rotations with more varieties and catch-crops. Focus on financial margins across your rotation, not just annual margins.

Government: Introduce requirements on tenants and land owners to ensure soil health is not degraded during tenancies. Change policies to enforce longer rotations for at risk crops, such as potatoes.

SO WHAT WOULD THE BENEFITS BE IF ALL THESE AREAS WERE ADDRESSED?

The benefits go right beyond soil health and long-term maintenance or increase of yields. **Farmers would see hugely improved flood and drought resilience:** For degrading UK arable soils which can contain as little as 1-2% soil organic matter in total, meeting our target would increase the water holding capacity by between 40-100 thousand litres per hectare or 4-10 litres per m2 [4]. **Water quality would also be improved** – increasing soil organic matter levels helps protect underground water supplies by neutralising or filtering out potential pollutants[5].

There would also be **less soil erosion and rivers would need to be dredged less:** Research in Southwest England found around 4 out of 10 farms studied were visibly increasing surface run-off[6] and there is grave concern that the production of maize in particular is leading to huge amounts of soil being eroded.

Lastly, based on what organic farms can achieve, meeting our target could result in **incredible climate change mitigation;** carbon sequestration equivalent to that stored annually by an area of forest three-quarters of the size of Wales[7]. If you include the reduced N20 soil emissions and the increased methane uptake[8], the greenhouse gas savings could amount to 13% of current annual UK agricultural greenhouse gas emissions[9].

References

1 http://www.sciencemag.org/ content/342/6158/565.short

2 Countryside Survey Soil Report from 2007 http://www.countryside survey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR9-revised.pdf

3 Palmer, R. C. and Smith, R. P. (2013) 'Soil structural degradation in SW England and its impact on surface-water runoff generation', *Soil Use and Management*, **29:** 567–575 http://eureferendum.com/documents/sum12068.pdf

4 1% SOM = an additional 20,000 to 25,000 gallons per acre, or at least 225,000 litres per hectare. 0.2-0.4% increase (20% increase on 1-2%) = 45000 to 90000 litres. Laura Byrant (2015) Blog: Organic Matter Can Improve Your Soil's Water Holding Capacity – covers these calculations and the assumptions made http://switchboard.nrdc.org/blogs/lbryant/organic_matter.html

5 European Commission Joint Research Centre European Soil Portal – 'key facts about soil' http://eusoils.jrc.ec.europa.eu/projects/soil_atlas/Key_Factors.html

6 Palmer, R. C. and Smith, R. P. (2013) 'Soil structural degradation in SW England and its impact on surface-water runoff generation', *Soil Use and Management,* **29:** 567–575 http://eureferendum.com/documents/sum12068.pdf

7 Based on the USA's Environmental Protection Agencies Greenhouse Gas Equivalencies Calculator - http://www.epa.gov/cleanenergy/energy-resources/calculator.html

8 Skinner et al 2014 http://www.ncbi.nlm.nih.gov/pubmed/24061052 found in a review of 12 comparative studies that organic farms emit the equivalent of 492kg CO_2e less N_20 and take up an additional 3.2kg CO_2e of methane per hectare per year on average.

9 Based on the croppable area of the UK as 4.8m ha https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/355868/structure-jun2014final-eng-18sep14.pdf and total current agricultural emissions of 53.7 m CO_2e https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/449266/agriclimate-6edition-30jul15.pdf

OUR BATTLE WITH SUGAR – MAKING THE SCIENCE FAMILY FRIENDLY

Dr Alison Tedstone
Chief nutritionist at PHE

Research shows that the New Year is a time when people are more willing to consider making positive lifestyle behaviour changes. As such, it provided Public Health England with a perfect opportunity to tap into this January mindset and help tackle a major health challenge: sugar consumption.

As chief nutritionist at Public Health England, one of my main concerns is the diet of our children. Following an expert review of the evidence by the Scientific Advisory Committee on Nutrition (SACN) in July 2015, it was recommended that no more than 5% of people's (from age 2 years and above) daily calorie intake should come from free sugars[1]. For children aged 11 upwards and adults, this is the equivalent of 30 grams or 7 cubes of sugar per day, based on average population diets.

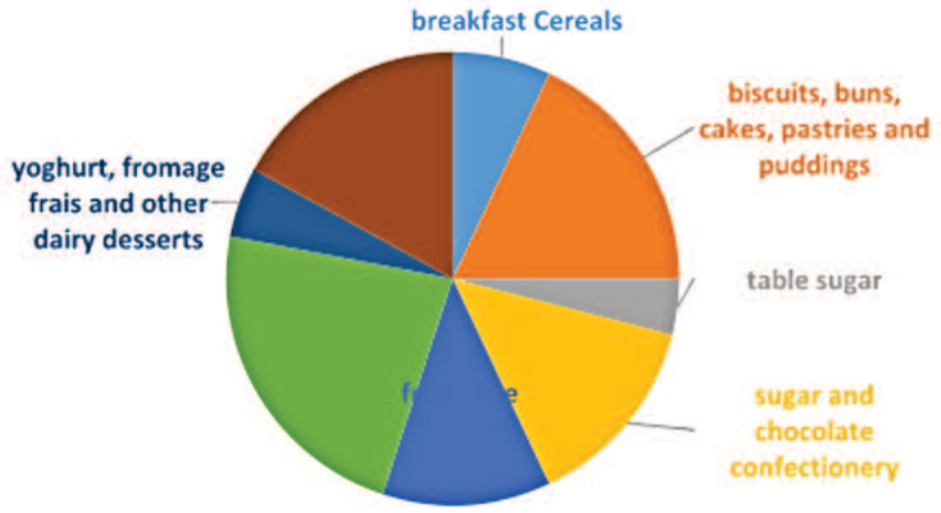
However, the National Diet and Nutrition Survey (NDNS), shows that average sugar consumption is three times higher than the maximum recommended level in school-aged children and teenagers. The main source of sugar consumption in children is sugary drinks, which have no place in a child's daily diet.

The evidence shows that there is a strong link between having too many sugary foods and drinks, and becoming overweight or obese. Too much sugar in the diet can result in too many calories being consumed, leading to weight gain and obesity. Obese children are more likely to have low self-esteem, be bullied, miss school and become obese adults who have a greater risk of developing type 2 diabetes, heart disease and certain cancers.

According to the latest data from our National Child Measurement Programme (NCMP), almost one in 10 children starting school is obese and this doubles to almost one in five by the end of primary school, which is deeply concerning. Childhood obesity is still unacceptably high and much worse in the poorest areas. Overweight and obesity is becoming normalised in children so it is no wonder that the evidence tells us that parents and even health professionals struggle to identify when a child is overweight by sight alone.

In addition to obesity, too much sugar causes tooth decay. One in three 5-year olds has tooth decay, which is painful and can lead to having rotten teeth removed under general anaesthetic in hospital.

There is no doubt sugar has been one of the most hotly debated and discussed health topics over the last 12 months.



Sources of sugar in the UK – children aged 4 to 18 years

The case is clear for us to do everything we can to help younger generations eat a healthy, balanced diet and have fewer calories and less sugar.

But while the message that too much sugar is bad for you seems to be gaining traction, arguably the more important aspect of this debate is how we help families to reduce the amount of sugar they are eating and drinking.

Turning the scientific evidence from the SACN report into something that consumers can easily understand and act upon has been a key component of Public Health England's latest Change4Life campaign. Our research shows that parents are looking for a simple way to understand how much sugar is in the food and drinks they are having so they can make informed decisions about their children's diet.

That's why we developed the Sugar Smart app which visualises the total amount of sugar in everyday food and drinks. It allows families to simply scan the barcode of over 80,000 everyday food or drink products to see how many 4-gram sugar cubes they contain (total sugar). The technology supports parents to take control of sugar consumption and helps protect their children from the potential future health implications of eating and drinking too much sugar.

Since the campaign's launch at the beginning of January, feedback from app users has shown that some of the biggest surprises in terms of sugar content have come from juice drinks (as opposed to fruit juice) and seemingly healthy afterschool snacks, such as split pot yoghurts or chilled desserts. These can contain over five sugar cubes, taking a four-year-old child over their maximum recommended sugar allowance.

The app was launched as part of the wider Change4Life Sugar Smart campaign which raises awareness of the new guidelines on sugar whilst also illustrating the levels of sugar children are actually consuming. The campaign revealed that typical four to 10-year-olds are eating and drinking more than 5,500 sugar cubes each year – the equivalent to the average weight of a five-to nine-year-old child.

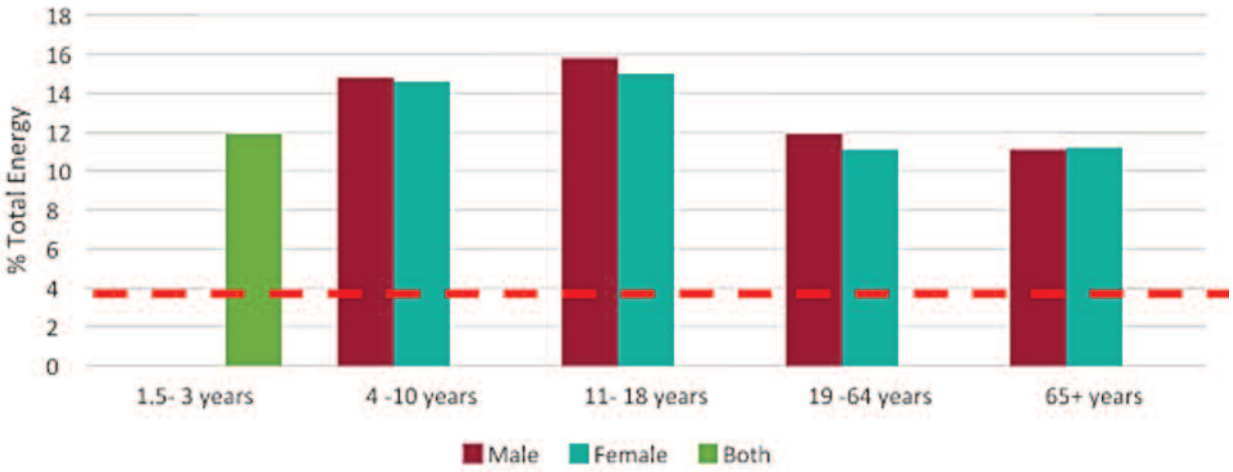
As well as encouraging parents to download the app, we also believe that it is vital for children to understand the importance of a healthy diet from a young age. With this in mind, we've worked with educational experts to develop a range of 'Food Detective' teaching resources for key stage 1 and key stage 2 age groups. The toolkit aims to help teach pupils about sugar and having 5 portions of a variety of fruit and vegetables every day as part of a healthy, balanced diet.

Schools will also receive free Sugar Smart packs which contain further information about sugar guidelines and practical suggestions for families on how to cut down on sugar. There is a range of further information, support and engaging materials available on the Change4life website.

There is not one definitive reason as to why children in England are eating too much sugar. Obesity has multiple complex causes which is why a corresponding range of bold measures are needed to tackle this issue – there is no single silver bullet solution. The childhood obesity strategy by the Department of Health will further help our efforts to reduce excess weight in children.

What is clear is that we need to provide people with the tools to help them make healthy choices while also changing the obesogenic environment in which we live. Our sugar evidence report highlights that while education is important we need to go much further and make the healthiest choice the easiest choice.

The Sugar Smart app jumped to11 number one on the iTunes app store and was downloaded more than a million times in its first three weeks, illustrating the clear demand for tools which can help people to make healthier choices. While we recognise that an app alone cannot change the behaviour of the nation, it is a step in the right direction.



UK sugar intake compared to the recommended maximum of 5% energy

Reference

1 Free sugars are those added to food or those naturally present in honey, syrups and unsweetened fruit juices, but excludes those naturally present in intact fruit and vegetables or dairy products.

LIGHTWEIGHT DRONES IN ENVIRONMENTAL SCIENCE

Dr Karen Anderson

Environment and Sustainability Institute, University of Exeter

The 'blue marble' image of the Earth captured by a camera on board the Apollo 17 mission transformed the way that humans understand the Earth. The blue marble became an icon of a new consciousness and since then, remote sensing of the Earth from space has transformed scientific understanding of Earth system functioning and facilitated an improved quantitative view of the life and processes that shape Earth. Remote sensing data are now used routinely and with hundreds of Earth observation satellites in orbit, it is possible to measure global dynamic cycles in near-real time. In the same vein, but operating within proximal airspace (up to 100 m above the ground, typically) drone-based remote sensing has recently emerged as a new, rapidly expanding toolkit for Earth and environmental scientists. Most of the environmental scientists in my field (landscape ecology, geomorphology, hydrology) are using lightweight drone platforms (in the sub-7kg take-off-weight category) to collect fine-grained observations [1]. I demonstrated how simple overlapping aerial photographs of surface features can now be translated into three-dimensional models with the help of 'structure from motion' photogrammetry – a process that translates the two dimensional information into point clouds in three dimensions[2,3]. Examples from my own scientific work [4-6], show how drone-based remote sensing can contribute to the global monitoring system and complement coarser-grained satellite remote sensing observations. Today, drones provide a unique opportunity for science and society to make a step change in global system understanding, in much the same way as the launch of the first satellite Earth observation sensors did 45 years ago. There are three reasons for this:

Figure 1: An example showing how drones can deliver fine-grained remote sensing data for specialised land management applications. In this example a farmyard has been surveyed for understanding water resource issues. (a) Is a screenshot from google Earth showing typical satellite products; (b) is a drone-captured photograph (25 m flying height), evidencing the capability to rapidly survey the state of farm buildings, drainage and guttering systems; (c) is a 2 cm resolution orthomosaic of the farmyard, while (d) is a 3D topographic model derived using a 'structure from motion' workflow, which can be readily used to quantify water flow around this complex area – understanding this is crucial to the optimal management of downstream water quality.

1. CALIBRATION AND VALIDATION.

We know that satellite remote sensing data needs improved local, fine-scale calibration and validation across a range of Earth systems. For example, recent work has suggested that there needs to be a "strategic combination" of remote sensing and *in situ* data if uncertainties in terrestrial carbon sinks and sources (critical to understanding ecosystem responses to global change and climatic trends) are to be better quantified and modelled [7]. Such validation can be achieved by local non-spatial observations (e.g. meteorological data, flux observations) but is probably better delivered by finer-grained spatial observations collected proximally to the Earth's surface and at a grain size appropriate to the patterns driving the processes. Drones uniquely provide researchers and citizens alike with a toolkit that can be readily used for such purposes. By fitting sensors to drones that allow similar radiometric remote sensing products to be gathered it is then within reason that satellite data products can be calibrated or validated using such approaches.

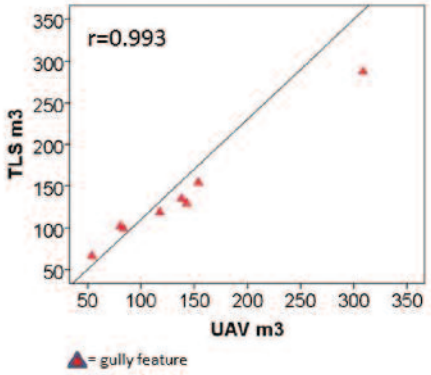
2. GRAIN SIZE, FLEXIBILITY AND RESPONSIVENESS.

Second, current data streams, even from the most capable satellite systems are often too coarse in time or space to be able to capture the dynamics and complexity in crucial environmental processes. Resultantly, existing spatial datasets from satellite systems are often not useful or suitable for guiding environmental decision making. An example is shown in Figure 1. Imagine that this is a dairy farm located in the headwaters of a sensitive catchment. Being able to model the way that water flows around the farmyard buildings, across fields and into small streams is critical effluent flow into nearby rivers is to be managed and reduced. To provide the best advice to the farmer on how to achieve this, an environmental adviser or consultant requires fine-resolution data both temporally and spatially. From satellites, it is currently not possible to model topographic variation around features at a farmyard scale, and yet, this is the scale at which water pollution incidents can be managed and mitigated most effectively. Drones uniquely provide a close-range 'proximal' viewpoint from which a wide range of features can be surveyed, and with the help of new image processing tools, it is also possible to turn the 2D photographs into accurate 3D topographic models from which hydrological flow can be modelled [2].

3. COST EFFECTIVENESS OF REMOTE SENSING SURVEY.

Finally, we can gather data from drones that cannot be captured so cost-effectively by other means. For example, we are monitoring the impacts of an upland restoration scheme on Exmoor which is seeking to improve downstream water quality, reduce flooding, and ensure water security in the region. The catchments that we focus on are around 100 – 200 ha in extent. Using piloted survey aircraft equipped with specialised laser scanning sensors, thermal imagers and optical sensors, we have previously generated a range of scientific products describing the structure and function of these landscapes [8-11]. However, these data are very costly to capture (upwards of £10,000 per survey) and with a drone costing a few hundred pounds, we have shown that we can deliver equivalent data repeatedly, for a fraction of the cost, at user-defined time-steps [5]. We are working with South West Water to pioneer this approach.

To provide further evidence of the cost-effectiveness of drone-based remote sensing over other approaches I want to refer to a case study. My group is also part of a broad consortium working with DEFRA, to explore and evaluate the potential that drone-based surveying offers for soil erosion monitoring. The role played by soils in providing well-being to society has been clearly articulated in the recent "Soil Strategy for England". Estimates for the UK put the total marginal cost of soil degradation at between £206-315 million per year. Evidence suggests that these costs are incurred in many different ways, affecting diverse ecosystems and stakeholders, over a range of spatial and temporal scales. Spatial data at fine resolution are required to quantify the impact of erosion, and to monitor change at landscape extents. In this extensive project with a range of academic institutions (Universities of Exeter, Lancaster, Cranfield, Manchester and the British Geological Survey) our aim was to test the effectiveness of new ways of quantifying spatial soil erosion parameters and therefore provide important information that can help target optimal soil conservation practices. Figure 2 shows some data from the project which shows how the spatial models derived from drone-based imaging compare to an existing and widely used method (terrestrial laser scanning, TLS) for quantifying gully erosion in



	Mean time per site (hours)	
	UAV	TLS
Field data capture	4.6	3.7
Post-processing CPU time (hours)	1.3	12.8
Post-processing person time (DTM creation, digitising, geo-referencing etc.)	2.0	8.0
Mean person time per technique per site	6.6	14.2
Approx. cost of equipment	£1,000	£100,000
Approx. cost of software	£1,000	£1,500 p.a.

Figure 2: Data from DEFRA Project SP1311 'Piloting a cost-effective framework for soil erosion monitoring in England and Wales'. The graph on the left shows the strength of relationship between drone-based volumetric estimates of soil lost from gully erosion (UAV, x axis) and estimates of the same features measured using terrestrial laser scanning (TLS, y axis), which is the most regularly used method. The table, shown right, demonstrates how drone data are processed more rapidly (200% quicker than TLS), and how drone survey equipment is 1% of the cost of laser scanning equipment, whilst spatial accuracy is equivalent (graph, left).

upland soil systems. The table, shown right in Figure 2, demonstrates how drone data are processed more rapidly (200% more quickly than TLS), and how lightweight drone survey equipment is typically 1% of the cost of TLS equipment, whilst spatial accuracy is equivalent (graph, left).

It is my belief that drone-based remote sensing data cannot replace the global extent surveying that is currently delivered operationally by satellites, drones do provide a complementary technology that allows 'fine-grained' data problems and upscaling questions to be tackled across the environmental sciences. My research group at the DroneLab of the University of Exeter is not alone. Globally, drone use has escalated and now, there is a lightweight drone on every continent on Earth. Figure 3 shows the number of publications with the words 'unmanned aerial vehicle' or similar term in the title, and inset, the number of citations to those papers in recent years. Sales figures for drones globally suggest that this trend will continue to increase. Scientists are only just beginning to realise the benefits of the self-service data potential offered by drones, and it is my belief that this trend will continue if legislation remains flexible enough to permit activities in this area to continue. It is my hope that the UK will remain as one of the world leading countries in which drone-based remote sensing can be developed, deployed and explored.

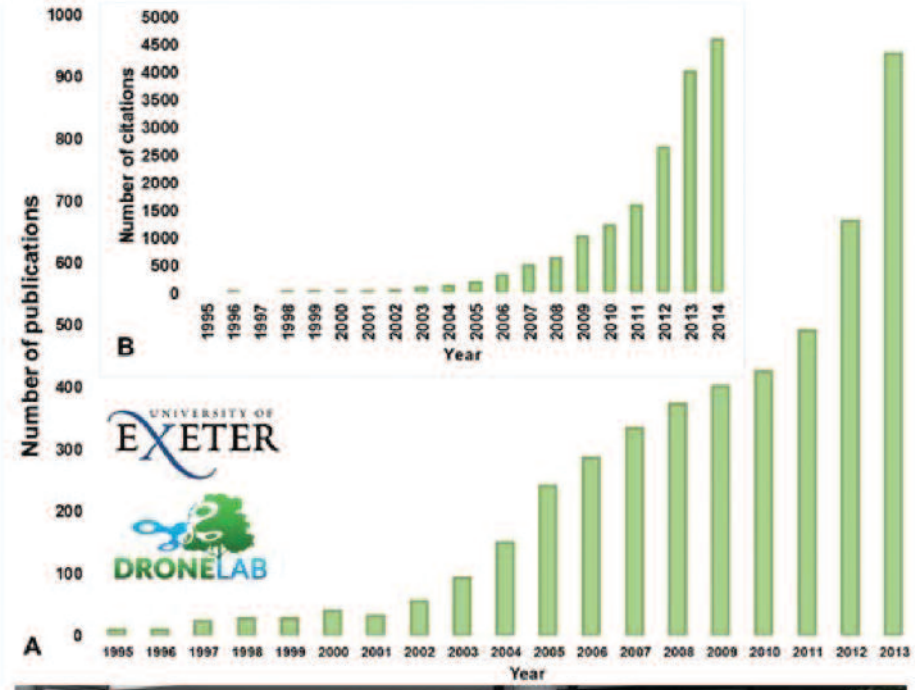


Figure 3: Top shows the growth in (A) publications and (B) citations to papers using terms 'unmanned aerial vehicle' or related terms, evidencing the expansion of drone use in science. Below is a photograph showing an engaged group of scientific drone users at a meeting hosted by the University of Exeter's DroneLab in June 2014.

References:

1. Anderson K, Gaston KJ (2013) Lightweight unmanned aerial vehicles will revolutionize spatial ecology. Frontiers in Ecology and the Environment 11: 138-146.
2. Westoby MJ, Brasington J, Glasser NF, Hambrey MJ, Reynolds JM (2012) 'Structure-from-Motion' photogrammetry: A low-cost, effective tool for geoscience applications. Geomorphology 179: 300-314.
3. Dandois JP, Ellis EC (2010) Remote Sensing of Vegetation Structure Using Computer Vision. Remote Sensing 2: 1157-1176.
4. Puttock AK, Cunliffe AM, Anderson K, Brazier RE (2015) Aerial photography collected with a multirotor drone reveals impact of Eurasian beaver reintroduction on ecosystem structure. Journal of Unmanned Vehicle Systems 3: 123-130.
5. DeBell L, Anderson K, Brazier RE, King N, Jones L (2015) Water resource management at catchment scales using lightweight UAVs: current capabilities and future perspectives. Journal of Unmanned Vehicle Systems 3: 1-24 DOI: 10.1139/juvs-2015-0026.
6. Anderson K, Griffiths D, DeBell L, Hancock S, Duffy JP, et al. (2016) A grassroots remote sensing toolkit using live coding, smartphones, kites and lightweight drones PLOS One in press.
7. Schimel D, Pavlick R, Fisher JB, Asner GP, Saatchi S, et al. (2015) Observing terrestrial ecosystems and the carbon cycle from space. Global Change Biology 21: 1762-1776.
8. Luscombe DJ, Anderson K, Gatis N, Wetherelt A, Grand-Clement E, et al. (2015) What does airborne LiDAR really measure in upland ecosystems? Ecohydrology 8: 584-594.
9. Luscombe DJ, Anderson K, Gatis N, Grand-Clement E, Brazier RE (2015) Using airborne thermal imaging data to measure near-surface hydrology in upland ecosystems. Hydrological Processes 29: 1656-1668.
10. Grand-Clement E, Anderson K, Smith D, Angus M, Luscombe DJ, et al. (2015) New approaches to the restoration of shallow marginal peatlands. Journal of Environmental Management 161: 417-430.
11. Gatis N, Luscombe DJ, Grand-Clement E, Hartley IP, Anderson K, et al. (2015) The effect of drainage ditches on vegetation diversity and CO2 fluxes in a Molinia caerulea-dominated peatland. Ecohydrology 10.1002/eco.1643.

Does Synthetic Biology increase the risk of inadvertent or malicious release of high-virulence pathogens?

John McCarthy

Professor of Molecular Systems Biology in the School of Life Sciences, and Director of the Warwick Integrative Synthetic Biology (WISB) Centre, University of Warwick, Coventry CV4 7AL, UK

Pathogens are a serious risk to the health of humans, animals and plants, and are consequently responsible for suffering and economic damage on a global scale.

High-profile epidemics caused by viruses and bacteria feature all too frequently in the media, thus reminding us of our vulnerability to attack by the microbial biosphere. We have learned that pathogens are highly adept at adapting to changes in their environment – the most worrying manifestation of this is their ability to develop mechanisms that confer resistance to antimicrobial drugs. There is also concern that dangerous pathogens might be released inadvertently from research laboratories or that terrorists might incorporate them into bioweapons. I consider the possibility that synthetic biology might enable the development and release of (genetically modified) pathogens, potentially with increased virulence, whereby release could be either inadvertent or malicious.

For those not fully familiar with the meaning of the term synthetic biology, researchers manipulate and rearrange existing biological systems, or to build new types of biological system that differ from naturally evolved ones[1]. The capabilities and achievements of synthetic biology are dependent upon detailed understanding of how biological systems function. Synthetic biology applies (a new type of) engineering to biological systems with the intention of (i) advancing understanding of the principles underpinning life and (ii) generating products, devices and processes that benefit society. In doing so, this highly interdisciplinary area draws upon multiple sources of knowledge and skills from across the sciences and engineering, thus pushing at new (and potentially ethical) boundaries. The synthetic biology community is subject to the same stringent set of health and safety regulations that apply to other areas of bioscience and is committed to exploring the ethical, legal and societal aspects of the research.

The core question is whether synthetic biology has the potential to create of new types of dangerous pathogen. Sensitivity around this issue has been heightened by some confused reporting on a number of projects involving known pathogens. This relates, for example, to the chemical synthesis of the poliovirus genome[2] and to the reconstruction of the 1918 Spanish influenza pandemic viru[3]. It is certainly true that developments in DNA synthesis and assembly methods are accelerating towards a scenario in which semi-automated synthesis of bacterial and viral genomes will become feasible for many suitably skilled laboratories. Such genomes could theoretically include those of the naturally evolved Variola (smallpox; against which vaccines can be readily available) or Ebola viruses. However, the fact that synthetic methods can enable the generation of complete pathogen genomes does not necessarily mean that synthetic biology provides encouragement, or even a shortcut, to the creation of bioweapons. As we shall see, this is because constructing a synthetic genome is only one of a large number of steps that are required to construct a bioweapon, particularly if this is to be applied on anything other than a small scale.

It has been suggested that current technological developments could be leading to a 'de- skilling' of synthetic biology, thus potentially providing a platform for 'garage bioterrorism'[4]. For example, a number of the procedures that underpin the construction of synthetic genomes can be performed by following established protocols and even using commercially available kits. However, the tacit knowledge and expertise that are gained by research scientists through multiple years of experience in formally recognised research institutions remain indispensible to the successful completion of

whole genome assembly projects. In addition, while the ongoing development of computational models and algorithms facilitates system design, these resources do not remove the need for project management by suitably trained individuals. Overall, synthetic biology is still far from providing (automated) 'black box' operations that can allow inexperienced personnel to perform complex genome construction projects.

While it is undoubtedly important to maintain a watchful eye on the potential for misuse of rapidly developing DNA technology, this should not be allowed to distract us from the bigger picture. The volume of research being performed that has the goal of creating variants of known pathogens is tightly regulated and therefore limited in scope and volume. Unintentional release of synthetically generated pathogens is accordingly even less likely than unintentional release of known (natural) pathogens. But how great is the risk of malicious release of genetically modified pathogens in the form of bioweapons? The reality is that this path is beset with a whole series of challenges *in addition* to those related to genome modification and/or synthesis[5], and these additional challenges can only be overcome through the application of multiple skills outside synthetic biology (Figure 1). One of these challenges is how to generate very large amounts of a synthetic pathogenic organism. Construction of a synthetic viral genome is of little use if this cannot be packaged into a viable (infectious) virus particle, and this process has to be scaled up using advanced technology that is likely to be expensive, far from easy to implement, and which can also pose major risks, especially to the non-expert user. Equally challenging are the mechanisms of weapon delivery and agent dispersal, both of which pose formidable challenges when the agent is an organism that has to remain biologically active[4].

In conclusion, the probability is low that current synthetic biology methods will provide, for the malicious user, a significantly accelerated path to the production of potent large-scale bioweapons. Indeed, the committed terrorist is likely to choose other, less technically challenging, ways of harming people. However, this does not mean that we should ever be complacent about the potential risk of misuse. We should also be conscious of the possibility that highly motivated (and well-funded) groups might attempt the dissemination of pathogens (not necessarily synthetic) on a small scale, although it is noteworthy that previous attempts have had little success[6]. We should continuously monitor the situation over time as technologies develop further, proactively reassessing the potential ease of exploitation for non-experts. Finally, in the interests of society as a whole, it is essential that public debate about such issues is fully informed by *all* of the relevant scientific knowledge.

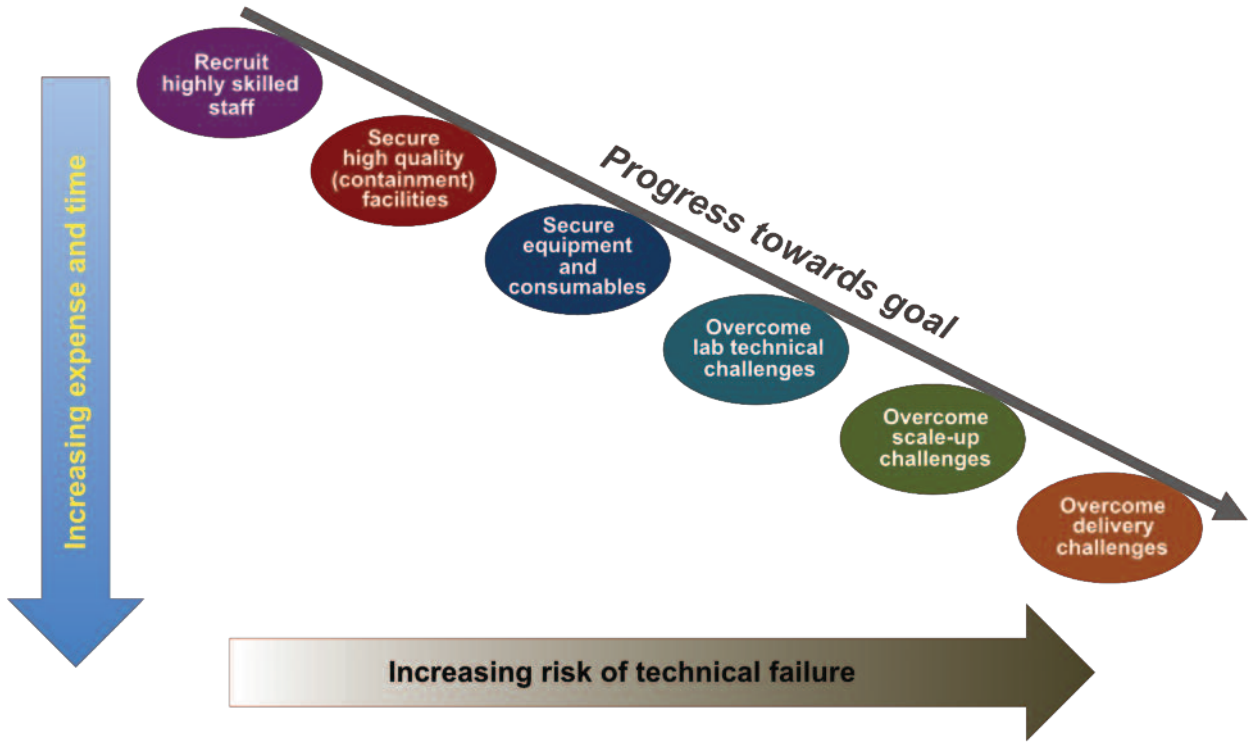


Figure 1. A series of technical and logistical challenges determine the overall likelihood of successful construction of a functional bioweapon. The hypothetical 'progress' trajectory is depicted as a downhill path since it represents an entirely negative type of potential human endeavour.

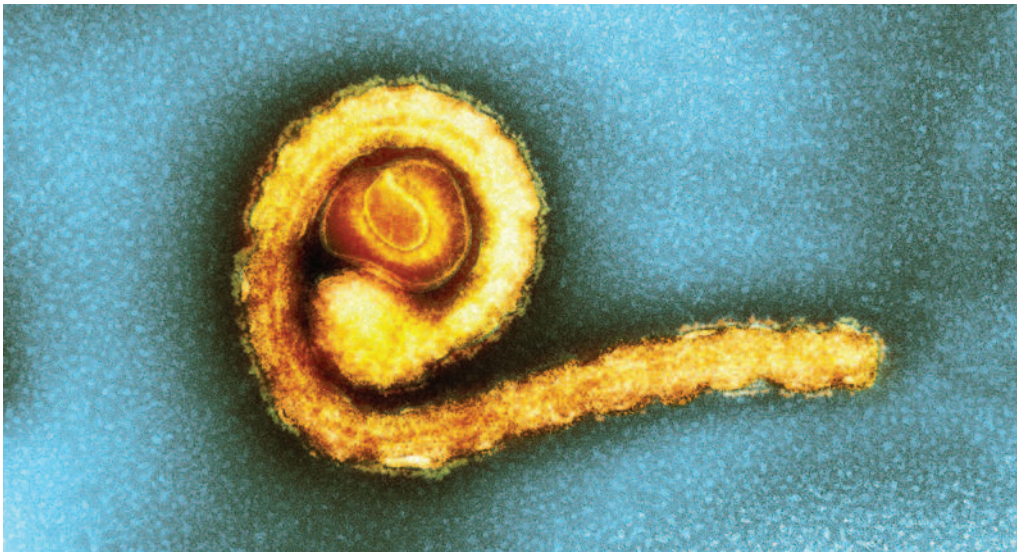
References

1. Khalil & Collins Nature Rev Genet 11 (2010) 367-379;
2. Cello et al Science 297 (2002) 1016-1018;
3. Tumpey et al Science 310 (2005) 77-80;
4. Jefferson et al Frontiers in Public Health 2 (2004) 115;
5. van Aken & Hammond EMBO Rep 4 (2003) S57 – S60;
6. Danzig et al (2011) Aum Shinrikyo: Insights into How Terrorists Develop Biological and Chemical Weapons. Washington DC: Centre for a New American Security.

REPAIRING THE PIPELINE OF NEGLECTED DISEASE VACCINES

Peter J Hotez

We learned several difficult lessons during the 2014-15 Ebola epidemics in Guinea, Liberia, and Sierra Leone. While much of the post-outbreak criticisms of our global response focused on public health preparedness, a critical realization is that we also have a broken system for developing, manufacturing, and testing countermeasures to combat neglected and emerging infections like Ebola.



Let's briefly review what happened – the fundamental science for developing the adenovirus-vectored Ebola vaccine was published in 2003; the VSV-Ebola vaccine a few years after that. But the technology waited a decade until the African situation became dire, and the US Government put up close to US$100 million through its Biomedical Advanced Research Development Authority (BARDA). The funds incentivized three major pharmaceutical companies to further develop these technologies in order to produce vaccines for large-scale clinical testing. By the time clinical trials commenced in West Africa the Ebola epidemic was mostly halted, but not before thousands perished.

Ebola was a debacle in terms of how we advance urgently needed neglected disease vaccines beyond research laboratory and into advanced process development, manufacture, regulatory filing, and clinical development. Our technical capacity has outpaced our financial and social instruments required to make vaccines for the poor.

The scary piece of this dilemma is that Ebola virus infection will not be the last catastrophic neglected disease that we will face. The same forces that promoted the emergence of Ebola in West Africa – poverty, conflict and post-conflict decimation of health systems, climate change, internal displacements and human migrations – remain in play. There are at least a dozen new serious neglected diseases that require vaccines. They include vaccines for:

• Neglected diseases in the Middle East and North Africa, including the ISIS-occupied conflict zones of Syria, Iraq, and Libya, as well as Yemen. Among them are MERS Coronavirus, leishmaniasis, schistosomiasis, and TB, which has seen an increase amongst refugee

populations. In some cases these and other diseases, such as Chikungunya and Dengue are also now threatening Southern Europe.

• Arbovirus infections, such as dengue fever, Rift Valley fever, chikungunya, and West Nile and Zika virus infections. Zika is now causing significant concern in Brazil, with potentially very worrying links with congenital infections, infants born with congenital birth defects such as microcephaly. The virus is spreading rapidly with more than one million cases in Brazil, almost as many in Colombia, and rapid dissemination to Mesoamerica and the Caribbean. Given the propensity of arboviruses like Zika to affect people who live in extreme poverty, there are particular concerns for the poorest areas of the Americas, including Haiti, and even impoverished areas of the US Gulf Coast. Zika represents the latest severe public health and socioeconomic threat to the Americas.

• Other chronic and debilitating neglected tropical diseases (NTDs), such as helminth infections, Chagas disease, Buruli ulcer, and mycetoma.

How then do we best close the technology gap in order to develop these neglected disease and NTD vaccines? There is no one-size-fits-all answer, but there are several opportunities and options. First, we need to recognize that the major pharmaceutical companies have an outstanding track record of developing new drugs and vaccines, including a few that target NTDs, as well as malaria and tuberculosis. But the failures in Guinea, Liberia, and Sierra Leone have taught us that we should not rely only on large pharmaceutical companies, but others in the vaccine development arena. We urgently need additional actors, including three types of organizations with a promising track record for advancing NTD technologies:

• *Academic research institutes*. In the UK, there are several important academic research institutes that are working to create a pipeline of neglected disease technologies. A good example is the Jenner Institute, a partnership of the University of Oxford and The Pirbright Institute. However, there are many others throughout the UK and globally.

• *Product development partnerships (PDPs)*. PDPs are non-profit organizations that were established to develop and test products for NTDs, TB, malaria, and other neglected diseases. There are approximately 20 PDPs globally, including a half-dozen that are developing vaccines. Our Sabin Vaccine Institute PDP in Houston, Texas, for example has a pipeline of six vaccines for NTDs.

• *Developing Country Vaccine Manufacturers Network (DCVMN)*. The DCVMN is an alliance of vaccine developers and manufacturers in the BRICS countries, as well as in nations such as Cuba, Indonesia, and Vietnam, which is leading innovation in the Global South to produce several important vaccines, many in partnership with the multinational pharmaceutical companies, or PDPs, or both.

We also urgently need new financing schemes. In a series of papers published in the *Public Library of Science (PLOS)* I found that most of the world's neglected diseases and NTDs are paradoxically found in the wealthy group of 20 (G20) nations (which includes large middle-income countries such as the BRICS) together with Nigeria. The extreme poor who live amidst the wealthy in these nations today account for one-half the world's helminth infections, and most of the dengue, leishmaniasis, Chagas disease, TB, and other NTDs and neglected diseases. I have used the term "Blue Marble Health" to describe this changing global health paradigm, with a new book on the topic forthcoming.

Accordingly, the G20 nations need to expand their commitment to fostering and supporting NTD technologies. The U.S., UK, Dutch, and Australian governments, as well as the EU stand out for their financial support of vaccines for the poor. It is especially exciting to see the UK Department of Health, Medical Research Council and Biotechnology and Biological Sciences Research Council establishing the UK Vaccine Network, with £120m of funding, as part of the £1bn Ross Fund announced by the Chancellor in November. The recent commitment by the Japanese Government and partners for a Global Health Innovation Technology (GHIT) Fund is also a welcome addition as are new revenue streams from the German government. However, we urgently need the other G20 countries to also step up and contribute to NTD innovation for vaccines. For instance, the BRICS nations and other NTD-endemic G20 countries have the capacity to do much more.

Finally the United Nations agencies have important roles. The World Health Organization (WHO) has established a product development for vaccines advisory committee, while the World Intellectual Property Organization (WIPO) is exploring the possibility of expanding its WIPO Re:Search enterprise.

Together the G20 nations and lead UN agencies have enormous capacity to expand the pipeline of urgently needed neglected disease vaccines. Last year's Ebola epidemic highlighted the fact that neglected diseases and NTDs are a global security issue that is every bit as important as wars, terrorism, and climate change. We desperately need innovation in our global response to produce neglected disease countermeasures.

Peter Hotez, MD PhD is President of the Sabin Vaccine Institute, Texas Children's Hospital Endowed Chair in Tropical Pediatrics, and Dean of the National School of Tropical Medicine at Baylor College of Medicine (Houston, Texas). He also serves as University Professor at Baylor University, Baker Institute Fellow in Disease and Poverty at Rice University and U.S. Science Envoy for the State Department and White House.

The views expressed are those of the author and not necessarily those of the US or UK Government.

ZIKA

Professor Jimmy Whitworth

Department of Infectious Disease Epidemiology at London School of Hygiene and Tropical Medicine. Professor Whitworth is co-ordinating the schools' response to Zika.

INTRODUCTION TO ZIKA VIRUS

• Zika was first identified in Uganda – first in monkeys (1947), then in humans (1952). At first confined to equatorial Africa, then moved into South East Asia and to the Pacific Islands. In 2015 it was recorded in Central and South America.

• Zika is a flavivirus generally transmitted by the *Aedes* genus of mosquitoes (these also carry dengue, chikungunya and yellow fever), although some sexual transmission occurs.

• Symptoms of Zika are usually mild and may include a rash, itching, fever, muscle pain and conjunctivitis, however there are two conditions thought to be associated with Zika which are especially worrying:

– **Microcephaly** - babies born with small and malformed craniums, and a non-fully developed brain

  • So far an increase in microcephaly cases, other neonatal malformations and adverse pregnancy outcomes has been reported only in Brazil and Columbia (about 1000 cases confirmed)

– **Guillan-Barre syndrome** – a temporary ascending paralysis, which is seen on recovery from a number of viral infections

  • 8 countries have reported an increased incidence of Guillain-Barré syndrome (GBS) and/or laboratory confirmation of Zika virus infection among GBS cases (about 1000 reported)

• These additional conditions are only seen in Central and South America, and the Caribbean

• Genetic analysis of the virus showed it arrived in Brazil in 2014, and the geographical distribution has steadily widened since. It was not noticed and recorded until 2015.

  • There were 1 million cases in Brazil in 2015, and 4 million are expected in 2016.

• Active transmission has been reported in 31 countries.

ACTIONS ON ZIKA IN ACTIVE TRANSMISSION ZONE

• Public Health Emergency of International Concern declared by WHO in February 2016 – their highest emergency category – due to the possible links to microcephaly and GBS, rather than the infection itself.
Launched a Strategic Response Framework, which incorporates:

  • coordination, surveillance, care, vector control
  • risk communication and community engagement
  • research at global, regional and country levels

• $56 million over 6 months has been requested by the WHO (World Health Organisation) for the response in the active transmission zone

ACTIONS ON ZIKA OUTSIDE ACTIVE TRANSMISSION ZONE

• Zika virus is likely to be transmitted and detected in other countries within the geographical range of competent mosquito vectors, especially Aedes aegypti – so there is a need to assess and mitigate the risk of spread by looking at:

  • Mosquito distribution
  • Preparedness of health services
  • Anti-mosquito measures and plans
  • Disinsection of aircraft – spraying of insecticide inside planes

• Travel – infected humans or mosquitos can spread the infection

- 10 countries have reported imported cases from this outbreak
- 9 imported cases in the UK
- Evidence of sexual transmission and transmission via blood transfusion

WHAT IS THE UK GOVERNMENT CURRENTLY DOING ABOUT ZIKA?

- Public Health England are supporting WHO control activities through expert assistance
- Contribution to WHO Contingency Fund for Emergencies
- Funding research through rapid response calls (MRC, DFID, EC)
- DFID is:
  - helping African countries prepare for future potential spread of Zika
  - providing health sector support in Caribbean
  - assisting disease surveillance in SE Asia
  - Contributing to outbreak response in Haiti

WHAT MORE DO WE NEED TO BE DOING ABOUT ZIKA?

Urgent:

- Develop a reliable diagnostic test – ideally we need diagnostics that can be used at the bedside to give a quick answer, rather than in the lab, but at the moment any reliable test would be an advance
- Assess modern anti-mosquito measures – currently relying on old methods
- Assess risks of microcephaly and GBS – currently not able to give accurate risk predictions
- Also need to understand when transmission from mother to foetus occurs in pregnancy
- Community engagement and communication – need to get messages around risk clear – hard to do for a disease which is usually mild, but can have devastating consequences
- Need to work out how best to provide information and advice on risks, pregnancy, contraception, abortion

Medium term:

- Vaccine development – vaccines are at least 18 months away
- Drug development - although if developed, could possibly be problematic – how do you persuade people, especially those who are pregnant, to take drugs for a disease which generally has mild symptoms?
- Establish host range in vectors – need to establish which mosquitoes could start acting as vectors
- Plans to care for those with disability – those with microcephaly will need life-long support

QUESTIONS

Q: Sir Peter Bottomley – What was the historic impact of Zika? Why has it only just come to our attention?

A: The disease used to be fairly inoffensive. It was only in Polynesia (5 years ago) that we started to see epidemics

Q: Stuart Taylor (Royal Society) – Is it known when in pregnancy that birth defects arise?

A: It is known from studying Rubella that the first trimester is the most risky stage of pregnancy. But early work on Zika seems to suggest any stage is risky – Zika infection in pregnancy has led to miscarriage at 37 weeks.

Q: Baroness Tonge – have we seen microcephaly associated with Zika virus before?

A: It is not thought there were the same epidemics in humans before – the virus was mainly endemic in primates, only 7-10% of the human population in endemic areas would have caught it.

Q: Claire Mouchot (French Embassy) – does the virus stay in the body and have longer term effects?

A: Currently no evidence of such.

Q: How long after infection is the virus found in semen?

A: Known to stay in blood in urine for a week. Longer in semen, but not known how long exactly.

Dr James Logan

Senior Lecturer in Medical Entomology at the London School for Hygiene and Tropical Medicine, and Director of arctec

THE MAIN VECTORS

- Primary vector: *Aedes aegypti* – a mosquito species highly adapted to the urban environment
  - Aggressive biters – bite even through clothing, and will take multiple blood meals
  - Bite during day and night, indoors and outdoors
  - Do not fly far: ~50m – so control measures around homes/schools can be effective
  - Mainly absent from Europe – too cold here
- Secondary vector: *Aedes albopictus*
  - Less adapted to urban environment – forest dwellers
    - Less aggressive biters
    - Usually smaller populations
    - Can survive in temperate regions
  - There are populations in southern Europe – probably only a matter of time before they arrive in the UK
  - The disease has been isolated from certain species from the following genera of mosquito, but not to the extent to prove them as vectors:
    - *Anopheles* (malaria vector)
    - *Aedes* (other) (vector of dengue, chikungunya, yellow fever)
    - *Culex* (vector of filariasis and West Nile virus)

WHAT VECTOR CONTROL IS BEING DONE?

- Insecticides are used to kill adult mosquitoes
  - Results of 'fogging' with insecticides are often short lived – resident mosquitoes killed, but there is influx of mosquitoes from surrounding populations
  - More of a PR exercise? Very visual, but evidence for effectiveness is sparse.
  - Residual spraying is long lasting but expensive
  - Insecticide resistance is an issue – mosquitoes can adapt to survive treatment with insecticides
- Can also use insecticides to target the larvae, which grow in stagnant water
  - Temephos – resistance has developed
  - Bti and Pyriproxifen show no resistance
- Can also just **remove** **stagnant water** from neighbourhoods – cheap but very labour intensive
  - Water pools in rubbish, tyres, flat roofs…
- Promotion of **bed net** usage – good for malaria (as the vector mosquitoes bite at night), but not so helpful for Zika, which is vectored by day biting mosquitoes
  - But importantly they still have a role for those sleeping during the day – eg. children napping, shift workers, those taking a siesta – so should be recommended
- Evidence that vector control reduces mosquito populations. So it could work in theory but there are many challenges:
  - Resistance
  - Education of communities
  - Co-ordination and sustainability
  - Lack of evidence for effectiveness in containing the disease due to lack of studies – more research needed
- **Insect repellents** highly recommended – provide personal protection. Are being given out to pregnant women in Brazil by government and clinics.
  - Four main active ingredients:
  - **DEET** (diethyl-m-toluamide): a synthetic repellent - the best and most widely used. 20-50% concentration recommended. Recommended for pregnant women. Safety proven.
  - **PMD** (p-menthane diol): a natural repellent from lemon eucalyptus
  - **Icaridin** (Bayrepel): synthetic repellent
  - **IR3535**: synthetic repellent

➢ Latter three are effective but require more frequent reapplication than DEET

- However, resistance to DEET has been shown to develop after just one generation in the lab (Stanczyk et al. 2010), so needs to be monitored in the wild. Repellents have not been used on this scale before, so need to watch closely for

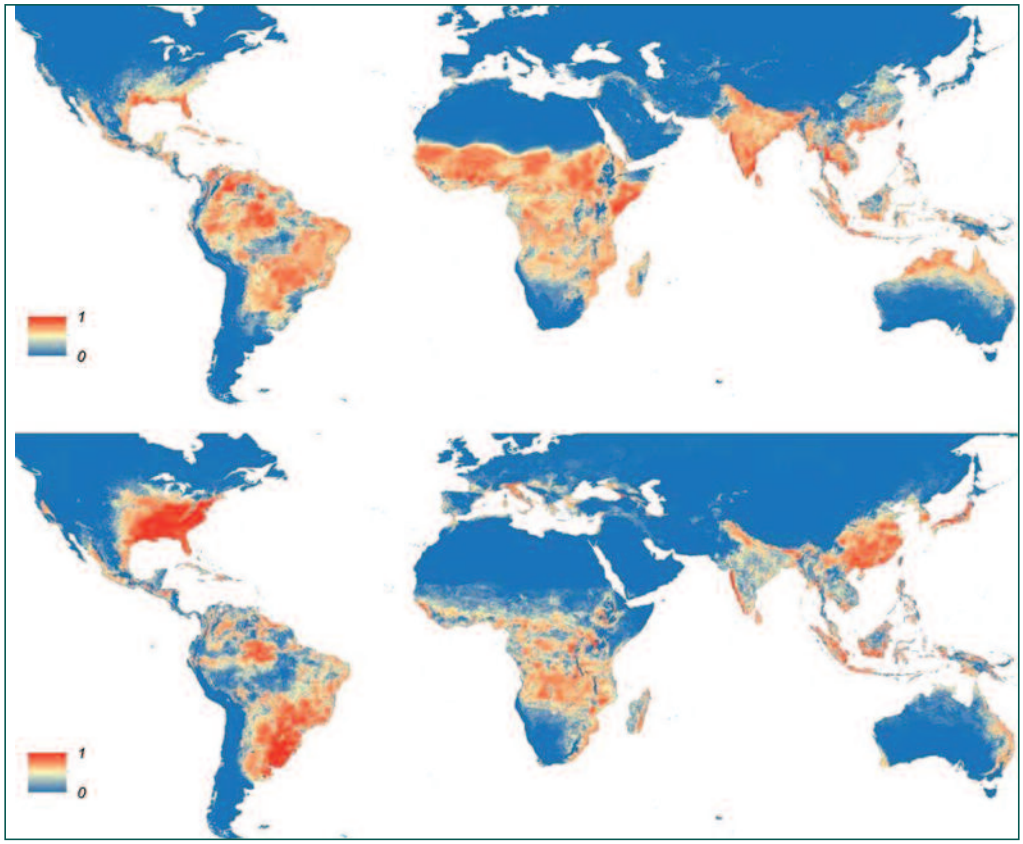


Figure 1 - Global map of the predicted distribution of the two main vectors: *Aedes aegypti* top, and *Aedes albopictus* bottom. The maps depict the probability of occurrence (from 0 blue to 1 red) at a spatial resolution of 5 km × 5 km. Taken from (Kraemer et al. 2015)

resistance.

- Evidence out on effectiveness of repellents in controlling disease. There have been eight trials of the effectiveness of repellents against malaria, four of which are adequate for meta-analysis. Meta-analysis found there was a non-significant reduction of 30% in risk of P. falciparum infection (Wilson et al. 2014) - more trials needed.

• **Aircraft disinsection** – cabin crew spray inside cabin with aerosol insecticide. Very little evidence this works; further trials needed – yet recommendations (for usage) have been made.

• **Wearable technologies** – clothing impregnated with repellent or insecticide, provide 50-100% protection against bites, and lasts for 4-5 months. Affective even against resistant mosquitoes

- Could be used to protect against mosquitoes that transmit malaria, Zika, dengue and other insect-borne diseases
- Further work underway at LSHTM and via arctec and a new spin-out company from LSHTM called Vecotech to develop this technology further

POTENTIAL NEW METHODS OF VECTOR CONTROL

• **GM Mosquitoes** – developed by Oxitec, a startup based in Oxford. Engineered to not produce viable offspring.

- Trials have been carried out in Brazil (several locations), Cayman Islands and Panama. They showed up to 90+% suppression of total Aedes aegypti mosquitoes (measured by direct counting of larvae).
- Over 150 million Oxitec mosquitoes released worldwide; no adverse effects on people or the environment.
- Potential issues: Social dislike, reinvasion of adults from other areas, technology is species specific, scale up is hard

➢ This is not an immediate solution, but it has potential

➢ There is a good opportunity now to take this technology to the next level and investigate its efficacy further

• Another potential method of control is the use of the bacteria *Wolbachia*. This is an endosymbiotic bacteria which lives inside cells and infects >65% of insects. It is maternally inherited and manipulates host reproduction to enhance transmission. Importantly it inhibits the replication of Dengue, Chikungunya & Zika viruses in *Aedes aegypti* mosquitoes.

- Rapidly invades and establishes in wild mosquito populations
- Released in wild mosquito populations in Brazil, Indonesia, Vietnam and Australia
- This technology is currently in very early stages – but this outbreak is a good opportunity to develop it further.

• We may be able to exploit humans' natural differential attractiveness to mosquitoes. It has been estimated that 10% of the population are unattractive to mosquitoes – if we can understand why we may be able to make others unattractive to mosquitoes too.

- This has never been investigated in disease endemic countries – again this is a good opportunity.
- We know that pregnant women are more attractive to malarial mosquitoes – is it the same for *Aedes*?
- Attractiveness to mosquitoes is under strong genetic control – so could there be populations that have evolved natural repellency? (Fernández-Grandon et al. 2015)

• If the genes can be identified, then a pill could be developed that upregulates the genes in question, and generates an 'aurora of repellency' around individuals.

NEEDS GOING FORWARD

• Global mosquito database – currently no global database of mosquito vectors of disease

• Guidelines & training for vector control in S. America

• Community educational campaigns

• Guidelines for vector control for mitigation and rapid response in at risk countries

• Define accurate levels of resistance to insecticides & repellents

• Development and large trials of new technologies

QUESTIONS

Q: Stephen Metcalfe MP – Are some countries better at vector control than others?

A: Yes – it's very much wealth dependant. Different countries also have different techniques they favour – and these are not necessarily the most efficient.

Q: Lord Selbourne – How practical is it looking to scale up the production of mosquitoes by Oxitec?

A: They think it is feasible, just a matter of getting enough funding. They have just built a second factory in Brazil – will be able to protect 1 million people. Are also able to build temporary factories in trucks. However for scale up to be effective they need to develop methods of aerial deployment (currently just throw mosquitoes out of lorries) – and that will require more research.

Q: Sally Cutter – Do we know how Zika virus interacts with the mosquito host?

A: Not yet – more research needed!

Q: Are there reservoirs in other animals?

A: Don't yet know how wide the host range is – but primates are definitely important. Rio has forested areas in the city, which hold animals which act as reservoirs.

Professor Trudie Lang

Professor of Global Health Research; Director of the Global Health Network and Senior Research Scientist in Tropical Medicine, Nuffield Department of Medicine; Senior Research Fellow, Green Templeton College

OVERVIEW

• **Drugs:** could assess existing anti-viral drugs - nothing on the shelf as there was with Ebola as it was not seen as a threat

- Could be effective too late to stop effect on pregnancies because anti-virals work best at early stages of infection and typically there are little or no symptoms to prompt treatment. Also issues in giving drugs to pregnant women, and so it is unlikely that drug therapy research will be a priority

• **Vaccines:**

- Progress with DNA vaccine – NIH program has been in news – will have Phase 1 trails by the summer
- But who do we target the vaccine at? How do we plan clinical trials and then scale it up? Issues with price and access –

will it be affordable and available to the countries affected? Vaccine manufacture is also an important issue.

- Traditional vaccine – slower – but work was underway to develop a vaccine for similar viruses like Western Nile disease.

• Need a diagnostic test to use in community settings - some progress has been made, but there is cross reactivity with Dengue or yellow fever

- It is also important to include foetal scanning in the discussion on diagnostics. Here standardised assessments need to be agreed and validated to determine what is abnormal and what is happening when in regard to the viral infection and developing baby. It needs to also be remembered that very few women in low-income countries have access to scans, and that abortion is illegal in most of the countries affected by Zika.

What did we learn from Ebola about drug, vaccine and diagnostic research and development during outbreaks?

• Scientists were only just starting to reflect on the Ebola response when Zika appeared – so they are having to apply lessons from Ebola straight away, before there has been time to embed them into international responses.

- In West Africa, for Ebola, there was very minimal clinical trial capacity and this slowed the response and resulted in outside organisations having to take the lead. Research infrastructure needs to be improved in low-resource countries so that they are able to respond to outbreaks locally.
    - Still managed to set up trials in 16 weeks (usually takes 18 months) – but this is not fast enough.

• We have to embed research into immediate response to a new outbreak in order that the disease can be understood and drug and vaccines can be evaluated within the very limited time within which an outbreak occurs

• need to ensure this the research effort is coordinated and led by a neutral agency, such as the WHO, and not by any one country

• WHO have developed an R&D framework - http://www.who.int/csr/research-and-development/blueprint/en/

- It is important that the response is strongly led and key questions such as to which studies to priorities as agreed by all. That way all stakeholders are able to contribute to the development of response.

• Collaborative efforts with Zika shows the need and importance of integrated research platforms – which typically cannot get funded. These need to operate outside of outbreaks to increase regional research capacity for tackling on going health issues and then are able to respond in outbreaks as they are already trained and active.

- Zika has required coordination between maternal health researchers, epidemiologists, vector experts, which just shows how this ability to collaborate and share knowledge via research platforms is so important as so many different types of research and research disciplines are needed – and they need to communicate, share and engage.
    - For example, data capture standards are really important – eg. InterGrowth are working to unify how baby measurements are taken – important if we are to have worldwide knowledge of the extent of microcephaly. Now their tools – 'The International Fetal and Newborn Growth Standards for the 21st Century' - are recommended by the WHO and 11,728 have been downloaded, in 163 countries from The Global Health Network (www.TheGlobalHealthNetwork.org). This means everyone is measuring in the same way, and therefore can agree what is abnormal and the situation can be properly assessed.

- ISARIC are coordinating an international research response and developing sharing protocols and data capture tools. The Global Health Network is providing ISARIC with a secure, online, digital information platform for sharing these research documents, standards and as a mechanism for agreeing research priorities, logging who is doing what and for providing training, tools and guidance - www.zikainfection.org . This work is lead by researchers in Brazil and everything is translated into Spanish and Portuguese

• It is vital to put in place the ability to undertake research in areas of the world where the next outbreak is likely to be. There will be others new diseases and we are not ready for future outbreaks, because it takes too long to set up research studies

• In 2014 WHO said that unless low income countries become generators rather than receivers of research and data, then we are not prepared for future outbreaks. This has not happened.

- Need a change in mind-set in low income countries – research seen as a Western thing. Start with simple pragmatic trials, then build up research base. Health and laboratory workers in these regions need to be engaged, supported and trained.

• There will be other outbreaks – and we are not prepared. Global travel and urbanisation are raising the stakes on a future outbreak.

- Therefore it is vital we work to develop (and get funding for) cross cutting research capacity development platforms. If we had these systems in place before Zika arose we would be much better able to answer all these unknowns much faster.
    - Important that MRC, DFID and the Wellcome Trust need to change their funding frameworks to reflect this, and fund capacity development and research platforms that operate in between outbreaks and therefore have the ability to respond.
    - We also need to look at what slows the process of setting up new studies. Delays such as regulatory approval and contracts can be solved ahead of time and this should be resolved through WHO working groups running cross-cutting projects to put solutions in place.

QUESTIONS

Q: Stephen Metcalfe MP – How much of this needs to be global?

A: It all does; and the UK takes a key leadership role, such as the work that the Wellcome Trust is doing. UK Organisations such as the MRC, DFID and the Wellcome Trust work alongside and in close partnership with WHO and Gates Foundation etc. to drive international effort and collaboration.

Comment: Stuart Taylor (Royal Society) – There has already been a call for freedom of information surrounding Zika research. Nature and Springer [science publishers] have agreed – Zika papers are no longer behind a paywall.

Response: This is a very important and game changing announcement – is a huge shift in the workings of science. But it will take time to see the full impact. Important to remember the need to enable the collection of data in the first place, and that it needs to be standardised and of good quality so that it is ready for sharing.

WIDER QUESTIONS AIMED AT ALL THE SPEAKERS

Q: Stephen Metcalfe MP – Is our government doing enough?

A: JW - The UK is second in terms of funding donated (only the US have donated more), and have made a considerable contribution to the contingency fund for the emergency. But we are not acting in Central and South America (instead the focus is on strategic areas in Africa and Caribbean) – so the government should think about expanding their response into the Americas.

A: JL - Also need concrete plans for what to do if *Aedes albiopictus* is found in the UK – including where funding for a response would come from. Currently the only monitoring is through the public sending in samples – not good enough.

- The mosquito has already been found in France and Belgium – could easily come over this summer, like Bluetongue disease did last year.

Q: Lord Selbourne – If Oxitec's mosquitoes are so promising, should the UK be leading on the scale up research?

A: JL – Would agree that this is the time to focus on scale up – but warns that the trials will take around 2 years, and we need viable control solutions now. Good success from other techniques too – need to scale up accessible tech. Conventional tools should not be ignored.

Q: Tim Roberts (Institute of Patent Attorneys) – The Nagoya protocol of 2014 requires the country of sample origin to give permission for any genetic research – does this raise difficulties for Zika research?

A: JW – At the level we work we haven't seen any impact. But there has been discussion going on at high levels in the WHO and Dept of Health. More likely to have an impact of influenza research? Thought article 4.4 – if research is for global health research in a pandemic then it is excepted – may be of help.

Q: What are we doing about screening blood products for Zika?

A: Minimal risk in UK, so no need as yet.

A: This is an issue in Puerto Rico, and they are having to import blood from the US.

Q: Baroness Tonge – Is there proof of the link between microcephaly and Zika? Could it not be other reasons – eg. Crop spraying?

A: TL – The link is indeed not proven yet, and 'normal' base levels of birth defects are hard to establish as recording is limited in many affected countries. Other factors are important to consider. Need more background research.

- May be that in Africa the human population has been previously exposed to Zika and so there are lower cases of microcephaly because women become immune before they reach child bearing age – but this is not proven either.

Q: Dr Jane Pritchard (GAIN) – GBS is treated with blood products, so do we need to mobilise such products from Zika-free areas?

A: The priority treatment for GBS in affected areas in currently ventilation in the ICU (intensive care unit) – patients get better over time without the need for blood products. But healthcare facilities are hugely variable in Central and South America.

Q: Cheryl Tweed – when/why did all this hit the news?

A: TL – The outbreak was widely known about in the medical community in early December, but in the UK the press were only mobilised when patients brought Zika back to the UK. BBC response has been very responsible. Great opportunity to explain why research is needed in low income regions of the world and in neglected tropical diseases, which normally gets ignored.

Q: is this incursion into South America of a certain subtype of Zika virus?

A: JW – There are two factors to consider:

- The strain of Zika seen is the Asian strain (not the African strain), which is more transmissible.
- The Central and Southern American population is naive – have not encountered the disease before – so more susceptible to the disease.
- Hard to say which of these factors is more important in this epidemic.

A: TL – Recent research has shown that this virus is quite highly conserved (similar genetically to other strains) – so it seems likely that this has occurred because these populations have not previously been exposed to the virus and so the problems arise as women are being infected for the first time when they are pregnant, when the foetal damage is occurring – but this is still a theory.

References

Fernández-Grandon, G.M. et al., 2015. Heritability of attractiveness to mosquitoes. PloS one, 10(4), p.e0122716. Available at: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0122716 [Accessed February 14, 2016].

Kraemer, M.U.G. et al., 2015. The global distribution of the arbovirus vectors Aedes aegypti and Ae. albopictus. *eLife*, 4, p.e08347. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4493616&tool=pmcentrez&rendertype=abstract [Accessed June 30, 2015].

Stanczyk, N.M. et al., 2010. Behavioral insensitivity to DEET in Aedes aegypti is a genetically determined trait residing in changes in sensillum function. *Proceedings of the National Academy of Sciences of the United States of America*, 107(19), pp.8575–80. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2889326&tool=pmcentrez&rendertype=abstract [Accessed March 23, 2016].

Wilson, A.L. et al., 2014. Are topical insect repellents effective against malaria in endemic populations? A systematic review and meta-analysis. *Malaria journal*, 13, p.446. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4246562&tool=pmcentrez&rendertype=abstract [Accessed March 23, 2016].

INTERNATIONAL WOMEN'S DAY 2016:

Scientific Organisations Celebrate the Contribution of Women

Taking place annually on the 8th March, International Women's Day (IWD) first started as Socialist political event in 1909. Today, its focus has shifted to being an international celebratory day to reflect on women's contribution and achievements across a wide variety of sectors, including science and politics. The official United Nations theme for this year's celebrations was "Planet 50-50 by 2030: Step It Up for Gender Equality", reflecting the UN's 2030 agenda for sustainable development goals.

In the UK, many scientific institutions took this occasion to celebrate the increased participation of women in STEM, but also to highlight where a change is required to encourage more women to take up leadership roles in science. In the light of this year's IWD, Science in Parliament takes a look at how two scientific organisations marked the occasion.

IMPERIAL COLLEGE LONDON

The achievements of Imperial's women were showcased during a week-long 'Women@Imperial' series of events which included an exhibition, reception evening, and an outreach event to encourage young women to enter STEM. A public exhibition of photographs and archive material was displayed in the entrance of the Business School to highlight the contribution of

female researchers, pioneering women from Imperial's history, and female entrepreneurs at Imperial.

The exhibition was unveiled during a reception evening at the start of week, in which guests gathered to listen to a welcome address by Imperial's President Professor Alice Gast (pictured). Professor Gast said that Imperial is "committed to improving gender equality, and I look forward to making progress over the coming days and months". She also discussed the rising challenges that women in leadership positions face in what she described as "today's competitive, connected and collaborative environment".

The week-long celebration was brought to a close with an outreach event to celebrate women in STEM at Imperial. This event allowed school girls to visit Imperial College to meet women who work in different areas of the College and to understand more about STEM-related careers. As well as a chance to experience an inflatable planetarium, there were opportunities to meet live earthworms and other soil animals.

THE MET OFFICE

As a leading and progressive scientific organisation, the Met Office is keen to encourage more women to consider a career in meteorological science. The Met Office marked IWD by looking at the key contribution that women make to our understanding of weather and climate. Chief scientists at the Met Office, Professor Dame Julia Slingo, visited the University of Leicester to officially open a photography exhibition, 'Space Girls Space Women'. The exhibition was commissioned by the European Space Agency in order to communicate space from the perspective of female scientist, engineers and students.

Commenting on her own scientific career, she said in an interview with the Met Office news team: "Throughout my career my scientific curiosity has taken me to many unexpected places: from working in deeply academic university research departments to advising the UK government on national emergencies. I have always found the pursuit of research thoroughly enjoyable, and I hope that future generations of women and girls find the same enjoyment in STEM subjects and are able to follow their own curiosity as far as they desire."

Since 2001 the Met Office has trained 34 women and 30 men to be World Meteorology Organisation qualified meteorologists. To continue the trend of increased participation of women in meteorology, the Met Office has a whole host of initiatives in order to recruit more women. This includes Met Office STEM ambassadors – of whom half are women – who will inspire girls to consider a career within the sector. They are also engaging with local communities in Exeter (where the Met Office HQ is based) by partnering with University of Exeter to put on a Soapbox event on 11 June 2016. Soapbox is a public-outreach platform for promoting women scientists and their work.

Professor Alice Gast

WOMEN IN SCIENCE – SO WHAT?

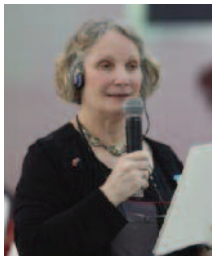
Woman influencing the Scientific Landscape in China

In the UK only 13% of all those working in occupations classed as STEM (including health occupations) are women. Only 21% of the people who studying A-level Physics and 24% of those studying A-level maths are woman.[1] Although these figures are improving (slowly) the UK has a long way to go in terms of encouraging and inspiring girls to study science to higher levels and go on to consider careers in these sectors.

The Science and Innovation Network (SIN) in China agrees, and during the British Embassy's Be Y♀urself campaign throughout March they recognised the achievements of women in society and in the economy. We have laid out some of the more inspiring stories for you below;

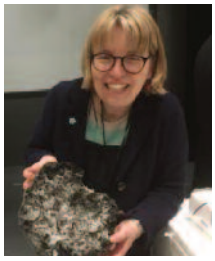
QIN CHUAN, PRESIDENT, CHINESE ASSOCIATION FOR LABORATORY ANIMAL SCIENCES (CALAS)

CALAS co-hosted the 3rd UK-China Seminar on Laboratory Animal Welfare with the British Government earlier this month. Qin Chuan and her team's involvement has ensured the annual seminar is now considered the top national level seminar in this field. The CALAS Committee under her oversight has drafted the first ever Standard for Animal Welfare in China and it will be published later this year.



JUDY MACARTHUR CLARK CBE, HEAD OF ANIMALS IN SCIENCE REGULATION UNIT (ASRU), HOME OFFICE

Judy is a key player in our UK-China collaboration projects on Animal Welfare and Ethics in China, and as Head of ASRU in the Home Office and a former President of the Royal College of Veterinary Surgeons, she is one of the top scientists and policymakers in the field of animal welfare. She visited Anhui Province in March for the 3rd UK-China Seminar on Laboratory Animal Welfare and Ethics to promote the replacement, reduction and refinement of animal use in the laboratory (the "3Rs"). Judy's energy and leadership has forged warm links with China and supported their authorities in incorporating these international principles into China's regulations under revision.



JUDITH GREEN, NATIONAL SPECIALIST LEADER IN EDUCATION AND NATIONAL SPACE ACADEMY MASTERCLASS TEACHER

Judith is an A-level teacher in Physics and Chemistry. She holds Advanced Skills Teacher status, and is one of the top science teachers in the UK. She works with the UK's National Space Academy and the European Space Agency to develop new chemistry teaching methodologies using space science. This month, Judith, with the NSA team, launched a programme in schools to offer teacher and student space science masterclasses in schools across China. In her awe-inspiring masterclasses in China she "cooked up a comet" (pictured).

The people who work in UK's Science and Innovation Network (which is a jointly funded network by the FCO and BIS works with host countries on promoting UK Science and Innovation) meet and work with inspiring woman (and men) every day. Karen Maddocks, SIN officer in Beijing and original author of a blog on this subject sums up the sentiment I have towards woman in STEM perfectly; 'My hope is that we can live in a world where seeing women in positions of influence and leadership, including our Senior Civil Servants and Ambassadors, can become so universally normal (not just in the science world) that it is no longer worthy of note, and certainly not worth a page of this blog'.

Reference

1 https://www.wisecampaign.org.uk/uploads/wise/files/WISE_UK_Statistics_2014.pdf

AUTHENTIC BIOLOGY – MAKING STEM REAL IN SCHOOLS

Dave Colthurst

Seven years ago, a phone call to the Wellcome Trust triggered a chain of events that led to the development of a national programme of genuine academic research being carried out by A-level students in their schools.

A cohort of MBP2 students, staff and university colleagues

The phone call was to see if anyone would consider funding the idea of a school carrying out research into a protein implicated in the development of Multiple Sclerosis. As a teacher and a former research scientist, I wanted to give my students the opportunity to be involved in some genuine research and I had a new-found interest in MS following my wife's diagnosis with the disease.

The Wellcome Trust has a number of funding opportunities available and I was told about their People Awards, sums of up to £30,000 to allow novel public engagement activities to go ahead. I was successful in my bid and MBP^2 – the Myelin Basic Protein Project started in September 2008. At the time, our school had about 90 students studying A-level Biology and 50 of them choose to become involved in the project.

The idea behind the project was to study human Myelin Basic Protein (MBP). Doing this type of work in a school immediately raised potential issues, but we were granted a licence to carry out transgenic work by the H.S.E. and were therefore able to work with the human gene. Our first step was to clone the gene into a plasmid which we could transfer into either *E. coli* or yeast. *E. coli* made the DNA relatively easy to work with, but we wanted to use yeast as a model organism, to mimic many of the biochemical pathways in humans, but in an entirely safe organism suited to work in a school.

Loading an SDS-PAGE gel

The project was quite complex, so the students were divided up into groups which would work on different areas, from bio-informatics, to working with yeast or *E. coli,* to purifying protein, carrying out western blots and working with DNA.

The work has progressed to the point that we are now purifying human MBP from yeast and assessing the degree to which the biochemical pathways in the yeast have modified the protein. We have been able to use antibodies to probe the MBP to see which modifications have been carried out and we are now mutating the gene to create variant forms of the protein to see what we can learn about the effect these changes have on the ability of MBP to carry out its function in the myelin sheath of nerve cells. We are currently preparing a manuscript for submission to a peer-reviewed science journal.

This will allow us to share our results with fellow researchers and validate our assertion that school students can carry out genuine, novel research.

At the end of two years, the project was progressing so well, that the Wellcome Trust granted a second People Award to extend it for a further year. At this point, the number of students studying biology in the school had doubled and we had about 100 students involved in the research work. 65% of our students leaving for university were choosing STEM subjects (the national average is around 45%).

Professor Jeremy Farrar addressess the 3rd AB symposium.tiff

At this point, the Wellcome Trust wanted to see if this was simply a phenomenon linked to our school or whether it could be replicated in other schools across the country. The granting of a Biochemical Society Award in January 2012 saw the creation of the Authentic Biology project, five state schools across the country all carrying out their own novel research projects under the guidance and supervision of their local university.

The funding allows each school to buy a "starter kit" of basic laboratory equipment with a budget of £6,300. Since each school has chosen a different project, the exact nature of this start-up kit has varied, but includes such things as breeding tanks for zebra fish, fluorescence microscopes, DNA and protein electrophoresis equipment, centrifuges and incubators.

Each school also receives salary replacement costs for a senior teacher and experienced technician for half a day each per week. This type of project could not run as a lunchtime club or after school activity, it requires dedicated curriculum time for the students, the teachers and the support staff. Finally, each school has an annual consumables budget of £2,000 per year; this covers the cost of plastic ware, chemicals, antibodies and other materials.

Another important feature of the project was the holding of an annual Research Symposium. This was an opportunity to bring all the schools together and have the students present their work to their peers both in talks and in a poster session. We also invited senior researchers to give key-note lectures to inform and inspire the students – speakers have included Professor Robin Franklin (Cambridge); Professor Russell Foster (Oxford); Lord Robert Winston (Imperial) and Professor Jeremy Farrar (Director of the Wellcome Trust).

Dr Dave Colthurst in the Lab

The first Authentic Biology Symposium was held at the People's Palace, Queen Mary University of London, but the subsequent symposia have all been hosted by the Wellcome Trust at their Headquarters in Euston Road. These symposia have proved to be a fantastic showcase for the students and clearly demonstrate the effectiveness and power of this programme.

Who are the other schools and what are they researching? The Tapton School in Sheffield is working with a team from the University of Sheffield and they are using zebra fish embryos to investigate genes associated with heart disease. They are growing the embryos in the school and using in-situ hybridisation techniques to identify the location and "activity" of specific target genes and their effect on the normal development of the circulatory system of the embryos.

The St Paul's Way Trust School in Tower Hamlets decided to study diabetes. Over 85% of

Students from SPWT present at the 3rd AB symposium

their students are of Bangladeshi origin and diabetes is significantly more prevalent in their community. A local GP collects blood samples from volunteers which are then passed on to research scientists at Queen Mary University of London. They purify the DNA from the blood and pass these samples on to the students in the school who then use PCR to identify different variants of the FTO gene. Different versions of the FTO gene show correlations with increased body mass and this is linked to an increased risk of developing diabetes.

Cotham School in Bristol is also using zebra fish embryos and GWAS (Genome Wide Association Studies) to identify novel genes involved in osteoarthritis. Working with researchers at the University of Bristol, they are selecting genes which are up-regulated in patients with osteoarthritis, finding the zebra fish homologue and using in-situ hybridisation techniques to localise the genes and assess their activity in the embryos.

The fifth school is Peter Symonds Sixth Form College in Winchester. They chose a slightly different path for their practical work, and decided to offer practical EPQ's. The Extended Project Qualification or EPQ is the equivalent of an AS and most students who complete one will research an issue, write a detailed report and present their findings as a talk to their peers and assessors. There is an option of carrying out a practical research project for the EPQ but this is relatively uncommon. Peter Symonds worked with researchers at the University of Southampton to identify a range of practical techniques that the students could apply to their research questions. They use *Drosophila melanogaster* (the fruit fly) and *Caenorhabditis elegans* (a nematode worm) as model systems and each student carries out their own experiments and writes a report on the outcomes.

The protein purification team

At the end of the initial three year grant, the Wellcome awarded us a two year extension to the funding which also allowed the project to expand to seven schools – we are now joined by the Archbishop's School in Canterbury and the Parkside Federation Academies in Cambridge.

The project has proved that school students are fully capable of engaging in highly sophisticated academic research and that this encourages them to be far more likely to consider biomedical research as a future career option. It has provided an excellent example of how universities and schools can work together on extended collaborations to the mutual advantage of both sides.

Our aim now it to explore ways of extending this type of research work to a much wider audience across the UK and to this end we are working closely with the Institute for Research in Schools (IRIS) to see how schools can be encouraged and supported to initiate novel research activities in physics; chemistry; biology and engineering. This would tap into a huge resource of enthusiastic, enquiring young minds and encourage a much wider participation in STEM.

dcolthurst@thelangton.kent.sch.uk

www.mbp-squared.org

Students from SLBS present their work at the 3rd AB symposium

FLOODING: WHAT IS NORMAL?

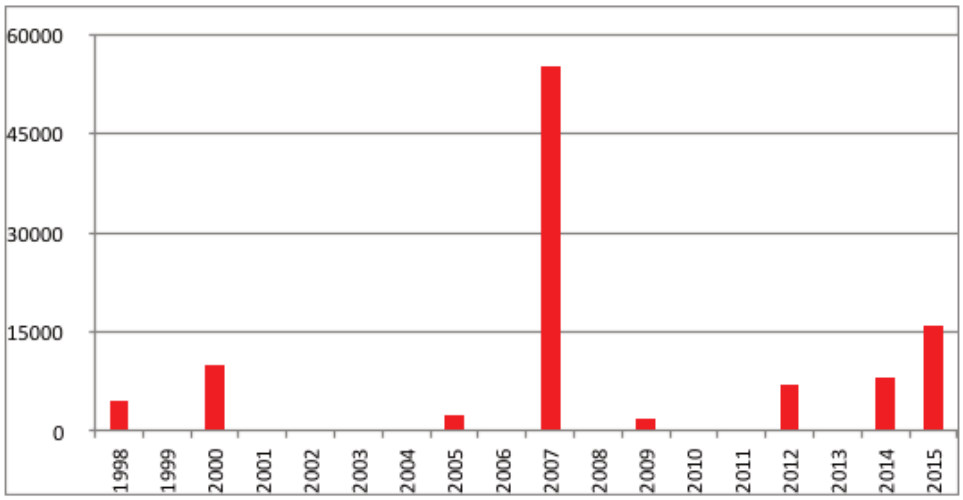
Professor Paul Bates
School of Geographical Sciences, University of Bristol

Over the last several years widespread episodes of flooding have led to extensive media coverage and national debate that at times has come to dominate the political agenda. Flooding of the Somerset Levels during the winter of 2013-14 and as a result of storms Desmond and Eva in 2016 have led to concerns over whether the UK is sufficiently resilient to flooding, whether we have correctly identified the risks we face and whether we are spending enough money on flood defences. An answer to any of these questions first requires that we understand just how often we can expect damaging floods, both in specific locations and in terms of national scale aggregated losses.

Almost by definition, river flows need to be extreme to cause to flooding at specific locations, and we therefore tend to view all episodes of flooding as somewhat unprecedented. Over many years in the UK a consensus emerged among politicians, risk managers and the public that communities should be protected against river floods that have a 1 in 100 (i.e. 1%) chance of occurring in any given year. On average, one would expect such a flood to occur at a specific location only once in a century, and hence this event is known as the '100 year flood'. This terminology is however misleading as it implies such floods can only ever occur once in a century; it is always possible, albeit unlikely, for very rare events to occur close together simply by chance.

We estimate the magnitude of the 1% annual chance flood for particular places by analysing multi-decadal series of river flow measurements and computing the statistical distribution for extreme floods. We then use this to estimate the magnitude of the 1% annual chance event in order to design defences to protect people and property against floods up to this size. Defences can always be over-topped or fail for floods larger than the design event, i.e. those with a less than 1% annual chance of occurring, and here the UK relies on the insurance system to collectivize the losses. The insurance system also deals with the losses for surface water flooding away from main rivers and for properties built within the floodplain.

Based on the above one might conclude that floods should be a rare occurrence, yet this does not seem to accord with our recent experience. Is flooding more common now, and if so why might this be? First, it should be noted that whilst particular places should only see flooding very rarely, damaging floods will occur somewhere in the UK on an annual basis. The Figure below shows the annual total number of properties flooded in the UK from 1998 to 2015. Every year sees '100 year floods' somewhere on the UK river network, and whilst storm Desmond broke the UK 24 hour rainfall record in terms of national annual flood losses 2015 was depressingly normal. Flooding in 2015 was extreme where it occurred, absolutely terrible for those affected, but the national annual loss was not at all unusual. In fact consideration of these data shows that we can expect to see annual flood losses similar to 2013/4 and 2015/6 every 2-3 years in the UK. Moreover, despite the 'unprecedented weather' narrative of much media coverage of recent flooding, similar losses occurred in 2000, 2007 and 2012.



Annual total number of properties flooded in the UK 1998 – 2015.

Has it always been like this? Is collective memory really that short, or are there more floods now than there were? We can answer this question by looking at the data from the very small number of relatively undisturbed sites in the UK where we have really long flood records. The next Figure shows data for the size of the largest flood in each year on the River Severn at Bewdley from the 1920s to the present day. The red line shows the changing trend in these data, and this clearly highlights the presence of 'flood rich' and 'flood poor' periods. We can clearly see a period of large floods during the 1940s and 1950s and again in the 2000s, with several decades of smaller annual maximum floods in between. Such decadal variations in the frequency of extreme floods are likely driven by large scale cyclical changes in the atmosphere and ocean, but will also be affected by long term trends such as those caused by man-made climate change. What is clear is that with the benefit of hindsight we can identify the Easter 1998 floods in the Midlands as the point at which we began to enter a flood rich period that is apparently still continuing.

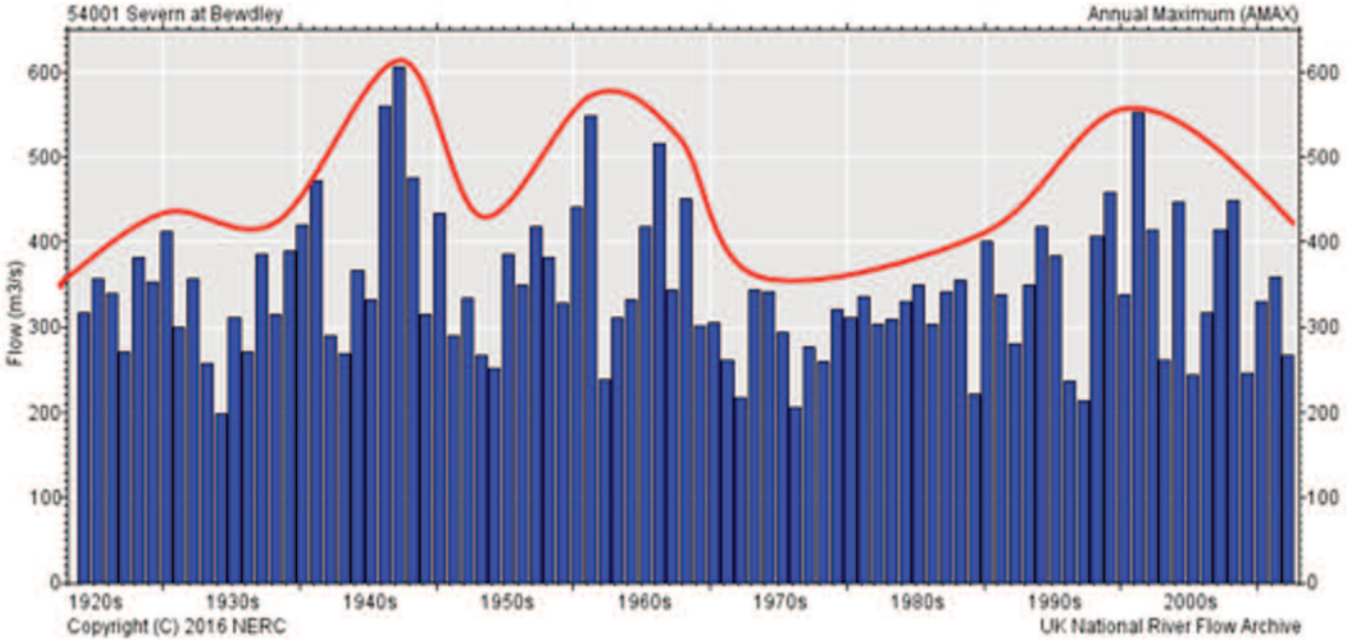
Decadal variability also makes it difficult to correctly estimate the magnitude of the 1% annual chance flood. The majority of our river flow measuring stations were installed in the 'flood poor' period of the 1960s and 1970s as a result of the 1963 Water Resources Act, and the data collected from this period may not be a good guide to the frequency of flooding during the 'flood rich' period we are experiencing today. Unfortunately, the obvious solution of using only the last 15 years of data to estimate our design flood magnitudes does not work well because with far fewer data points available large statistical errors can creep in.

There are two other reasons why flooding seems more common now than in the past. The first is that we have substantially increased our exposure to floods over the post-war period. Population increases since 1950 have resulted in a substantial expansion of housing and development, a significant proportion of which took place on floodplains as the land was flat and cheap to develop. Unfortunately the planning system has not been sufficiently robust in enforcing flood risk control, and whilst this situation is much improved inappropriate development in floodplains still continues. Data presented to the latest UK Climate Change Risk Assessment shows that between 2001 and 2014 250,000 homes, approx. 12% of all development, were built in areas classified as having a greater than 1 in 100 annual chance of flooding. More worryingly, since 2001 approximately 23,000 homes have been built in areas having of high risk (defined as a 1-in-30 or greater annual chance flooding). With the UK population projected to increase from 64.6 million in 2014 to 74.3 million by 2039 these trends are highly likely to continue.

Secondly, over the post-war period our vulnerability to flooding has also increased. Rising incomes have increased the assets at risk and losses are now proportionately greater. As a result resilience has reduced. We now own far more than our parents did, and consequently when flooding does occur we have more possessions that can be damaged. Economic growth will exacerbate this trend too.

In fact, it is very likely that increasing exposure and vulnerability have, to date, done at least as much to increase flood risk in the UK as changes in the magnitude and frequency of flooding that we have experienced. By definition risk is the product of the scale of the threat, the number of assets that are exposed and how vulnerable these things are to damage, so all three factors need to be taken into account when we think about flood risk. As well as increasing exposure and vulnerability, the future may also bring increases in flood hazard as a result of both natural variability, catchment alterations and man-made climate change. As the River Severn flood data indicate, the natural variability in flood climatology is large, and decadal scale cyclical variations and confounding factors within the catchment, such as land use change, will mean it may be some time before we can identify conclusively the effect of man-made climate change on the frequency of flooding. However, there are very good physical reasons to believe that warmer atmospheres will also be wetter atmospheres, and this is very likely to lead to more frequent and larger floods in the future.

In conclusion, in terms of national scale annual losses we can see that, contrary to the standard media narrative, flooding during winter 2015/6 was, by recent experience, entirely normal. At present it seems we should expect annual total flooded properties to exceed 10,000 every few years. Whether this degree of resilience is acceptable needs a wider debate; personally I don't think it is. We also need to examine openly whether the consensus of protecting against the 1% annual chance event is something we as a society are still comfortable with. At the same time scientists need to undertake further work to make sure our hazard assessments are not biased by the 'flood rich' and 'flood poor' periods in our data. Most importantly we need a more sophisticated view amongst politicians and the general public alike of how events which may be extreme in particular places can lead to levels of national scale loss that are seen much more frequently.



Largest annual floods on the River Severn at Bewdley 1920 to present day (Source: UK National River Flow Archive, http://nrfa.ceh.ac.uk/).

OUR APPROACH TO FLOOD RISK MANAGEMENT

David Balmforth

THE THREE QUESTIONS

When I meet people who have suffered from flooding they invariably have three questions:

"How much am I at risk of flooding?"

"What are you going to do about it?" and

"What can I do about it?"

The second question is usually delivered with a pointed finger. These questions form a useful framework for exploring our approach to flood risk management in this country[1].

HOW MUCH AM I AT RISK OF FLOODING?

In the absence of any real understanding of the complexities of flooding, where do ordinary people go to answer this question? A quick search on Google reveals that some way down the list of organisations offering professional risk assessment services there appears the Environment Agency's web site, which for England1 is the primary place to gain an understanding of flood risk. Here we find maps indicating the parts of the country at risk from coastal flooding or inland flooding from rivers. It is clear that areas shaded blue are at some risk of flooding. However the likelihood of flooding is not clear to many users. Expressing the likelihood of flooding as a return period often lulls the public into a false sense of security (does a 1% chance of flooding mean that I will not be flooded for the next 100 years?). A further complication is that areas "protected" by flood defences are show with cross hatching on top of the blue shading. Does this mean those areas will not then now flood? How secure are the defences? What if they are overtopped? Then we find, with a little more searching, a surface water flood map. This appears in an entirely different format but has the advantage for many that it indicates if a particular location is at high, medium or low risk of flooding. For many this is easier to understand. What we do not find here is any information on the risk of sewer flooding, or the risk from groundwater flooding. There are maps to show the impact of reservoir failure, but only for those reservoirs containing 25000m^3 or more. Smaller reservoirs are not included (e.g.10000 to 25000m^3). Following the 2007 floods, the Pitt Review recommended that there should be a more joined up approach to flood risk management with better information of flood risk available to the public (http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html).

Tier 1 Local Authorities (County Councils and Unitary Authorities) have been given the responsibility for overseeing flood risk management in their area. They have a duty to investigate flooding incidents and to undertake strategic flood risk assessments. With the EA, they are also statutory consultees over planning applications for major development where this might have an impact on flood risk. But

The sad fact is that the first time many people realise that they are at risk of flooding is when they actually flood.

the level of resource allocated to this function is often inadequate, meaning that they are unable to develop the expertise necessary to properly quantify and communicate flood risk or to coordinate responsible bodies in a meaningful effort to tackle flood risk holistically. Some 8 years after the Pitt Review, we still have to fully implement many of the recommendations. The sad fact is that the first time that many understand that they are at risk of flooding is when they actually flood.

It is also clear that many of our infrastructure operators are also confused about the risk of flooding to their assets. At times they appear unable to reliably answer the question "what if it floods?" This results in critical failure of key infrastructure during floods such that the effects of the flooding are felt over a much wider area than that actually inundated by flood water.

In defence of this we describe floods as "unprecedented", "once in a lifetime" and "extreme". When such floods occur year after year, this message wears a bit thin. We have world class weather forecasting in the Met Office and excellent modelling and flood assessment capability in the Environment Agency. Yet we do not seem to be able to communicate with the public in a meaningful way. Perhaps now is the time for us to step up to the challenge and be more open with the public over the risk that they face – and if there are uncertainties around answering that question, then let's be open about that too.

WHAT ARE YOU GOING TO DO ABOUT IT?

The Environment Agency estimates that over 2.4 million properties in England are at risk of flooding from rivers and the sea (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381939/FCRM_Long_term_investment_scenarios.pdf . Of the total agricultural land in England, approximately 1.3 million hectares (14%) is within flood risk areas. During the winter floods of 2015/16 some 20 000 properties were flooded in England compared with about 55000 in 2007. But in 2007, almost none of the property flooding came from rivers or the sea. The 2007 floods were largely attributable to localised surface water flooding. There are over 770000 properties at risk of surface water flooding and the responsibility for managing surface water flood risk rests with local authorities. However, surface water flooding in urban areas is very much influenced by the effectiveness of sewerage systems which are the responsibility of water companies. OFWAT, the Government regulator for water companies estimates that there are between 5000 to 8000 incidents of property flooding a year from the sewerage system (http://www.ofwat.gov.uk/wp-content/uploads/2015/11/prs_pre1103susdrain_ofw4.pdf). Further to this there can be flooding from local water courses and culverts (jointly the responsibility of local authorities and riparian land owners), and for groundwater (local authority responsibility).

So the first challenge our questioner faces here is at who do they point the finger? Such a diverse range of responsibilities split across many bodies without an effective overarching policing function fails to achieve the "one stop shop" to strategic flood risk management envisaged by the Pitt Review. Even professionals in the business struggle from time to time to be sure about who is responsible for what.

The Water Companies have made significant progress on reducing flooding from overloaded sewers (but still have some way to go on blockages and collapse). The 2013/14 floods showed that our coastal

The first challenge our questioner faces here is at who do they point the finger?

defences just about held up to the storms. The 2007 floods demonstrated the effectiveness of river defences, but in the recent 2015/16 floods our river defences in many parts of England fell well short of the mark.

Whilst a good deal of the additional flooding experienced in 2015/16 can be attributed to the severity of rain events, a significant part can be put down to inappropriate development. Local authority responsibilities for flooding are separated from decisions on planning, leading at times to inappropriate development and a lack of uptake of SUDs. Splitting the responsibility for flood risk management across so many agencies does not make sense. It means that our strategy becomes far too fragmented resulting in non-optimal schemes being developed. Worse than that, it inhibits engagement with the public and acts as a barrier to effectively dealing with the third question.

Our understanding of the likely effects of a changing climate, growing population and constraints on investment mean that we will not be able to protect every community from the risk of flooding from all future events. This means that we must learn to live with floods and build resilience in our communities and infrastructure. We need to be honest and open with the public and business about this, to build trust in the community, engage the public and make them part of our future strategy.

WHAT CAN I DO ABOUT IT?

There is much that the public and businesses can do to help themselves and much that they can contribute to a flood resilient future. Perhaps the most important action they can take is to get involved. For this to happen, those of us professionally engaged in flood risk management need to see the public and business as part of the solution rather than part of the problem. Engaging the community opens up the potential to significantly reduce flood risk by building resilience.

Resilience involves both structural measures (those involving a physical intervention) and non-structural measures (personal actions to prepare or recover from flood events). The Met Office and the Environment Agency have together made very significant progress on flood forecasting and can now forecast floods with good accuracy four days in advance. A free flood alert service is available to allow the public to prepare.

Householders and businesses can do much to make their property more resistant and resilient to flooding. Fitting temporary flood barriers to doors and air-bricks can help to keep floodwater out of property, though it is important that adjacent properties are similarly protected. Good advice on this can be obtained from the National Flood Forum http://www.nationalfloodforum.org.uk/ . Such measures can help to keep properties free of flooding for all but the most severe events. Beyond that, the use of cementitious wall linings and concrete floors with tiles can enable flooded properties to be restored to use quickly after flood events. Setting electrical sockets higher up walls can avoid the need to rewire, and lightweight furniture at ground level will allow rooms to be quickly cleared out in preparation for a flood event. Property owners who have made their properties resilient and resistant to flooding demonstrate that it is possible to return to "business as usual" quickly after a flood event, with minimal loss and without the need for extensive drying out and renovation works.

Flooding should be considered at day 1 of any new development or regeneration project…measures to reduce flood risk can also deliver amenity, biodiversity and water resource benefits.

Or course there are strategic measures that can also be implemented to make communities and infrastructure more resilient to flooding. Flooding should be a key element of spatial planning, considered at day 1 of any new development or regeneration project. More creative spatial planning can see roads act as flood channels in extreme events and parks and urban squares used as sacrificial flood areas. All this can help to keep flood water away from vulnerable areas. New properties in flood risk areas can be built with raised thresholds and flood resistant materials, and this should be considered when renovating properties after a flood. There is a strong argument for tightening planning guidelines and amending building regulations to facilitate this. The additional cost incurred during new construction or building restoration would be small compared with the benefits from reduced flood risk.

Finally, the application of flood resilience measures within the wider community can be seen in the context of the wider water cycle where measures to reduce flood risk can also deliver amenity, biodiversity and water resource benefits. A more sympathetic approach to urban planning which fosters the concept of living with water is a future aspiration that is worth recognising.

Footnote

1. This paper is written in the context of England, though similar roles and responsibilities exist in other member states of the UK

WEATHER DIPLOMACY

Diplomacy is usually thought to be the preserve of Foreign and Commonwealth Office diplomats working overseas to build and maintain relationships with other nations. Who would have thought that television weather forecasters were part of a powerful and important diplomatic tool? Welcome to the world of weather diplomacy!

The weather is something we talk about everyday and we often feel it is part of what makes us uniquely British. But weather not only brings the British together, it brings nations around the world together to share information on what is happening, and what might happen, with our weather and climate. Our global community works together on weather-related activities such as:

• **Monitoring** – Most nations are monitoring their weather and climate, but all countries recognise that they can't just look at their own weather if they want to make sense of what the weather is doing or, perhaps more importantly, what it might do next. Around the world, every single day, nations freely share the observations they collect from land sensors, ships, ocean buoys, aircraft and increasingly from satellites.

• **Forecasting** – These observations are a vital part in forecasting the weather. Without a good picture of what our weather is currently doing we can never forecast what it might do next. Once we have shared these observations, some National Meteorological Services, like the Met Office in the UK, run large global weather forecasting models to predict what the weather might do in the next days, weeks, months and seasons ahead. These forecasts are then shared, allowing nations around the world to make the best use of these global forecasts, maybe by running local models to add more detail, or combining the information from many different sources to make an assessment of what the future holds.

• **Warning** – These forecasts are then used to support National Met Services to provide services to their own governments, businesses and citizens, helping to protect life and property from the impacts of weather and climate extremes. In a recent example, people on the Eastern Seaboard of the USA were warned in January about the exceptionally heavy snow storm before it hit, no doubt saving lives as a consequence.

WEATHER AND CLIMATE – WHAT IS THE DIFFERENCE?

Weather: the day-to-day conditions of the atmosphere that can vary quite quickly

Climate: the average weather conditions over longer periods and over large areas

191 nations, from Australia to Iran and North Korea to Zimbabwe, work together through the **World Meteorological Organization**, the UN specialised agency for weather, climate and water. Each nation undertakes to ensure 'free and unrestricted exchange of data and information, products and services on matters relating to safety and security of society, economic welfare and the protection of the environment'.

Such an undertaking to share data, information and forecasts across national borders, including with countries where traditional diplomatic relationships are difficult, is possibly unique. It happens because of a recognition that through this open exchange, meteorologists and their governments can do more to keep people safe, drive their economies and increase security and stability within their own borders but also beyond.

This collaboration also operates at the European level, with nations across the continent coming together to make the most of our shared expertise. Through the European Centre for Medium Range Forecasts (ECMWF) or EUMETSAT, who operate our shared weather satellites, we are working together to deliver and exploit world-leading science and technology.

The UK's Met Office, for example, has exported its world leading weather forecasting model. This "Unified Model" is now used by partners in Australia, South Korea, South Africa and India. In addition, the Met Office has formal agreements to work with China, South Africa, Philippines, USA, Australia, South Korea, Finland, Singapore, France, Germany, Rwanda, Kenya, Brazil and Malaysia. By collaborating on this world-leading capability, nations are able to benefit while also contributing to its development, which in turn brings benefit back to the UK. Other areas of diplomacy could learn from this openness and transparency. It fosters trust and greater levels of collaboration which can further our scientific understanding of our shared weather and climate.

To ensure these collaborations continue, the Met Office needs to maintain its credibility as a world- leading science institution. To this end, Met Office scientists have co-authored papers with scientists from over 440 institutions across 41 countries, and they represent the UK on over 220 independent science committees. The Met Office participates in the Intergovernmental Panel on Climate Change (IPCC), supporting work to catalyse understanding and response to climate change, and which was awarded the Nobel Prize for Peace, surely the ultimate achievement for any form of diplomacy!

There are always opportunities to do more. The Newton Fund, which is part of the UK's official development assistance, builds science partnerships that promote economic development and welfare of developing countries. The Met Office is a key partner for Newton Fund work on weather and climate in China, South Africa, Malaysia and Indonesia and expanding to Brazil. Enabling countries to understand and forecast their own weather and to prepare for weather emergencies supports national stability which in turn enhances global security. Also, by working collectively in an area such as weather and climate it is hoped that this may break down barriers, or open opportunity for countries to speak on wider issues.

Perhaps the next time we find ourselves discussing the weather, we should be mindful that by doing so, we are part of a global conversation!

POPULATION, POLICY AND PRACTICE PROGRAMME

Professor Tim J Cole
MA PhD ScD HonFRCPCH FMedSci

UCL Institute of Child Health,
30 Guilford Street, London
WC1N 1EH

Tim Cole, Professor of medical statistics at UCL's Institute of Child Health, has been awarded the 2016 Rank Prize for Nutrition, for "*seminal contributions to mathematical modelling of childhood growth and its application in nutrition, epidemiology, medicine and public health*". He is well-known for his work on the statistics of growth, in particular his LMS method, which he developed for the construction of growth centile charts. He applied it most famously to derive international body mass index (BMI) cut-offs for childhood overweight, obesity and thinness. Based on reference data for BMI in six countries, his BMJ paper in 2000 with Katherine Flegal, Mary Bellizzi and Bill Dietz provided overweight and obesity cut-offs, while a follow-up BMJ paper in 2007 with Katherine Flegal, Dasha Nicholls and Alan Jackson developed analogous thinness cut-offs. Originally sponsored by the International Obesity Task Force, the IOTF cut-offs have subsequently become the international standard for defining child obesity, and the two papers have been cited 12,000 and 1500 times respectively on Google Scholar.

After studying at the Universities of Cambridge and Oxford, in engineering and then biomathematics, Tim Cole joined the Medical Research Council's Pneumoconiosis Research Unit in South Wales in 1970 as a junior statistician. He was presented with data from two cohort studies that had been set up to investigate chronic bronchitis in the mining town of Staveley Derbyshire, and he used them to explore the relationship between lung function (forced expiratory volume in 1 second, FEV_1), height and age. The clinical management of lung disease involves comparing the patient's FEV_1 with an expected value based on their age and height. Up to then the procedure had been to predict their FEV_1 for age and then add or subtract a height adjustment. But Tim showed it is better to multiply or divide the age prediction by the square of height. This exploits the body size scaling that relates lung volume and height, in that lung volume is proportional to height^3. But for statistical reasons the adjustment works better with height^2 than height^3 (the same argument applies to BMI, which is defined as weight/height^2).

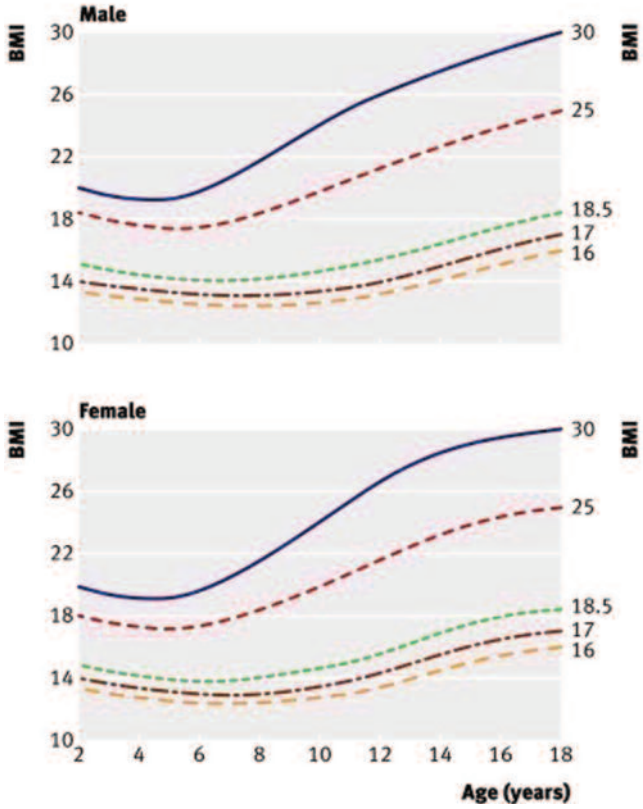


Figure 1. International BMI cut-offs for thinness, overweight and obesity in children aged 2-18, based on BMI at age 18. Obesity corresponds to BMI 30 at age 18, overweight to BMI 25, and thinness (three grades) to BMI 18.5, 17 and 16 (Cole et al. BMJ 2007;335:194-7).

Recently Tim Cole has collaborated with Professor Janet Stocks of ICH, Professor Philip Quanjer (Erasmus University) and Dr Sanja Stanojevic

(Hospital for Sick Children, Toronto) to create international lung function references extending from age 3 to 95 years. Based on work of 20-30 years earlier, the paper was published in 2012 and already has 500 Google citations.

In 1975 he transferred to the MRC Dunn Nutrition Unit in Cambridge, where his interest in child growth developed. Working with colleagues Roger Whitehead and Mike Rowland in The Gambia he first quantified the impact of infection, particularly diarrhoea and malaria, on growth in malnourished infants. Arising from this he became interested in the performance of weight-height indices to measure child malnutrition and obesity, showing in 1979 that with age adjustment the body mass index (BMI), already widely used in adults, was also valid for children.

This in turn led to an interest in ways to construct growth reference ranges, which are widely used as growth centile charts. The procedure is to measure large numbers of children (e.g. their heights and weights) and plot the values against age. The statistical challenge is then to draw growth centiles that summarise the distribution of the measurement as it changes with age. This culminated in the publication in 1988 of his LMS (λμσ) method, subsequently improved with Professor Peter Green of Bristol University in 1992. The LMS method provides a way to construct age-related reference ranges based on the normal distribution but including an age-varying adjustment for skewness, and also allowing the calculation of z-scores. As such it has revolutionised the construction of growth charts, particularly for measurements with a skew distribution such as weight and BMI. The Cole-Green paper has over 1400 Google citations, and its methodology has been used to construct growth charts in some 40 countries worldwide.

Working with Professor Mike Preece of the UCL Institute of Child Health Tim used the LMS method to construct new growth charts for the UK. The British 1990 charts were published in 1995 and subsequently became the official UK growth reference, distributed to all new parents in the parent-held child health record (usually known as the Red Book). With around seven hundred thousand births a year, this has meant that many British parents have become familiar with growth charts. During the 1990s the increasing worldwide interest in child obesity was constrained by the lack of a suitable BMI reference, and the British 1990 reference was one of the first in the world to include BMI.

The World Health Organization published its own growth standard in 2006, and the UK decided to incorporate it in the UK growth reference. The result was the UK-WHO growth reference, published in 2009, which combined the WHO chart for age 0-4 with the British 1990 chart for age 4-18. The UK-WHO charts were designed by an expert group led by Professor Charlotte Wright of Glasgow University, and they set new standards for the quality of chart

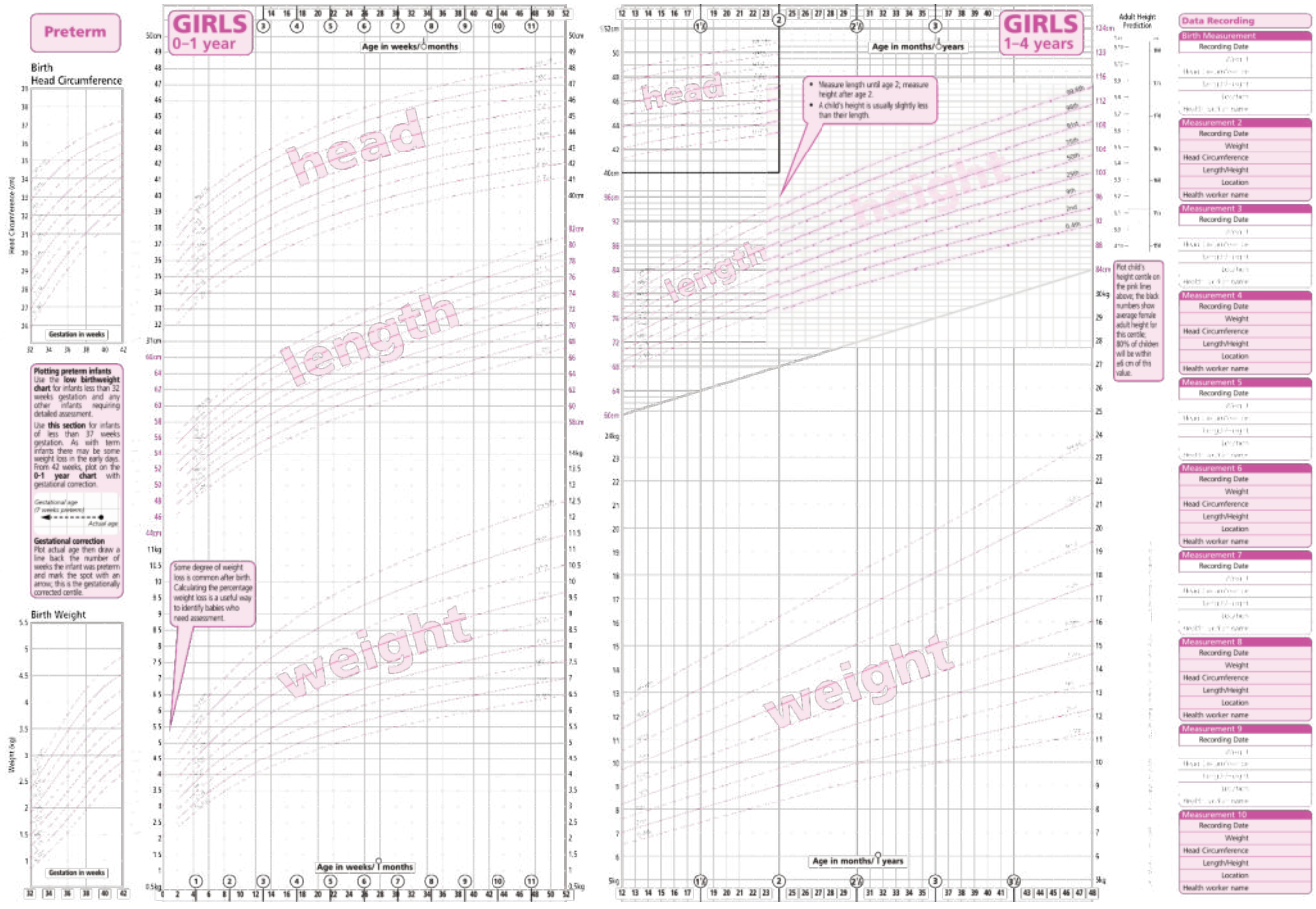


Figure 2. UK-WHO growth chart for weight, height and head circumference in girls aged 0-4 (Wright et al. BMJ 2010;340:c1140).

design and associated training materials.

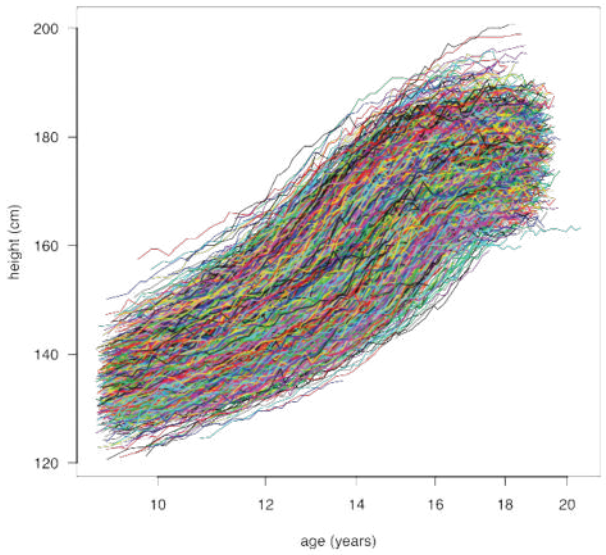
Tim Cole moved to the UCL Institute of Child Health in 1998, while continuing to be funded by the Medical Research Council (funding which continues to now). His work from around that time covered several distinct areas of growth: developing ways to extend the conventional growth chart to measure growth velocity; improving methods for predicting adult height from height in childhood (later incorporated in the UK-WHO charts), and documenting the nature of secular trends in growth over time – how children have become larger earlier during and since the 19th century.

He has become interested in modelling the pattern of growth in individuals, that is to say the shape of growth curves made up of serial measurements, for example height, plotted against age. His SITAR (SuperImposition by Translation And Rotation) growth curve model is unusual in that it adjusts for developmental age. This means that it deals appropriately with growth during puberty, where the pubertal growth spurt may occur as early as age 10 or as late as age 19. Taking into account puberty timing, the rate of passage through puberty and individual height prior to puberty, the model can explain as much as 99% of the variance in height (see Figure 3). So differences in pubertal height growth between individuals can be summarised by these three numbers. As a summary of individual growth patterns they are useful in experimental medicine and life course epidemiology.

Over 25 years ago, working in collaboration with Professor Colin Morley of Cambridge University, Tim Cole developed a system called Baby Check for helping mothers to decide if their baby is seriously ill. Based on a large research study of 1007 well and ill babies, Baby Check consists of 19 simple questions about signs and symptoms (e.g. "does your baby seem more floppy than usual?"). Each question scores a number of points if positive, and the scores are added up. The total score is a sensitive measure of illness, where well babies score 0 while seriously ill babies needing be assessed immediately score 20 or more. Baby Check has recently been produced as a smartphone app, thus providing access to the diagnostic skills of an experienced paediatrician in one's pocket.

Tim has also recently acted as an expert witness in age assessment court cases in the UK and Australia, where radiographs of hand bones or wisdom teeth are used as markers of developmental age to decide if individuals are aged over 18. For example Indonesian fishermen convicted of crewing ships bringing asylum seekers to Australia (people smuggling) are jailed for five years unless they can show they are minors, in which case they are repatriated. The age test used has until recently been based on bone age. Tim has testified that markers such as these are unreliable, giving the wrong answer over one-third of the time, and that they should not be used for this purpose.

He has been a statistical editor with the BMJ for 25 years, and supervises statistical review for the Archives of Disease in Childhood. He was appointed an Honorary Fellow of the RCPCH in 2006 and Fellow of the Academy of Medical Sciences in 2007, and awarded the 2015 Royal Statistical Society Bradford Hill Medal.



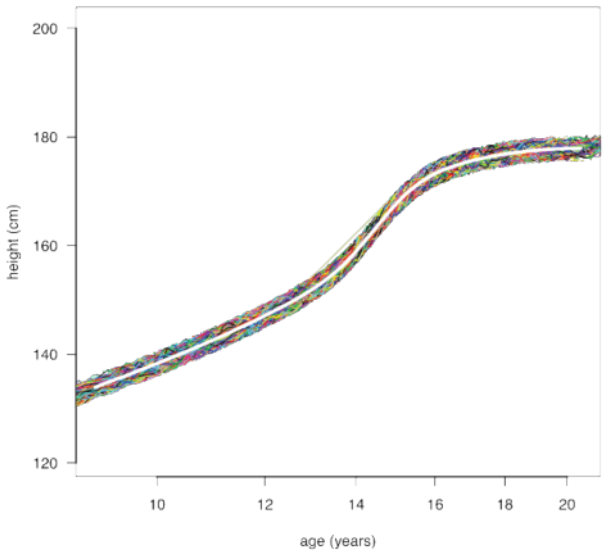


Figure 3. Height growth curves for 3245 boys during puberty (left), and the same growth curves after SITAR adjustment for mean height, puberty timing and growth rate (right), with the mean curve shown in white (Cole et al. International Journal of Epidemiology 2010;39:1558-66).

SCIENCE AT DAVOS


Each January, 2,500 public and private sector leaders gather in Davos, Switzerland for the Annual Meeting of the World Economic Forum. This year's agenda was built around 'The Fourth Industrial Revolution'; a forecast shift in product manufacturing arising from developments in rapid prototyping, new manufacturing techniques and automation. Recognising the critical underpinning role of research, a dedicated programme of interactive IdeasLab sessions placed science in the spotlight by introducing delegates to the vision and expertise of leading academics from Imperial College London, Cambridge University and other global science institutions.

Prof Alice Gast
President
Imperial College London

At this year's World Economic Forum meeting in Davos, UK institutions played a leading role in encouraging an audience of policy-makers and industry leaders to share ideas and to collaborate.

The focus of discussion at this year's Davos meeting was 'The Fourth Industrial Revolution'. In this revolution, rapid prototyping, computer simulation and intelligent systems speed up the design process, while new manufacturing techniques, coupled with robotics and automation, offer alternatives to centralised models of production[1]. Novel materials, artificial intelligence and neuroscience open up entirely new product categories. This revolution will transform our lives, and fundamental research is embedded at its core.

The World Economic Forum held interactive IdeasLab discussion sessions hosted by universities and other institutions such as Nature Publishing Group. The IdeasLab programme recognised the strength of universities in fundamental blue-skies research and subjects ranged from the neural basis of decision-making hosted by Stanford University, to carbon reduction technologies presented by Cambridge University. Imperial College London's session explored materials of the future; an area where the UK boasts world-class expertise.

IdeasLabs are presented in a format called PechaKucha, which means 'chit-chat' in Japanese. Four experts give five-minute presentations with fifteen slides displayed continuously for only twenty seconds each. Having laid out a provocative idea or vision, discussion then opens to delegates. Delegates benefit from a discussion grounded in the latest science and the opportunity to talk to world-leading experts. Scientists benefit from being able to communicate opportunities and challenges with a diverse audience of decision-makers.

The IdeasLabs showed how the problems facing the world today include a broad range of scientific, technical and societal issues. This provided a welcome opportunity for researchers, policy-makers and business leaders to consider long range, open-ended research that will provide the breakthroughs that the world needs; the kind of discoveries that are driving 'The Fourth Industrial Revolution'.

The four scientists from Imperial College's IdeasLab[2] showcase the ideas that they presented at Davos in 2016. Videos of their five-minute talks are available online at http://tinyurl.com/WEF16 Materials.

ENGINEERING CRYSTALS FOR BETTER TELECOMMUNICATIONS

Prof Neil Alford
Professor of Materials Science and Nanotechnology
Imperial College London

Noise is the bane of electronic engineers. We see it on our TVs and hear it on our mobile phones and our radios. A recent discovery indicates that there may well be a solution.

In the world of Big Data, we are increasingly dependent on accurate, reliable and secure communications. Countries with the best communications infrastructure experience faster rates of economic growth[3]. The rapidly falling costs of data connections means that the number of services built around connected devices will increase.

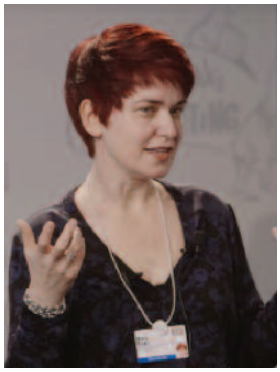
This rapid growth poses a challenge. The microwave technologies that underpin today's communications infrastructure – from satellite networks to Bluetooth to 4G – are all susceptible to electromagnetic interference. We have all experienced microwave noise: unexpectedly dropped calls, crosstalk and Wi-Fi that grinds to a halt. As more devices attempt to communicate, this problem will get worse.

Engineering electronics resistant to noise is technically possible but has been costly. One early promising noise-limiting technology was the maser, discovered by Charles Townes in the 1950s and a sister technology to the laser. But while lasers are ubiquitous today, masers are rarely used. Unlike the relatively simple laser, linked problems of complexity and cost had always proved insurmountable for the maser.

At Imperial, we have a discovered a new design for a maser that overcomes these problems.[4] The performance of this new maser is orders of magnitude better than the best competing technology. The breakthrough means the cost of manufacturing and operating masers could be dramatically reduced, paving the way for their widespread integration into telecommunications.

When lasers were invented no one knew exactly how they would be used; yet they are now used everywhere. Already we can foresee additional applications for the re-engineered maser that include more sensitive medical scanners; chemical sensors for remotely detecting explosives; and better radio astronomy devices for detecting life on other planets. In the near term, the discovery of a room temperature maser solves a real world challenge. It promises better communications that are resilient to the growing problem of noise in our connected infrastructure.

HOLISTIC HEAT MANAGEMENT



Prof Mary Ryan
Professor of Materials Science and Nanotechnology
Imperial College London

From transistors to industrial processes, waste heat is always produced when machines do work. This year seven billion people will consume about 25 trillion kilowatt hours of electricity and much of this will end up generating waste heat. Today, we treat heat like an unwanted by-product: a persistent challenge for industrial design. But what if heat were not a waste product, but a resource? Then we would be throwing huge amounts of resource away. Dealing with heat also consumes energy. In aircraft, controlling heat increases fuel use and reduces efficiency. At the other end of the temperature scale, 15% of global electricity production is already used for cooling.

To reduce energy consumption and waste, we need to change our approach to heat management. A transformational approach would involve the ability to efficiently convert between heat and electricity. Recent materials research promises new smart materials that can be embedded into systems to remove and recycle heat. Smart materials can be swapped into existing systems to provide energy-efficient cooling.

Current research is focussed on two key challenges. It takes the right chemistry for materials efficiently to convert between heat and electricity. It takes the right structure to control heat and energy transport. We will need new materials, structured at the nanoscale, to perform both functions well. When we look into nature we see this combination of chemistry and nano-structuring everywhere, so we know that it is possible! Creating these composites – and

making them efficient, reliable and easy to manufacture – is work that we do in my lab at Imperial College.

Being able to combine structure and chemistry will open up new applications. You could build miniature sensors that simply scavenge energy from their environment. Combined with local renewable production and energy storage, you could imagine a future of factories or data centres that operate totally off-grid. By developing closed heat-energy cycles we would reduce resource use, production costs and environmental impacts.

Today we face a triple challenge of energy security, equity and sustainability. Heat is such a huge part of our energy ecosystem that even small changes will have big impacts. In the future, smart composites will make it possible to build heat capture into everyday objects, to transform our approach to heat in both industrial and urban design. The first challenge is to recognise heat as a key resource.

PLASTICS THAT CAN MANIPULATE LIGHT

Prof Natalie Stingelin
Professor of Functional Organic Materials
Imperial College London

With seabirds trapped in discarded packaging, and mid-ocean islands of indestructible rubbish, the idea that plastics could play a big part in a more sustainable future world might seem far-fetched. However, new smart plastics are challenging this perspective. In sports we already rely on smart plastics to make sails that are ultra-strong, yet ultra-light. Artificial tissues made of plastic can be incredibly intricate, yet stable and flexible, and plastics that conduct electricity promise a future of bioelectronics.

It Is not just individual plastics. By layering different plastics together, we can produce new materials with exactly the properties we want. At Imperial College, we blend different materials to create new 'hybrid' plastics with new functional properties. We use them to make transparent mirrors – which is a paradox. These mirrors are perfectly transparent to visible light and yet reflect infrared heat with total precision. They are designed to reduce the energy we waste keeping buildings at the right temperature because they are perfectly transparent and can keep heat in – or keep heat out.

When we start to stack our materials in two and three dimensions, the possibilities multiply. Today, fibre-optics transmit light for telecommunication, but we can envisage products lightweight and cheap enough to be able to 'plumb' heat and light, just as we plumb water today across our buildings and infrastructure. We can even imagine a plastic light-powered computer chip. For these, we need manufacturing approaches that can scale up. With tunable plastics that can control light, such as those we have developed at Imperial College, we are one step closer to that goal. And if transparent mirrors or plastic computer chip are possible, we can now start asking ourselves: "In the future what else could we do for agriculture… for medicine… or for architecture?"

COMPUTER SIMULATION OF TOMORROW'S MATERIALS

Prof Robin Grimes
Professor of Materials Physics
Imperial College London
CSA to the FCO

Our success as a civilisation is based on our ability to continually find the right materials. When we talk of the stone and iron ages – or the era of plastics and steel – we recognize the central role of materials in shaping societies and economies. Today we know of at least 10 million materials but there are *at least* a hundred times more yet to be discovered, from novel composites and smart materials to the genuine 'unknowns' – exotic materials with properties we cannot yet anticipate. The problem is that to explore all possibilities through experimentation, as we have been doing, would take billions of lifetimes.

Yet the need rapidly to identify new materials options has never been greater. We face interlinked constraints of resource scarcity, energy security, climate change and population growth. Some of the materials that are the "right tools for the job" today will no longer be available. Their constituent elements will be too scarce, too expensive or they will be too resource hungry to produce. So, we need to get quicker and smarter at materials identification.

This is the promise of computer simulation, which is

already "a UK success story".[5] Sheer processing power allows rapid prediction of material properties – even those that have yet to be made. For example, my own research has predicted the radiation tolerance of materials using atomic scale simulations. However, we need to go well beyond the atomic scale if we are to make predictions relevant to materials used in manufactured products. Modelling across scales is today an active and multidisciplinary research challenge that spans the natural sciences, computer science and materials research.

What we do know is that computer simulation can never be the whole picture. Predicted materials still need to be tested in the real world. Computer simulation can help us focus in on interesting possibilities, but it is experimental work that tells us if computer predictions are right, and – in turn – challenges us to build ever better computer models. In other words, the key is to develop an approach to materials research that combines the power of both approaches.

Putting this power to work promises smarter, cleaner and more sustainable materials. It gives us the resilience to adapt to our changing world – whether it's re-engineering industry or addressing resource scarcity.

References

1 Department for Business Innovation and Skills. **Future of manufacturing: a new era of opportunity and challenge for the UK – summary report.** https://www.gov.uk/government/publications/future-of-manufacturing (2013)

2 http://www.imperialtechforesight.com

3 Deloitte LLP. **What is the impact of mobile telephony on economic growth?** GSM Association (2012)

4 Oxborrow M., Breeze J. D., Alford N. M. **Room temperature maser**. *Nature* 488:353–356 (2012)

5 Grimes R. **The rise of scientific computing – a UK success story.** *Science in Parliament* 71/4 (2014)

BRITISH SCIENTISTS HONOURED WITH PRESTIGIOUS NEUROSCIENCE PRIZE

A trio of British scientists have claimed the prestigious Grete Lundbeck European Brain Research Prize – the largest prize for neuroscience in the world. It was announced in Copenhagen on 1st March that Tim Bliss, Graham Collingridge and Richard Morris will share the €1 million award for their contribution to our understanding of memory. This is the first time the prize has been won by an all-British team.

The scientists were awarded the prize for their studies on how the brain makes and retains memories through a mechanism known as long-term potentiation (LTP). Sir Colin Blakemore, chair of the selection committee, said: "Memory is at the heart of human experience. This year's winners, through their ground-breaking research, have transformed our understanding of memory and learning, and the devastating effects of failing memory."

Prior to their work, we had identified the hippocampus as an area of the brain involved in memory, but we lacked any real understanding of how the process worked. The three scientists have shown how synapses – the connections between nerve cells – can be strengthened through repeated stimulation in the hippocampus. Their work crystallises the idea that LTP is the basis for our ability to learn and remember.

Tim Bliss, who was previously associated with National Institute for Medical Research but more recently a visiting worker at the Francis Crick Institute in London, is no stranger to winning prestigious awards, having previously won the Ipsen Prize and the Croonian Prize. Responding to the news of his latest prize, he said "I am of course delighted to be awarded a share of this prestigious prize. Research into LTP has been a wonderfully stimulating field to work in. Experimentally it can be studied at so many levels, from the molecular machinery that underpins it to the behaviours that depend on it. And from the beginning it has held up the promise of explaining the neural basis of memory."

The three scientists overcame the challenge of not being located in the same lab. Morris is professor of Neuroscience at University of Edinburgh, whilst Collingridge splits his time between the University of Bristol and the University of Toronto. This recent advancement holds may hold promising implications for conditions affected by memory, such as Alzheimer's. In response to the potential treatment implications, Collingridge said "I am really excited about now translating discoveries about LTP into new treatments for dementia".

The recent award is a testament to to the strong support that UK research funding bodies have given to their research over the past three decades, particular the Medical Research Council. The prize will be presented at a ceremony on 1 July in Copenhagen by His Royal Highness Crown Prince Frederik of Denmark.

UK-TURKEY YEAR OF SCIENCE AND INNOVATION 2015-2016

Celebrating successful partnerships and reflecting on excellent cross-team work

On 7-11 March the UK Science and Innovation Network in Turkey (SIN Turkey), FCO, BIS, British Council and other UK partners celebrated the conclusion of the UK-Turkey Year of Science and Innovation. Closing events were held in Manchester, one of the cities at the centre of HMG's Northern Powerhouse agenda, and host city for the upcoming EuroScience Open Forum (ESOF) in July 2016. UK colleagues were joined by a 40-strong Turkish delegation of rectors, researchers and entrepreneurs from Turkey's leading universities and research centres as well as representatives from Turkey's Ministry of Science, Industry and Technology, and the Scientific and Technological Research Council of Turkey (TUBITAK).

Launched at the TUBITAK headquarters in Ankara in March 2015, the Year of Science (YoS) comprised some 50 events - reaching over 850 researchers, policy makers and businesses - held at a number of leading universities and research organisations across both Turkey and the UK. The resulting academic and commercial partnerships are already helping to boost the UK's profile and our growing bilateral scientific collaboration with Turkey. High-level visits and a series of thematic missions, including a joint mission to the Milan EXPO, helped the UK and Turkey improve understanding of one other's strengths, priorities and infrastructure capabilities, paving the road to what President of TUBITAK, Professor Arif Ergin called 'future-targeted research collaboration'. The YoS has shaped a sustainable UK-Turkey network of scientists, entrepreneurs and businesses, building the kind of mutual awareness and trust which should continue generating positive academic and commercial partnerships well into the future.

More than 50 UK and Turkish Universities participated in YoS activities. Universities, including Manchester, Edinburgh, Sussex and Imperial College, took up a range of societally important issues: from energy efficiency, through marine sciences, to disaster resilience. The Newton Katip-Celebi Fund (NKCF), a seven-year £40 million joint UK-Turkey grant-giving fund, was crucial in laying foundations for intensive two-way researcher exchanges with as many as 100 awards granted so far, to partnerships between 51 UK and 53 Turkish universities and research institutions, worth a total of £3 Million. Initially planned for 5 years, NKCF has now been extended until 2021 aiming to increase bilateral entrepreneurial activities, bringing the brightest and the best to make a contribution to the UK's research excellence. Annual NKFC investment of up to £4m enables UK researchers to collaborate with leading Turkish counterparts in energy, agri-tech and food security, health and biotechnology. Following BIS-TUBITAK agreement, 6 different MoUs have been signed between TUBITAK and different UK Delivery Partners for the implementation of these programmes.

The YoS programme has been a living example of science diplomacy. Over the past 12 months, the programme has helped to forge bilateral scientific links, while also strengthening economic, cultural and policy relationships between our countries. YoS support helped to open the door for the establishment of at least three formal institutional and business partnerships. With a focus on the Turkish aerospace and nuclear supply chain, the Rolls Royce

Advanced Manufacturing Technology Centre will help to build capacity for future planned projects in these fields. Following a study visit by Ricardo Software, three major Turkish universities specializing in the automotive sector have now purchased Ricardo Software products for academic research (not commercially funded) or for use in the Formula SAE. In 2015-2016, SIN Turkey and the Royal Academy of Engineering supported 15 Turkish researchers, as part of the Leadership in Innovation Fellowships scheme developed under the Newton-Katip Celebi Fund. Focused primarily in health and biotechnology, these fellowships include intensive training on commercialization, business plan development, and pitching in the UK.

As key note speakers from BIS and TUBITAK concluded during the YoS closing events in Manchester, the YoS is just a beginning, not the end of the UK-Turkey collaboration on science and innovation. The Year has laid the groundwork for further work and demonstrated what Lord Janvrin, the PM's Special Trade Envoy to Turkey, described as 'a huge potential for cooperation in technology, infrastructure, financial services and healthcare'.

International cooperation under the YoS has opened up new opportunities for UK scientists, giving them access to Turkey's best infrastructure and resources and generating powerful synergies. It has showcased UK research excellence on the international stage and boosted UK and Turkish capacity to tackle some of the most pressing global challenges. At HMG level, it also illustrated the capabilities and dynamism of the UK Science and Innovation Network, and its ability to convene leads from BIS, FCO, Newton Fund and the British Council in an effective delivery partnership. Working as part of cross-organisational team of this kind multiplies SIN the depth and breadth of our understanding and influencing capacity, and better enables us to develop high-performing international UK science and innovation partnerships which will support UK growth.

INTERNATIONAL ACADEMIC EXCHANGE PROGRAMMES – BETTER SCIENCE, DEEPER LINKS

In January this year, British Council and Professor Lord Hunt of Chesterton convened a symposium in the House of Lords to bring together international PhD and early career postdoctoral researchers who are currently based in the UK supported by Department for Business, Innovation and Skills (BIS)-funded Newton Fund[1] scholarships and travel grants. The premise of the symposium was to give participants the opportunity to hear about how UK Government and Parliament operate and facilitate conversations with parliamentarians, members of the Lords Science and Technology Select Committee, the Parliamentary Office of Science and Technology and Professor Robin Grimes (Chief Scientific Adviser to the Foreign and Commonwealth Office) about how science interfaces with policy making in the UK. The visiting researchers – from China, Colombia, Egypt, Kazakhstan and Turkey – learnt about how science interacts with policy making here in the UK. Meanwhile, UK parliamentarians and parliamentary staff were able to learn from the diverse perspectives – and insightful questions – from these future global research leaders.

For the British Council, who organised this event, it makes intuitive sense that supporting scientific links and knowledge exchange between the UK and other countries is a worthwhile endeavour – but what exactly are the benefits? How do such linkages benefit the UK itself? And what is being done to foster them?

The world has witnessed a shift from an age of the 'solitary genius' breaking new ground in the sciences towards much more collaborative ways of working with other scientists to create and apply knowledge. Lines between disciplines and between institutions are becoming blurred, and national science and innovation ecosystems are increasing in complexity in line with this multi-institutional/multi-disciplinary way of working.

RESEARCH THRIVES ON INTERNATIONAL COLLABORATION

There can be great value in collaborating not only within one's own institution or country, but also beyond national and cultural boundaries. Prominent examples of successful international collaborations include large-scale, national government-driven partnerships such as CERN's particle physics laboratory (which hosts many thousands of physicists and engineers from 21 countries) and the multitude of scientists feeding into the Intergovernmental Panel on Climate Change. But more modest-sized multi-country collaborations, involving just a few research groups, are also producing high-impact outputs.

Indeed, there is growing evidence[3] that a country's scientific excellence and impact of its research are strongly correlated to the extent to which its researchers are mobile and collaborate internationally. One of the widely accepted metrics of research quality measures how and where scientific publications are cited, and citation rates have been shown to increase with increasing international co-authorship. Similarly, productivity levels of researchers who are internationally mobile are higher than those of researchers remaining within their countries.

UK SCIENCE HAS THE EDGE – FOR NOW

A recent analysis commissioned by BIS established that the UK research base is world class, generating almost 16% of the world's most highly-cited academic papers across all major research fields, second only to the USA. Germany, China and France ranked as the third, fourth and fifth, respectively. This is significant in that the UK represents less than 1% of the world population and, with a comparatively modest Gross Expenditure on Research and Development, just over 4% of researchers worldwide. Indeed, another indicator of research quality, the field-weighted citation impact, suggests that the UK is right at the top of the game.

Importantly, a key contributing factor to the UK's pole position in science appears to be its disproportionally high level of international collaboration. More than 50% of all UK publications list international contributors, resulting in publications with international co-authorship that have a markedly larger field-weighted citation impact than those articles authored exclusively by UK researchers. Many of these are pan-EU collaborations funded through the European Commission, and the UK is the largest beneficiary of EU research funds in some sectors of science, for example health research.

The mobility of researchers into and out of the UK is also thought to be a key driver of scientific success. UK researchers themselves are highly mobile across national borders, while more than a third of academics employed in UK Higher Education Institutions come from outside of the UK. The constant influx of highly-qualified postgraduate and postdoctoral researchers from abroad and returning UK scholars bring in new ideas and skills as well as different perspectives.

THE BENEFITS OF HAVING A STRONG AND INTERNATIONALISED RESEARCH BASE

The UK hosts a plethora of multi-disciplinary research with a global dimension that fundamentally relies on international collaboration, including research into disaster risk reduction, the food-water-energy nexus, rapidly emerging infectious diseases, climate change and other issues with a worldwide impact and relating to the Sustainable Development Goals. The UK's input into these pressing topics will contribute to the well-being of vulnerable populations globally – but is also clearly in the UK's national interest.

The UK's global reputation for research is a key factor in attracting not only international researchers but also young people from overseas wishing to study at a UK university. This is not inconsequential in economic terms since, for example, some figures suggest that each non-EU student generates an average of £20,000 per annum for the UK economy and the income of UK higher education institutions from non-EU students currently hovers around the £4bn mark.

A strong, internationalised research base brings many other benefits to the UK and there is increasing recognition that skills in science, technology, engineering and mathematics, and scientific literacy more generally, can be vital to evidence-informed decision making and underpin economic prosperity.

Science collaboration as a vehicle for deepening cultural relations

The British Council was founded in 1934 in a time of global uncertainty and impending war to create 'a friendly knowledge and understanding between the people of the UK and the wider world'. It has a clear mission anchored in its Royal Charter to encourage cultural, educational and also scientific and technological cooperation. Still pursuing the same mission today, the British Council promotes 'cultural relations' between the UK and third countries across the sciences, enabling researchers to work together for mutual benefit and longer-term, sustainable collaboration.

As highlighted in a recent article in this publication[4], the UK has a keen interest in science collaboration as a platform for bilateral relationships with other countries. British Council's focus on scientific cultural relations enables us to work even under politically and diplomatically challenging circumstances because science is widely perceived as primarily neutral territory and a vehicle to build trust and deepen links. For example, recently we ran the UK-Iran Water Management Research Symposium, the first official science cooperation between the two countries in seven years[5] and also fund UK-Russia collaborations through a long-standing partnership with the Royal Society and the Russian Foundation for Basic Research.

'Brokers' of international research links are in prime position to deepen relations between countries beyond the joint pursuit of scientific knowledge. Serving, in a sense, as ambassadors for their own countries, scholars visiting the UK represent the future of global research, and many of them will become conduits for sustained links to the UK. Therefore, we see great benefit in supporting them as they immerse themselves in another culture.

CONCLUSION

International collaboration and researcher mobility have become the lifeblood of the UK research base and play an increasingly important role globally. But only if conditions for academic exchange continue to be safeguarded and fostered – through political will, strategic funding and enabling legal frameworks – can science be sustainably internationalised, continuing to generate mutual benefit and deepening cultural relations between countries and peoples.

References

1 The £375M BIS-administered Newton Fund supports bilateral science and innovation partnerships between groups in the UK and 15 partner countries to work collaboratively on research questions that have the promotion of economic development and welfare of the poor at their core. The Fund is delivered by a range of UK organisations – including the learned academies, the Research Councils, Innovate UK, the Met Office and also the British Council – and in-country funding partners.

2. Adams, J. (2013) 'The fourth age of research'. Nature 497, 557-560.

3 'International Comparative Performance of the UK Research Base', Elsevier 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf

4 Grimes, R. and Hennessy, E. (2015) 'Why science is in the diplomatic toolkit'. Science in Parliament 72:2, 10-11.

5 https://www.britishcouncil.org/organisation/press/first-uk-iran-science-and-research-cooperation-7-years

Meeting of the Parliamentary and Scientific Committee on Tuesday 24 May

IS OUR AIR FIT TO BREATHE?

Written by
Cheyenne McCrae

London's air quality is a matter of public concern. MP Stephen Metcalfe chaired the P&SC's monthly meeting on the topic of air pollution levels in the city on 24 June in the Boothroyd Room. Four speakers (Professor Frank Kelly, Ruth Calderwood, Dr. Ian Mudway, & Professor Terry Tetley) with varying backgrounds in academic sciences, government, and medical sciences introduce the current state of London's air pollution and explain its causes, affects, and calls for actions from their qualified perspectives. Professor Frank Kelly, the head of Environmental Health at King's College London, begins the discussion describing the sources of London's air pollutants, particularly focusing on those of power generation and road traffic. Kelly defines the most prevalent air pollutants resulting from these sources as Particulate Matter (PM), Nitrogen Dioxide (NO2), and Ozone (O3) and asserts that over 29,000 premature deaths result from PM exposure annually (UK in 2008). He shows that increase exposure to road traffic increases pollutant levels present in body, the London Underground being the highest exposure chamber. The impacts of air pollution on the public burdens both individuals on the clinical level and the NHS on the institutional level. Following this, Ruth Calderwood, the Environmental Policy Officer for City of London Corporation, elucidates the governmental action taken on air pollution in London as an EU Member State. Calderwood describes that limit values are met on lead, carbon monoxide, benzene, and sulphur-dioxide, but PM and NO2 levels still require further actions to reduce current limits. She adds that while Member States must rectify air quality issues found in their reporting zones (43 total in the UK), Defra's Air Quality Plans are being challenged by Client Earth as insufficient to meet necessary quality improvement demands within an appropriate time scale. Calderwood cites actions taken by the City Corporations through its Air Quality Strategy (reducing emissions, working with the new Mayor of London, & raising awareness) but also stresses the need to consider future challenges of attainment of diesel alternatives and meeting WHO limit levels for PM when recommending governmental actions on air pollution. Next, to demonstrate the biological plausibility of illness to diesel exposure, Dr. Ian Mudway, lecturer in Respiratory Toxicology at Kings College, discusses his results from several past scientific experiments. Through controlled diesel exposure modelling, Mudway shows that PM induces inflammation in the airways and causes impairment to lung function. Mudway further expresses that lung functionality damage is irreversible and that hundreds of children in the Hackney and Tower Hamlets areas show this health consequence in one study's findings. To end, Professor Terry Tetley, a lung cell biologist at Imperial College London, discusses the cellular implications of exposure to nano-sized diesel PM once combined with ceria. Tetley states that ceria allows for oxidation in the cell to increase. As oxidation stress is crucial to lung inflammation, adding ceria to diesel lowers bio-reactivity in cells acting as a possible anti-inflammatory. Following the speakers' presentations, committee members pose questions about the consequences air pollution has on unborn babies and the vertical accumulation of pollutants in buildings, while emphasizing the need for polluters to take actions to reverse the damage they are causing in lieu of citizens taking personal precautions to avoid pollution exposure. Government, scientists, and academics are currently acting on the air pollution matter in London, though further collaborative actions must be put forth to notably improve London's air quality. The next meeting will discuss the Haldane Principle on Monday 27 June.

HOUSE OF COMMONS SELECT COMMITTEES 2015

BUSINESS INNOVATION AND SKILLS COMMITTEE

The Business, Innovation and Skills Committee is appointed by the House of Commons to examine the administration, expenditure and policy of the Department for Business, Innovation and Skills (BIS) and its associated public bodies, including the Office of Fair Trading (OFT). Mr Iain Wright (Labour, Hartlepool) was elected Chair. Other members of the Committee, formally appointed on Wednesday 8 July 2015, are: Paul Blomfield (Labour, Sheffield Central); Richard Fuller (Conservative, Bedford); Peter Kyle (Labour, Hove); Amanda Milling (Conservative, Cannock Chase); Jonanthan Reynolds (Labour, Stalybridge and Hyde); Amanda Solloway (Conservative, Derby North); Michelle Thomson (Scottish National Party, Edinburgh West); Kelly Tolhurst (Conservative, Rochester and Strood); Craig Tracey (Conservative, North Warwickshire); Chris White (Conservative, Warwick and Leamington).

Contact: Business, Innovation and Skills Committee, House of Commons, London SW1A 0AA. Telephone: 020 7219 5777;

Email: biscom@parliament.uk

INQUIRY

Business views on EU Referendum inquiry

The Business, Innovation and Skills Committee launches an inquiry aiming to test business reasons cited by businesses on both sides of the EU referendum debate. The Committee wishes to help inform the debate in the run up to the referendum on 23 June by exploring the rationale for the views expressed by British businesses on the question of Britain's continued membership of the European Union. Written evidence was submitted by 15 April 2016.

EDUCATION COMMITTEE

The Education Committee monitors the policy, administration and spending of the Department for Education and its associated arms' length bodies, including Ofsted. Mr Neil Carmichael (Conservative, Stroud) was elected Chair. Other members of the Committee, formally appointed on Thursday 6 July, are: Lucy Allan (Conservative, Telford); Ian Austin (Labour, Dudley N); Michelle Donelan (Conservative, Chippenham); Marion Fellows (Scottish National Party, Motherwell and Wishaw); Suella Fernandes (Conservative, Fareham); Lucy Frazer (Conservative, SE Cambridgeshire); Catherine McKinnell (Labour, Newcastle Upon Tyne North); Ian Mearns (Labour, Gateshead); Stephen Timms (Labour, East Ham); William Wragg (Conservative, Hazel Grove).

INQUIRY

The inquiry is based on a memorandum from the Department for Education on the Government's approach to children's social work reforms. The Committee invites written submissions on the Government's approach to children's social work reform outlined in the memorandum, seeking comments on its content, focus, and breadth. Oral evidence sessions are currently underway.

Contact: Education Committee, House of Commons, London SW1A 0AA.

Telephone: 020 7219 1376;

Email: educom@parliament.uk

ENERGY AND CLIMATE CHANGE COMMITTEE

The Committee is appointed by the House of Commons to examine the expenditure, administration and policy of the Department of Energy and Climate Change (DECC) and its associated public bodies. Angus Brendan MacNeil (Scottish National Party, Na h-Eileanan an Iar) was elected Chair. Other members, appointed 8 July, are: Rt Hon Alistair Carmichael (Liberal Democrats, Orkney and Shetland); Glyn Davies (Conservative, Montgomeryshire); James Heappey (Conservative, Wells); Matthew Pennycook (Labour, Greenwich and Woolwich); Dr Poulter (Conservative, Central Suffolk and North Ipswich): Antoinette Sandbach (Conservative, Eddisbury); Julian Sturdy (Conservative, York Outer); Rushanara Ali (Labour, Bethnal Green and Bow); Tom Blekinsop (Labour, Middlesbrough South and East Cleveland); Jamie Reed (Labour, Copeland).

INQUIRIES

2020 renewable heat and transport targets inquiry

The Committee will explore the main challenges

with, and potential solutions to, meeting the UK's 2020 renewable energy targets for heat and transport. Oral evidence to begin shortly.

Setting the fifth carbon budget inquiry

The Committee gathers views on the fifth carbon budget, in particular in relation to the advice provided by the Committee on Climate Change and challenges faced by the Government in setting and meeting the fifth carbon budget. The report was published on Wednesday 27 April 2016.

Contact: Energy and Climate Change Committee, House of Commons, London SW1A 0AA

Telephone: 020 7219 2158; Email: ecc@parliament.uk

ENVIRONMENT FOOD AND RURAL AFFAIRS COMMITTEE

The Environment, Food and Rural Affairs Committee (EFRA) is appointed by the House of Commons to examine the expenditure, administration and policy of the Department for Environment, Food and Rural Affairs (Defra) and its associated public bodies. Mr Neil Parish (Conservative, Tiverton and Honiton) was elected Chair. Other members (appointed on 8 July) are: Chris Davies (Conservative, Brecon and Radnorshire); Jim Fitzpatrick (Labour, Poplar and Limehouse); Simon Hart (Conservative, Carmarthen West and South Pembrokeshire); Dr Paul Monaghan (Scottish National Party, Caithness, Sutherland and Easter Ross); Rebecca Pow (Conservative, Taunton Deane); Margaret Ritchie (Social Democratic & Labour Party, South Down); David Simpson (Democratic Unionist Party, Upper Bann); Rishi Sunak (Conservative, Richmond); Angela Smith (Labour, Penistone and Stocksbridge); Valerie Vaz (Labour, Walsall South).

INQUIRY

The work of Defra

The Environment, Food and Rural Affairs Committee examines the work of Defra and hear from the Secretary of State and the Permanent Secretary on topics such as flood recovery and Common Agricultural Policy. Discussions also focus on funding of the Department and the work of its agencies following the Comprehensive Spending Review in November 2015.

ENVIRONMENTAL AUDIT COMMITTEE

The remit of the Environmental Audit Committee is to consider the extent to which the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development, and to audit their performance against sustainable development and environmental protection targets. Mary Creagh (Labour, Wakefield) was elected Chair on 10 February 2016. The remaining members of the Committee were appointed on Monday 20 July 2015: Peter Aldous (Conservative, Waveney); Caroline Ansell (Conservative, Eastbourne); Jo Churchill (Conservative, Bury St Edmunds); Geraint Davies (Labour, Swansea West); Zac Goldsmith (Conservative, Richmond Park); Margaret Greenwood (Labour, Wirral West); Luke Hall (Conservative, Thornbury and Yate); Carolyn Harris (Labour, Swansea East); Peter Heaton-Jones (Conservative, North Devon); Mr Peter Lilley (Conservative, Hitchin and Harpenden); Caroline Lucas (Green Party, Brighton Pavilion); John Mc Nally (Scottish National Party, Falkirk); Rebecca Pow (Conservative, Taunton Deane); Rory Stewart (Conservative, Penrith and The Border).

INQUIRY

Flooding: Cooperation Across Government

Following another winter of severe UK floods, EAC is launching an inquiry into Government policy and action on flooding. The committee will be focusing on whether the Government's approach is 'joined-up', and the extent to which cooperation across Government on this matter is successful. As part of the inquiry we will be using the resilience of UK infrastructure as a case study. We will use this to investigate issues such as: how Government departments and public bodies can better cooperate to offer coherent policy and action on flooding; what the strengths and weaknesses of the Government's current approach are; and what is required from Government to ensure that the UK's development is sustainable and best-placed to face future floods. If you would like to submit evidence relating to cooperation across Government regarding flooding, please contact the Committee team on eacom@parliament.uk.

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 Dr Sarah Wollaston was elected Chair. The remaining members of the Committee, who were elected by the House on Wednesday 8 July, are: Dr James Davies (Conservative, Vale of Clwyd); Andrea Jenkyns (Conservative, Morley and Outwood); Andrew Percy (Conservative, Brigg and Goole); Paula Sherriff (Labour, Dewsbury); Maggie Throup (Conservative, Erewash); Helen Whately (Conservative, Faversham and Mid Kent); Dr Philippa Whitford (Scottish National Party, Central Ayrshire); Emma Reynolds (Labour, Wolverhampton North East); Julie Cooper (Labour, Burnley); Ben Bradshaw (Labour, Exeter).

INQUIRY

Impact of membership of the EU on health policy in the UK

In order to inform the debate ahead of the referendum on EU membership on 23 June, the Health Committee invites written evidence on the impact of membership of the EU on health policy in the UK. Accepting written submissions until 31 May 2016.

SCIENCE AND TECHNOLOGY COMMITTEE

The Science and Technology Committee exists to ensure that Government policy and decision-making are based on good scientific and engineering advice and evidence. The Science and Technology Committee is unusual amongst departmental select committees in that it scrutinises the Government Office for Science (GO-Science), which is a "semi-autonomous organisation" based within the Department for Business, Innovation and Skills (BIS). GO-Science "supports the Government Chief Scientific Adviser and works to ensure that Government policy and decision-making is underpinned by robust scientific evidence". The committee therefore

has a similarly broad remit and can examine the activities of departments where they have implications for, or made use of, science, engineering, technology and research.

The Members of the Science and Technology Committee are: Nicola Blackwood (Conservative, Oxford West and Abingdon) was elected as Chair. The other members, appointed on 13 July, are: Victoria Borwick (Conservative, Kensington); Jim Dowd (Labour, Lewisham West and Penge); Chris Green (Conservative, Bolton West); Dr Tania Mathias (Conservative, Twickenham); Carol Monaghan (Scottish National Party, Glasgow North West); Graham Stringer (Labour, Blackley and Broughton); Derek Thomas (Conservative, St Ives); Matt Warman (Conservative, Boston and Skegness).

INQUIRIES

Graphene inquiry

The inquiry will explore the lessons from graphene for research and innovation in other areas, as well as the management and commercialisation of graphene's intellectual property. The Committee is still accepting submissions.

Forensic Science Strategy inquiry

The Science and Technology Committee scrutinises the Government's Forensic Science Strategy and the extent to which it addresses the concerns of the previous Science and Technology Committee. The Committee also seeks views on the links between the Forensic Strategy and developments in biometric sciences and regulation, ahead of the still awaited publication of a separate government biometric strategy. The Committee is still accepting submissions.

Regenerative medicine inquiry

The Science and Technology Committee is undertaking an inquiry into regenerative medicine. Regenerative medicine (or advanced therapies) involves replacing or regenerating cells, tissues or organs in order to restore or establish normal function in people with chronic illnesses. It has been used, for example, in bone marrow transplants and offers the prospect of more effective repairs for faulty hearts, skin burns and worn-out joints. Regenerative medicine includes cell therapy, gene therapy, tissue engineering and other methods. Accepting written submissions; the deadline is Tuesday 31 May 2016.

Science in emergencies: chemical, biological, radiological or nuclear incidents inquiry

The Science and Technology Committee is undertaking an inquiry into science advice in relation to planning for and responding to chemical, biological, radiological or nuclear (CBRN) incidents. CBRN emergencies include events such as industrial fires, chemical contamination and nuclear accidents. The inquiry follows previous Committee reports 'Scientific advice and evidence in emergencies' in 2011 and 'Science in Emergencies: UK lessons from Ebola' in January 2016. The inquiry coincides with the 5th anniversary of the Fukushima Daiichi nuclear disaster in Japan and the 30th anniversary of the Chernobyl disaster in Ukraine. Accepting written submissions; the deadline is Friday 20 May 2016.

Robotics and artificial intelligence inquiry

The Science and Technology Committee is undertaking an inquiry into robotics and artificial intelligence. Robotics and Autonomous Systems (RAS) is one of the 'Eight Great Technologies' identified by the UK Government in 2012. A national strategy for RAS innovation from a 'RAS Special Interest Group' was published by Innovate UK in 2014. The Committee is still accepting submissions.

Zika virus inquiry

The Science and Technology Committee holds a one-off session on the Zika virus. The session examines the state of knowledge on the link with babies born with microcephaly and the increased incidence of Guillain-Barre syndrome. The Committee also examines what monitoring and research have been done on the virus, and the scientific advice being presented to the UK Government and the public. The Committee recently published a report on the UK lessons from Ebola, and the Committee explores the extent of read-across of the issues to Zika.

TRANSPORT COMMITTEE

The Transport Committee examines the expenditure, administration and policy of the Department of Transport and its associated public bodies. Mrs Louise Ellman (Labour, Liverpool, Riverside) was elected Chair. The remaining members of the Committee, appointed on 8 July, are: Robert Flello (Labour, Stoke-on-Trent South); Mary Glindon (Labour, North Tyneside); Karl McCartney (Conservative, Lincoln); Stewart Malcolm McDonald (Scottish National Party, Glasgow South); Mark Menzies (Conservative, Fylde); Huw Merriman (Conservative, Bexhill and Battle); Will Quince (Conservative, Colchester); Iain Stewart (Conservative, Milton Keynes South); Graham Stringer (Labour, Blackley and Broughton); Martin Vickers (Conservative, Cleethorpes).

INQUIRY

Improving the rail passenger experience inquiry

The Transport Committee's inquiry looks to identify recommendations to improve the main aspects of a rail journey from the perspective of the passenger: from planning a journey, arriving at a station, making the journey, and any necessary post-journey information.

HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE

The members of the Committee (appointed 8 June 2015) are: the Earl of Selborne (Chairman), Lord Cameron of Dillington, Lord Fox, Lord Hennessy of Nympsfield, Lord Hunt of Chesterton, Lord Kakkar, Baroness Manningham-Buller, Lord Maxton, the Duke of Montrose, Baroness Morgan of Huyton, Baroness Neville-Jones, Viscount Ridley and Lord Vallance of Tummel.

GM Insects

In July 2015, the Committee launched an inquiry into GM Insects. Written submissions were sought by 18 September and oral evidence will be taken in the autumn. The Committee report was published on 17 December 2015 and the government response was published on 1 March 2016.

The Relationship between EU Membership and the effectiveness of Science, Research and Innovation in the UK

In July 2015, the Committee agreed to conduct an inquiry into the relationship between EU Membership and the effectiveness of science, research and innovation in the UK. The inquiry has concluded and the report has been published.

FURTHER INFORMATION

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

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

RECENT POST PUBLICATIONS

Trends in the Environment

January 2016 POSTnote 516

Human activities interact with natural systems in complex ways; they can cause long-term damage to systems humans are dependent on. This POSTnote summarises a range of such pressures on the environment. It also identifies a number of trends and their effects on the UK, as well as the policy options that could protects the environment while meeting human needs.

Intellectual Property and Plants

January 2016 POSTnote 517

Plant breeding is an essential practice in agriculture and horticulture. Plant breeders may seek intellectual property rights (IPR) over plant varieties and breeding techniques to protect their investment in research. This POSTnote considers the different IPR approaches available to plant breeders.

Psychological Health of Military Personnel

February 2016 POSTnote 518

The prevalence of common mental health problems in the military is higher than in the general population. This POSTnote examines the impact of military service on the psychological health of serving personnel, reservists, veterans and their families. The MOD has several strategies to protect the mental health of the Armed Forces, however stigma associated with mental ill health is a major barrier to accessing help. The paper outlines what is known about the effectiveness of interventions, and highlights areas for further research.

Electronic Health Records

February 2016 POSTnote 519

This POSTnote explains the plans to introduce electronic health records for everyone. Electronic health records contain information about patients' medical histories, health, care preferences and lifestyles (such as diet and exercise). The paper discusses the opportunities

and challenges of implementing electronic health records will involve.

Digital Forensics and Crime

March 2016 POSTnote 520

Digital forensic science is the process of obtaining, analysing and using digital evidence in investigations or criminal proceedings. Digital evidence ranges from images of child sexual exploitation to the location of a mobile phone. This note looks at the use of digital forensics by UK law enforcement agencies. It covers how evidence is obtained, the legislation and regulation in this area, and the efforts being made to address the challenges faced by practitioners.

Access to Water and Sanitation

April 2016 POSTnote 521

This POSTnote discusses the challenge of increasing access to water and sanitation in the context of the Sustainable Development Goals (SDGs). Almost a third of the global population (2.4 billion people) lack access to sanitation facilities. Improving access to water, sanitation, and hygiene (WASH) has been a key aim of the UN's Sustainable Development Goals (SDGs) to achieve universal access to safe water and sanitation by 2030

CURRENT WORK

Biological Sciences – Pregnancy and Breastfeeding Guidelines, Nature and Health, Putting a Value on Nature, Anti-ebola Treatments, Trends in Infectious Diseases, Trends in Non-communicable Diseases, UK Neonatal and Infant Mortality, Sugar and Health Update, Integrating health and social care, Electronic Cigarettes Update

Environment and Energy – Managing the Plutonium Stockpile, Trends in Agriculture, Carbon Footprint of Heat Generation, Adapting Urban Drainage, Marine Microplastics Pollution, Ecological rewilding, Designing a circular economy,

Physical sciences and IT – Space Weather, Trends in Defence, Financial Technologies, Automation and the workforce

Social Sciences – Global Health Inequality, Preventing Extremism, Minimum Age of Criminal Responsibility, Educational Provisions for Young Offenders, Creating age-friendly cities, Comparing economic and behavioural interventions, Access to Healthy Food

CONFERENCES AND SEMINARS

Managing the Water Cycle More Effectively

Some of the most challenging societal questions of the next two decades will concern water and well-being. On 3rd May, POST hosted a joint All Party Parliamentary Water Group and POST session in order to explore the practices of integrated catchment management, to examine how evidence is used, how decisions are made and how interventions could be undertaken effectively with the community. The session was chaired by Neil Parish MP, Chair of the EFRA Committee. Speakers included: Professor Louise Bracken, Executive Director, Institute of Hazard Risk and Resilience, Durham University; Dr Paul Quinn, Civil Engineering and Geoscience, Newcastle University; Dr Mark Wilkinson, Research Scientist, The James Hutton Institute; Dr David Brown, Environment Agency, Senior Advisor in Flood Risk Management and Michael Norbury, Liverpool University; Minni Jain, Director, The Flow Partnership; and, Paul Nolan OBE, Director, Mersey Forest and Prof David Shaw, Liverpool University.

Assessing the Global Status of Pollinators

The purpose of this POST session on 11th May was to explore the findings of a report published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services with UK authors prominent in the production of the assessment and discuss the options for safeguarding pollinators highlighted in the report. The session was chaired by Huw Merriman MP. Speakers included: Professor Simon Potts, Professor of Biodiversity and Ecosystem Services, Reading University; Dr Tom Breeze, Research Fellow in the School of Agriculture, University of Reading; Dr. Adam Vanbergen, Invertebrate Ecologist, Centre for Ecology & Hydrology; Emily Musson, Senior Policy Adviser, Nature and Pollinators Strategy Team; and, Mark Stevenson, Natural Science Adviser and Evidence Programme Manager, Defra

Evidence Based Policing

On 20th April, POST hosted a session for MPs, Peers and their staff to discuss evidence-based policing. It helps the police service make more informed decisions about what policies and practices are cost-effective and improve their service to the public. One session focused on domestic abuse, estimated to account for 11% of reported crime in 2015. It was chair by James Berry MP, for Kingston and Surbiton. The speakers included: Rachel Tuffin, Director of Knowledge, Research and Education, College of Policing; Inspector Steve Goodier, Hampshire Constabulary; Inspector Ben Linton, Metropolitan Police; Carol Vigurs, Evidence for Policy and Practice Information Co-ordinating Centre, UCL Institute of Education; Assistant Chief Constable Scott Chilton, Hampshire Constabulary and Thames Valley Police and Chair of the Society of Evidence-Based Policing; Sian Hawkins, Campaigns and Public Affairs Manager, Women's Aid; Catherine Owens, Evidence and Evaluation Adviser, College of Policing & Commander Jeremy Burton, Metropolitan Police; and, Professor Martin Innes, Cardiff University; Dr Jason Roach, Huddersfield University.

INTERNATIONAL ACTIVITES

POST is collaborating with the African Institute for Development Policy as part of the DFID funded SECURE health consortium which seeks to strengthen the capacity of policymakers to utilize research evidence in health policymaking in Kenya and Malawi.

In 2016 POST will be hosting two Parliamentary research staff from each parliament on one-month internships to help develop their skills in handling research evidence and briefing their parliamentarians.

Research Councils UK

Contact: Alexandra Saxon
Head of RCUK Strategy Unit
Research Councils UK
Polaris House
North Star Avenue
Swindon SN2 1ET

Tel: 01793 444592
E-mail: communications@rcuk.ac.uk
Website: www.rcuk.ac.uk

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

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

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

Biotechnology and Biological Sciences Research Council (BBSRC)

Contact: Matt Goode
Associate Director, Communications & External Relations
BBSRC, Polaris House, North Star Avenue
Swindon SN2 1UH. Tel: 01793 413299
E-mail: matt.goode@bbsrc.ac.uk
Website: www.bbsrc.ac.uk

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

Economic and Social Research Council

Contact: Jacky Clake, Head of Communications,
Economic and Social Research Council,
Polaris House, North Star Avenue,
Swindon SN2 1UJ
Tel: 01793 413117
E-mail: Jacky.Clake@esrc.ac.uk
Website: www.esrc.ac.uk

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

EPSRC

Pioneering research and skills

Contact: Sarah Crew,
Parliamentary Relations Manager,
EPSRC, Polaris House,
North Star Avenue, Swindon SN2 1ET
Tel: 01793 444570
E-mail: sarah.crew@epsrc.ac.uk
Website:www.epsrc.ac.uk

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

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

Medical Research Council

Contact: Sophie Broster-James
Public Affairs Manager
One Kemble Street, London WC2B 4AN.
Tel: 020 7395 2275
E-mail: sophie.broster-james@headoffice.mrc.ac.uk
Website: www.mrc.ac.uk

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

Natural Environment Research Council

Contact: Andy Jones
Government and Parliament
Communications Manager
NERC, Polaris House, North Star Avenue,
Swindon, SN2 1EU
Tel: 01793 444238
Mobile: 07867553053
Email: CONSPINQ@nerc.ac.uk
Website: www.nerc.ac.uk

NERC is the UK's leading public funder of environmental science. We invest £330 million each year in cutting-edge research, postgraduate training and innovation in universities and research centres.
Our scientists study the physical, chemical and biological processes on which our planet and life itself depends – from pole to pole, from the deep Earth and oceans to the atmosphere and space.
We partner with business, government, the public and the wider research community to shape the environmental research and innovation agenda. Our science provides knowledge, skills and technology that deliver sustainable economic growth and public wellbeing.

Science & Technology Facilities Council

Contact: Natalie Bealing
Head of Stakeholder Engagement
STFC Rutherford Appleton Laboratory
Harwell Campus, Didcot OX11 0QX
Tel: 01235 445484
E-mail: natalie.bealing@stfc.ac.uk
www.stfc.ac.uk

The Science and Technology Facilities Council is one of Europe's largest multidisciplinary research organisations undertaking and supporting a broad range of research across the physical, life and computational sciences. We operate world class, large-scale research facilities in the UK and Europe and provide strategic advice to the UK Government on their development. We partner in two of the UK's Science and Innovation Campuses. We also manage international research projects in support of a broad cross-section of the UK research community, particularly in the fields of astronomy, nuclear physics and particle physics.

Alzheimer's Research UK

The Power to Defeat Dementia

Contact: Dr Matt Norton
3 Riverside, Granta Park
Cambridge, CB21 6AD
Tel: 01223 824575
E-mail: policy@alzheimersresearchuk.org
Website:
http://www.alzheimersresearchuk.org/

Alzheimer's Research UK is the UK's leading dementia research charity. Currently, we support 132 projects worth over £26.4m and have committed over £60m to research since the charity began. As research specialists, we fund pioneering research at leading universities across the UK and the globe with the goal of defeating dementia. Our expertise brings together leading dementia scientists to share ideas and understanding. We work with people with dementia to reflect their concerns and firmly believe that science holds the key to defeating dementia.

Association of the British Pharmaceutical Industry

abpi
Bringing medicines to life

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

AIRTO

airto
making innovation happen

Contact: Professor Richard Brook OBE FREng
AIRTO Ltd: Association of Innovation
Research & Technology Organisations Limited
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 – Association of Innovation, Research & Technology Organisations – is the foremost membership body for the UK's innovation, research and technology sector, representing 80% of organisations in the sector.

AIRTO's members deliver vital innovation and knowledge transfer services which include applied and collaborative R&D, (frequently in conjunction with universities), consultancy, technology validation and testing, incubation of commercialisation opportunities and early stage financing. AIRTO members have a combined turnover of over £5.5bn from clients both at home and outside the UK, and employ over 47,000 scientists, technologists and engineers.

AMPS

AMPS
The Association of 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.

BIOCHEMICAL SOCIETY

Contact: Gabriele Butkute
Science Policy Assistant
Biochemical Society
Charles Darwin House
12 Roger Street, London WC1N 2JU
Tel: +44 (0)20 7685 2401
Email: gabriele.butkute@biochemistry.org
Website: www.biochemistry.org

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

We achieve our mission by:

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

The British Ecological Society

British Ecological Society

Contact: Jackie Caine, Policy Manager
British Ecological Society
12 Roger Street, London WC1N 2JU
Email: jackie@britishecologicalsociety.org
Tel: 020 7685 2510
Website: www.BritishEcologicalSociety.org
Ecology & Policy Blog
http://britishecologicalsociety.org/blog/
Twitter: @BESPolicy

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

British In Vitro Diagnostics Association (BIVDA)

BIVDA

Contact: Doris-Ann Williams MBE
Chief Executive
British In Vitro Diagnostics Association
Devonshire House
164 – 168 Westminster Bridge Road
London SE1 7RW

Tel: 0845 6188224
Email: doris-ann@bivda.co.uk
www.bivda.co.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.

British Nutrition Foundation

BRITISH Nutrition FOUNDATION

Contact: Professor Judy Buttriss,
Director General
Imperial House 6th Floor
15-19 Kingsway
London WC2B 6UN
Tel: +44(0) 20 7557 7930
Email: postbox@nutrition.org.uk

Websites: www.nutrition.org.uk
www.foodafactoflife.org.uk

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

BRITISH PHARMACOLOGICAL SOCIETY

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.

The British Psychological Society

Contact: Tanja Siggs
Policy Advisor - Legislation
The British Psychological Society
St Andrews House
48 Princess Road East
Leicester LE1 7DR
Tel: 0116 252 9526
Email: tanja.siggs@bps.org.uk
Website: www.bps.org.uk

The British Psychological Society is an organisation of 50,000 members governed by Royal Charter. It maintains the Register of Chartered Psychologists, publishes books, 11 primary science Journals and organises conferences. Requests for information about psychology and psychologists from parliamentarians are very welcome.

The British Society for Antimicrobial Chemotherapy

Mrs Tracey Guise
Chief Executive Officer
British Society for Antimicrobial Chemotherapy
Griffin House | 53 Regent Place | Birmingham
B1 3NJ
www.bsac.org.uk | www.antibiotic-action.com
www.e-opat.com | www.nas-pps.com
lwww.appg-on-antibiotics.com
www.bsacsurv.org

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

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

British Society for immunology

Contact: Jo Revill, CEO
Vintage House
37 Albert Embankment
London SE1 7TL.
Tel: 020 3031 9800
Fax: 020 7582 2882
E-mail: bsi@immunology.org
Website: www.immunology.org

The BSI is one of the oldest, largest and most active immunology societies in the world. We have over 5,000 members who work in all areas of immunology, including research and clinical practice.

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

British Society of Soil Science

Contact: Ian Brown
LR8, Vincent Building, Cranfield University,
Cranfield, Bedfordshire MK43 0AL
Tel: 01234 752983
E-mail: admin@soils.org.uk
Website: www.soils.org.uk

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

Brunel University London

Contact: Geoff Rodgers
Brunel University London
Kingston Lane
Uxbridge UB8 3PH
Tel: 01895 265609
Fax: 01895 269740
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 Savvas Tassou, the main themes of the Institute are *Advanced Engines and Biofuels, Energy Efficient and Sustainable Technologies, Smart Power Networks*, and *Resource Efficient Future Cities*.

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

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

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

Cavendish Laboratory

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

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

The Cosmetic Toiletry & Perfumery Association | ctpa

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.

Clifton Scientific Trust

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 Citizenship and Employability, Science for Life, Science for Real

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

- for young people of all ages and abilities
- experiencing science as a creative, questioning, human activity
- bringing school science added meaning and notivation, from primary to post-16
- locally, nationally, internationally (currently between Britain and Japan; also the Ukraine)

Clifton Scientific Trust Ltd is registered charity 1086933

The Council for the Mathematical Sciences

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

Eli Lilly and Company Ltd

Contact: Thom Thorp, Senior Director, Corporate Affairs
Tel: 01256 315000
Fax: 01256 775858
Eli Lilly and Company Ltd, Lilly House
Priestley Road, Basingstoke, Hants,
RG24 9NL
Email. thorpth@lilly.com
Website: www.lilly.co.uk

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

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

Energy Institute

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

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

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

EngineeringUK

Tamzin Caffrey
Head of Communications
EngineeringUK
5th Floor, Woolgate Exchange
25 Basinghall Street, London EC2V 5HA
Tel: 020 3206 0444
Fax: 020 3206 0401
E-mail: tcaffrey@engineeringuk.com
Website: 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.

Fera

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

First Group

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

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

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

GAMBICA Association Ltd

Contact: Dr Graeme Philp
Broadwall House
21 Broadwall
London SE1 9PL
Tel: 020 7642 8080
Fax: 020 7642 8096
E-mail: assoc@gambica.org.uk
Website: www.gambica.org.uk

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

The Geological Society

Contact: Nic Bilham
Director of Policy and Communications
Burlington House
Piccadilly
London W1J 0BG
Tel: 020 7434 9944
Fax: 020 7439 8975
E-mail: nic.bilham@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.

Glass and Glazing Federation

Contact: James Lee
54 Ayres Street
London SE1 1EU
Tel: 020 7939 9100
Fax: 0870 042 4266
E-mail: info@ggf.org.uk
Website: www.ggf.org.uk

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

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

Institute of Food Science + Technology

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.

Institute of Marine Engineering, Science and Technology (IMarEST)

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.

Institute of Measurement and Control

Contact: Mr Peter Martindale,
CEO and Secretary
The Institute of Measurement and Control
87 Gower Street, London WC1E 6AF
Tel: +44 (0) 20 73874949
Fax: +44 (0) 20 73888431
E-mail: ceo@instmc.org.uk
Website: www.instmc.org.uk
Reg Charity number: 269815

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

IOP Institute of Physics

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

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

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

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

Institute of Physics and Engineering in Medicine

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 bio-engineers, and clinical technologists. It organises training and CPD for them, and provides opportunities for the dissemination of knowledge through publications and scientific meetings. IPEM is licensed by the Science Council to award CSci, RSci and RSciTech, and by the Engineering Council to award CEng, IEng and EngTech.

IChemE

ADVANCING CHEMICAL ENGINEERING WORLDWIDE

The Institution of Chemical Engineers

With over 42,000 members in 120 countries, IChemE is the global membership organisation for chemical engineers. A not for profit organisation, we serve the public interest by building and sustaining an active professional community and promoting the development, understanding and application of chemical engineering worldwide.

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

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

Institution of Civil Engineers

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.

Institution of Engineering Designers

support inspire achieve

Contact: Libby Meyrick
Courtleigh
Westbury Leigh
Westbury
Wiltshire BA13 3TA
Tel: 01373 822801
Fax: 01373 858085
E-mail: ied@ied.org.uk
Website: www.ied.org.uk

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

IET

The Institution of Engineering and Technology

Contact: Paul Davies
IET,
Michael Faraday House,
Six Hills Way,
Stevenage,
SG1 2AY
Tel: +44(0) 1438 765687
Email: pdavies@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.

Institution of Mechanical Engineers

Contact: Richard Campbell
1 Birdcage Walk
London SW1H 9JJ
Tel: 020 7973 1293
E-mail: publicaffairs@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.

LGC

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

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

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

The Linnean Society of London

Contact: Dr Elizabeth Rollinson,
Executive Secretary
The Linnean Society of London
Burlington House, Piccadilly,
London W1J 0BF
Tel: 020 7434 4479 ext 12
E-mail: elizabeth@linnean.org
Website: www.linnean.org

As the world's oldest biological society, the Linnean Society of London is an essential forum and meeting point for those interested in natural history. The Society holds regular public events, publishes three peer-reviewed journals, promotes the study of the natural world with several educational initiatives and is home to a world famous library and collection of natural history specimens. The Society's Fellows have a considerable range of biological expertise that can be harnessed to inform and advise on scientific and public policy issues.

A Forum for Natural History

L'Oréal UK and Ireland

Contact: Anna Lucuk,
Director of Corporate Communication,
L'Oreal UK & Ireland
255 Hammersmith Road, London W6 8AZ
Tel: 0208 762 4374
E-mail: anna.lucuk@loreal.com
Website: www.loreal.co.uk

L'Oréal employs more than 3,800 researchers world-wide and dedicates over €850 million each year to research and innovation in the field of healthy skin and hair. The company supports women in science research through the L'Oréal UNESCO For Women In Science Programme and engages young people with science through the L'Oréal Young Scientist Centre at the Royal Institution. L'Oréal also collaborates with a vast number of institutions in the UK and globally.

Marine Biological Association

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.

Met Office

Contact: Dr Matt Huddleston
Met Office
127 Clerkenwell Road
London EC1R 5LP.
Tel: 020 7204 7469
E-mail: matt.huddleston@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.

Microbiology Society

Contact: Dariel Burdass
Deputy Chief Executive
Microbiology Society
Charles Darwin House
12 Roger Street, London
WC1N 2JU
E-mail: d.burdass@microbiologysociety.org
Website: www.microbiologysociety.org

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

National Physical Laboratory

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.

Natural History Museum

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 – its past, present and future

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

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

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

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

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

NEF: The Innovation Institute

Contact: Michelle Medhat
NEF: The Innovation Institute
29 Harley Street
London W1G 9QR
Tel: 0208 786 3677
E-mail: info@thenef.org.uk
Website: www.thenef.org.uk

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

- Businesses
- Education providers
- Government bodies

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

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

SCIENCE DIRECTORY

THE UNIVERSITY OF NORTHAMPTON

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.

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.

PHARMAQ

PHARMAQ Ltd

Contact: Dr Benjamin P North
PHARMAQ Ltd
Unit 15 Sandleheath Industrial Estate
Fordingbridge
Hants SP6 1PA.
Tel: 01425 656081
E-mail: ben.north@pharmaq.no
Website: www.pharmaq.no

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

The Physiological Society

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.

Prospect

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

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

Rainbow Seed Fund

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: www.rainbowseedfund.com

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

risksolutions

leave nothing to chance

Contact: Helen Wilkinson
Dallam Court, Dallam Lane
Warrington, WA2 7LT
Tel: 01925 41 3984
E-mail: helen.wilkinson@risksol.co.uk
Website: www.risksol.co.uk

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

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

Our small, highly motivated and client focused team delivers:

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

ROYAL ACADEMY OF ENGINEERING

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.

Royal Botanic Gardens, Kew

Kew ROYAL BOTANIC GARDENS

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

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

The Royal Institution

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®, a national programme of Masterclasses for young people in mathematics, engineering and computer science, educational activities at the L'Oréal Young Scientist Centre and policy discussions with science students. And through the Ri Channel we share the stories behind cutting-edge science with people around the world.

The Royal Society

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

Royal Society of Biology

Contact: Dr Stephen Benn
Director of Parliamentary Affairs
Royal Society of Biology
Charles Darwin House
12 Roger Street
London WC1N 2JU
Tel: 020 7685 2550
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 evidence-based opinion, representative of the widest range of bioscience disciplines. Our vision is of a world that understands the true value of biology and how it can contribute to improving life for all.

Contact: Clare Viney
Executive Director, Communications,
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 not-for-profit organisation with 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

Society for Applied Microbiology

Contact: Lucy Harper
Society for Applied Microbiology
Bedford Heights, Brickhill Drive
Bedford MK41 7PH
Tel: 01234 326661
Fax: 01234 326678
E-mail: lucy@sfam.org.uk
Website: www.sfam.org.uk

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

Society for Underwater Technology

Society for Underwater Technology
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.

Science Chemistry Innovation

Contact: Reshna Radiven
SCI
14-15 Belgrave Square
London SW1X 8PS

Tel: 020 7598 1500
E-mail: reshna.radiven@soci.org
Website: www.soci.org

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

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

Society of Cosmetic Scientists

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.

Society of Maritime Industries

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

STEMNET

Contact: Kirsten Bodley, Chief Executive
5th Floor, Woolgate Exchange
25 Basinghall Street
London EC2V 5HA
Tel: 020 3206 0450
E-mail: info@stemnet.org.uk
Website: www.stemnet.org.uk

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

- STEM Ambassadors - We run the UK network of STEM Ambassadors: over 30,000 inspiring volunteers
- STEM Clubs Programme - We provide free, expert advice and support to all schools which have set up or plan to develop a STEM Club
- Schools' STEM Advisory Network (SSAN) - We deliver free impartial advice to teachers and use our business links and partnerships to enhance the STEM curriculum in secondary schools in the UK

Universities Federation for Animal Welfare

Contact: Dr Robert Hubrecht
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.

The Welding Institute

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.

SCIENCE IN PARLIAMENT

sip

Where Science, Innovation and Politics Meet

www.scienceinparliament.org.uk