Stephen Metcalfe MP and the Parliamentary and Scientific Committee would like to thank all those organisations supporting STEM for BRITAIN 2020; without you the event would not be possible!
Stephen Metcalfe MP  
Chairman, Parliamentary & Scientific Committee (All-Party Parliamentary Group)

A warm welcome to our first edition of 2020.

I was very pleased to have been elected to Parliament for the fourth time, on the 12th December, and subsequently re-elected as Chair of the Parliamentary & Scientific Committee at the Inaugural Meeting on the 13th January.

Congratulations to my fellow Officers, Lord Broers, Chi Onwurah MP, Carol Monaghan MP, Lord Willis of Knaresborough and others on their re-election. I am also delighted to welcome Chris Green MP to the Committee.

Just before this edition went to print, the results of the House of Commons’ Select Committee Chair elections were announced. My congratulations, in particular, to: Rob Halfon MP (Education), Jeremy Hunt MP (Health and Social Care), Rachel Reeves MP (Business, Energy & Industrial Strategy), Neil Parish MP (Environment, Food and Rural Affairs) and Greg Clark MP (Science and Technology). We shall resume reports from these key Committees when they are fully constituted, along with those from the House of Lords.

Since the Inaugural Meeting the Committee has resumed its programme of meetings beginning with two excellent discussions on the topics of ‘Smart Energy’ and ‘Noise, Sound and Acoustics’, generously sponsored by UKRI and the Institute of Acoustics respectively.

Lord Broers  
Dame Jocelyn Bell Burnell

The Annual Lunch, postponed from November, due to the General Election, was held in the Cholmondeley Room on the 21st January. It was hosted by the President, Lord Broers, who was delighted to welcome as our distinguished guest speaker, Dame Jocelyn Bell Burnell.

We look forward to STEM for BRITAIN, on the 9th March, in the Attlee Suite, Portcullis House, our prestigious annual competition celebrating the excellent achievements of early career researchers from across the UK.

In this issue we have commissioned a brilliant array of articles and features covering a wide variety of topical subjects, which I am sure you will enjoy reading. My grateful thanks to each of our writers.

Amongst the contributions is an excellent tribute to the late Andrew Miller, from Dr Stephen Benn, Vice President of P&SC.

We will always remember Andrew, not only for his engaging and stimulating personality but also for his wonderful service as Chair of the Science and Technology Committee - the first MP to be elected to that position - and also as Chair of the Parliamentary & Scientific Committee.

Andrew contributed greatly to the understanding of science at Westminster and beyond. He will be very sorely missed.

Lord Broers  
Dame Jocelyn Bell Burnell

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CLIMATE CHANGE – IS THERE A PLAN B?
RESILIENT NATION

Four years ago, at COP21 in Paris, the nations of the world committed to Climate Change ‘Plan A’. They agreed to take actions to keep global warming to well below 2°C relative to pre-industrial times, and as close as possible to 1.5°C. To do so requires us to ‘Leave it in the ground’, where the ‘it’ corresponds to 82% of known coal reserves, 49% of oil reserves and 33% of gas reserves.

UNFORTUNELY, PLAN A IS NOT WORKING.

CO₂ emissions in 2018 were a record 37 billion tons, corresponding to a 2% annual growth. Atmospheric concentrations are at a multi-million year high. The 2015-2019 five-year period is destined to be the warmest on record. The global average temperature rise is already +1.1°C above pre-industrial. Climate impacts are hitting harder and sooner than predicted. To achieve the Paris commitments would require a tripling to quintupling of current commitments. Oil and gas companies continue to invest in discovering new reserves.

At issue is not just whether we can cope with the growing climate impacts, but whether or not we can remain masters of our destiny. The 2°C ‘guardrail’ was chosen to avoid triggering climatic Tipping Points. These include the collapse of the Greenland and West Antarctic ice sheets, irreversible changes in ocean and atmospheric circulation, the release of methane from the Arctic ocean and permafrost, and the die-back of the Amazon rainforest. There is a risk of a domino effect. Once started, the chain reaction would be unstoppable – we would lose control.

It is not clear in what state the system would ultimately settle. But for a temperature rise exceeding ~7°C, significant areas of the Earth would become uninhabitable due to heat stress. Combined with the disruption of water resources, the direct impacts of storms and wildfires, and the impacts of sea level rise, mass migrations of millions, if not billions, would follow (see for example Vinke et al). In its 2014 Climate Change Adaptation Roadmap, the US Department of Defence observed “Rising global temperatures, changing precipitation patterns, climbing sea levels, and more extreme weather events will intensify the challenges of global instability, hunger, poverty, and conflict.”

They refer to climate change as a ‘threat multiplier’ - exacerbating problems in an already troubled world.

More specifically, in its ‘Security Outlook 2030’, the WEF sought to answer “What is the worst that can happen?” Based on a substantial multi-nation exercise, they present three possible scenarios: ‘Walled Cities’, ‘Strong Regions’ and ‘War and Peace’. ‘Walled Cities’ may be characterised as follows:

- Greater penetration of information and communications technology broadens the horizons of citizens in many countries, raising expectations in areas such as health, education, infrastructure and quality of governance.
- Fiscal challenges and political dysfunction erode state provision of public services.

Since January 2014 Chris has been Chair of European Space Agency.
Citizens become disillusioned by their exposure to public sector corruption, poor service delivery and ineffective institutions.

Inequalities widen and middle classes are hollowed out.

Elites retreat to gated communities and turn to private sector for basic services.

Fertile soil, fresh water and even clean air become increasingly commoditized.

Society becomes increasingly polarized between elites and impoverished classes with little social mobility.

Rootless and disillusioned young people become anti-system and vulnerable to radicalisation.

States lose ability to cohere people around a shared narrative or identity.
• Insurgencies, terrorist groups and criminal organisations exploit the security deficit
• The world divides into islands of order in a sea of disorder
• As large numbers of people are displaced by climate change and social violence, still-functioning states seek to protect themselves

The upshot is a ‘World of Walls’, in which nation states adopt a ‘Fortress’ mode. Interestingly, when the Berlin Wall fell in 1989 there were 15 border walls worldwide. Today there are 70. Examples include the 3m high partly electrified barbed wire fence that runs along 70% of the 4,100km border between India and Bangladesh, and President Trump’s plan to complete the isolation of the 3,200km border between the USA and Mexico. The trend is already well-established.

‘Strong Regions’, envisages a volatile and competitive but stable world with several seats of power. Overwhelmed by mistrust, governments invest their political, financial and diplomatic capital in bilateral or regional processes. In ‘War and Peace’ the world drifts into a major conflict which ultimately leads to a transformational reworking of the global system.

The WEF emphasise that the scenarios are not predictions, but plausible trajectories. They are useful to challenge current thinking, and to serve as a call to action for the development of more adaptable and resilient response systems. In all three cases, however, an inescapable conclusion is that for nations to remain viable, a high degree of self-sufficiency will be critical.

Responsible and prudent governance should therefore seek to ensure the robust health of key national capabilities such as agriculture, water supplies, energy production, information technology, transport infrastructure, raw material access, industrial production, pharmaceuticals, skills production, and defense.

In practice, the state of play and direction of travel in the UK are not encouraging. Food security has declined from 78% in 1984 to ~60% in 2018 ¹⁰. The steel industry, following a period of overseas ownership, has been allowed to collapse. The defense of off-shore wind farms is hard to achieve in principle, and virtually impossible in practice, given the nations’ current military assets. In an age in which digital information flows are crucial for effective societal organization and governance, a reliance on Chinese communications technology is arguably deeply unwise.

The conclusion? No nation or individual will escape the looming impacts of climate change. In combinations with the other factors shaping our global collective future, profound social instability is a material risk. With this in mind, ‘Resilient Nation’ would be a wise precautionary strategy, and hence an appropriate and desirable Plan B.

References
SCOTLAND’S ENERGY FUTURE

In June 2019, the Royal Society of Edinburgh (RSE) published its final report into Scotland’s Energy Future. The report was the culmination of almost two years of work, undertaken with the intent of contributing to the debate about Scotland’s energy supply, demand and use, while properly recognising Scotland’s moral and environmental responsibilities against the backdrop of a changing climate and a need to reduce carbon emissions.

As Scotland’s National Academy, the RSE is in the unique position of having access to a wide-range of expertise provided by some of the foremost experts in Scotland. Moreover, the RSE’s status as a renowned, impartial, learned society allows it to utilise this experience and knowledge to produce a considered view of the issues Scotland faces regarding energy production, use, governance and the options that are available to Scotland to meet its energy needs.

The expert Committee undertaking the Inquiry came from a wide range of backgrounds and disciplines covering areas such as engineering, law, sociology, climate and economics, as well as energy.

The RSE took evidence in a variety of ways from hundreds of individuals, organisations and businesses from across Scotland and beyond. Written responses to a consultation were received, public engagement events were held around Scotland, roundtable discussions convened to discuss issues affecting different sectors, and meetings held with many stakeholders to ensure that the final report covered as much of the vast and complex area of energy policy as was possible.

THE FINAL REPORT
The final report serves as a guide to the energy landscape in Scotland, reviewing the governance of Scotland’s energy system, analysing the context in which we produce and use energy and in which decisions will occur, and explaining the trade-offs that need to be made. The Inquiry report discusses the advantages and drawbacks of all of the options available to Scotland to meet its energy needs now and into the future, with particular attention drawn to the issues the expert Committee conducting the inquiry considered to be most pressing.

Some of the options, for example the use of fossil fuels, are already a significant part of the energy mix, but have severe consequences for our climate and Scotland’s ability to meet its carbon reduction targets. A decision to move away from carbon intensive industries, however, has significant impacts on jobs and communities and must be adequately considered and planned for.

Other options may provide the energy we need in a more carbon neutral manner but could also be some way from being viable at scale. Carbon capture and storage technology could potentially facilitate continued use of fossil fuels or support a transition to the use of hydrogen, resulting in lower carbon emissions. This would, however, require a high level of investment.

Whether the option is a generation technology, a new kind of storage, a change in public behaviour, or a regulatory reform, none of the choices the Committee assessed provided a silver bullet to solve the ‘energy quadrilemma’ of reducing carbon emissions, ensuring affordability, providing energy security, and doing all this in a way that is socially acceptable and economically sustainable.

While the report’s analysis of the merits and demerits of the options available came to one overarching conclusion – namely, that there are no easy answers – some options did present considerably more advantages.
than others. Improving energy efficiency and reducing demand, for example, came out strongly under the traffic light system the Inquiry Committee utilised to highlight the advantages and drawbacks of the options. While a need for substantial investment and the obstacle of Scotland’s ageing housing stock were highlighted as issues, improving efficiency and reducing demand was viewed as being imperative to meeting energy goals, reducing emissions and improving energy security.

Other options, such as continued importation, fared significantly less well. While the continued importation of fossil fuels scored well in terms of affordability, due to access to world markets, the fact that Scotland would not fully be taking responsibility for the impacts of production and use, the carbon footprint of transporting the fuel, and an acceptance that the continued burning of fossil fuels exacerbates the problem of climate change were all highlighted as significant drawbacks.

The report stressed that, irrespective of what path is followed, policy makers will have to be up front, direct and honest with the public about the fact that trade-offs are unavoidable. It is then up to our elected representatives to communicate why these trade-offs are being made and attempt to bring the public along with the decisions that have been made.

While the task ahead is undoubtedly incredibly challenging, the hard choices that must be made cannot be kicked into the long grass. With the closure of Scotland’s fossil fuel plants in recent years, and planned closures of the two remaining nuclear stations over the coming decade, choices will need to be made on how to generate the electricity previously produced from these technologies. As mentioned, the fall-back choice of simply importing a greater proportion of our energy has serious implications and should not be adopted without serious consideration of these.

It is imperative that, whatever decision is made, the process in reaching this choice is grounded in robust scientific evidence and honest debate over the consequences. Indeed, the ramifications of doing nothing and allowing potential opportunities to slip away could prove far higher and wider-reaching.

The report makes ten recommendations including the need:

- To establish an expert advisory commission on energy to help advise decision makers on all aspects of energy policy and governance;
- For considered and timely investment into options to meet Scotland’s energy needs;
- To reduce overall demand for energy and improved energy efficiency measures;
- For a clearly articulated position on security of supply and the need for an increase in domestic generating capacity;
- For serious consideration on how best to socialise the costs of transition to address issues of social justice;
- For all levels of government to review and change existing policies where these are at odds from the overall goal of carbon reduction.

Fortunately, despite the difficult decisions that must be made, the report concluded that there are genuine reasons for optimism. The challenges Scotland, and the world, faces regarding energy should not only be seen as a threat, but also viewed as an enormous opportunity; and one which Scotland must grasp. Some of the options available for meeting future energy needs may prove more financially costly than ‘business as usual’, but this investment is also a real contribution towards the country’s prosperity and wellbeing and could position Scotland as a global innovator.

POST PUBLICATION WORK

Since Scotland’s Energy Future was published in the summer, work has continued to highlight the report’s findings and continue the important debate on energy. In October the RSE held its first policy event at a political party conference, hosting a panel discussion on the report’s findings with Scottish Government Minister for Energy, Connectivity and the Islands, Paul Wheelhouse, and Chaired by former Scottish Parliament Presiding Officer Sir George Reid.

In December 2019, the Scottish Parliament’s Economy, Energy and Fair Work Committee took up the RSE report as the starting point for its own inquiry into energy, with a particular focus on electric vehicles and smart energy. The RSE was pleased to send RSE Inquiry Deputy Chair Prof Becky Lunn, along with Prof Gareth Harrison, Prof John Underhill and Prof Gavin Little to Holyrood to brief the MSPs on the Committee on the report’s main recommendations and findings.

As we enter 2020, the RSE will continue to encourage and facilitate informed, evidence-led debate on energy policy and the decisions that will need to be made to ensure that Scotland’s Energy Future is a bright one for all the people of Scotland.
CAN OBESITY GASTRIC SURGERY CURE DIABETES?

Ali Alhamdani Consultant General Surgeon

Diabetes is the epidemic of the century. Type 2 diabetes is related to obesity and cases in the UK and worldwide have quadrupled over the past 30 years. In the UK alone, more than 2 million people are affected with more than 10% of UK health spending being directed to diabetes treatment. This increase in type 2 diabetes is mainly related to the obesity pandemic. Currently there is no specific cure for type 2 diabetes, just management techniques. Unfortunately, for many patients, within a few years of being diabetic, they develop life threatening complications such as heart attacks, strokes, hypertension, peripheral vascular disease, blindness and kidney failure. Hence, finding a better solution for type 2 diabetes is important.

Mr Ali Alhamdani, a senior bariatric surgeon and leader in revolutionising the way we treat diabetes with surgery, explains how we can rethink the treatment of this disease.

HOW CAN SURGERY HELP CURE TYPE TWO DIABETES?

There was a report in the Lancet in 1925 which suggested that a side effect of an operation to treat peptic ulcer disease (an early version of what we now call a gastric bypass) was the remission of diabetes in diabetic patients. They found this by testing glucose levels in their urine, which was one of the early ways to diagnose diabetes. This observation was seen more frequently in the 1980s and in 1990 when obesity surgery was offered to obese patient with diabetes.

Gastric bypass surgery is essentially the last resort to treat obese patients. This operation consists of dividing the stomach into two parts – the small, top part and the remaining lower, large part – and then connecting the top part of the stomach to the small bowel after bypassing 1-2 meters of the small bowel. Recent evidence showed that this type of surgery can control or cure diabetes.

An increasing amount of evidence from the literature now favours the effect of surgery on type 2 diabetes in comparison to other modalities of treatment like medications, diet and exercise. Evidence shows that obesity surgery attacks the symptoms, in addition to the cause of diabetes. Diabetic patients after surgery have their blood sugar normalised within just a few months. They also have less chance of developing diabetic complications like blindness and heart disease. Surgery also helps to reduce high blood pressure and lower high cholesterol levels.

WHY DOES SURGERY HAVE THIS EFFECT?

The exact mechanism of why diabetes is controlled after obesity surgery if not fully understood. A few theories suggest that after the gastric bypass, when food reaches the lining of the small bowel, increasing amounts of gut hormones are excreted which results in increased production of insulin and hence the control of diabetes. Medical insulin after obesity surgery is stopped on day one, even before the patient starts to lose weight, because of the strong hormonal effect of surgery to control this chronic condition.

A more recent studies showed that this hormonal effect is a result of increase bile acids concentrations in the blood after gastric bypass surgery which stimulates the secretions of those hormones. Bile acids increased concentration in the blood after the operation further helps to decrease the insulin resistance by increasing complex fat synthesis and decreasing the production of glucose in the liver.

The same operation also hits another pathway by affecting the microbiota of the gastrointestinal tract having more...
favourable microbiota after surgery that facilitate the absorption of bile acids and hence its higher concentration in the blood after the operations.

In general, gastric bypass works in the obese body by multi-hit hypotheses.

**WHAT ARE THE BENEFITS OF TREATING DIABETES WITH SURGERY?**

Other than the health benefits and diabetes remission for patients, studies have shown the economical benefits. It is suggested that the cost of the surgery, which is around £10,000-£12,000, will be gained after 2-3 years due to the reduced spending on diabetic medical treatment.

The UK National Bariatric Surgery Registry (NBSR), which conducts a continuous auditing process of the result of obesity surgery in the UK, showed that diabetic people who received surgery had a 75-80% chance of diabetes remission. In addition, the National Institute of Health and Clinical Excellence in UK (NICE) has recently approved obesity surgery to treat diabetic patients with a BMI of 30 and above.

**ARE THERE ANY SETBACKS FOR THIS NEW TREATMENT?**

There are a few obstacles in view of providing surgery to treat diabetes on a nation-wide scale. One of those obstacles is the high cost of the surgery, however, as already stated this has been shown to be made back in due course. The second obstacle is the prejudice the community has for obese patients, with many holding the belief that these patients bring poor health onto themselves by not following a healthy diet.

I believe it is a time to think differently about diabetes. Type 2 diabetes is a disease that is related to obesity and can be cured, or at least controlled with surgery. When patients know that this is a curable disease, with the last option being surgery, then that might give hope to patients, making them more determined to try the treatment ladder from the start of medical treatment and lifestyle changes and up to surgery if required. Changing the perception of diabetes from a picture of an untreatable disease to a problem that can be solved by surgery is difficult to imagine but as Albert Einstein said once “imagination is more important than knowledge”.

"**WHY THIS IS THE BEST WEIGHT LOSS SURGERY FOR YOU – WHAT I WOULD CHOOSE FOR YOU AS YOUR OBESITY SURGEON**"

Ali Alhamdani Consultant General Surgeon

There are many different factors which must be considered when deciding on the right path to follow for weight loss surgery. Senior bariatric surgeon Mr Ali Alhamdani explains how he decides the best course of action and procedure for the patient.

**HOW YOUR OBESITY SURGEON HELPS YOU TO MAKE THE RIGHT CHOICE**

Consider patient eating habits

Patients eat differently: they are either large volume eaters, sweet eaters or combination of both. Knowing this is paramount in the decision-making process since each bariatric operation has its limitations with regards to its ability to induce weight loss. For example, sleeve gastrectomy and gastric band are restrictive operations - their impact on soft and sweet food is limited and therefore we could not expect significant weight loss if a ‘sweet eating person’ is offered a sleeve gastrectomy.

Another example: gastric bypass or mini gastric bypass could cause dumping syndrome for sweet eaters (when sugar moves to the small bowel from the stomach too quickly, causing cramps and diarrhoea), therefore patient knowledge and understanding of their diet habits would help in their recovery. Although this is often mentioned as one of the side effects of this procedure, I believe it is an advantage: it will force the sweet eating patient to switch to the healthy Mediterranean type of
food. This dumping syndrome occurs in 40% of gastric bypass patients.

**ASSESS THE MEDICAL HISTORY OF THE PATIENT**

Past medical history affects the choice of the operation. For example, patients with severe gastroesophageal reflux and hiatus hernia should not have an operation that exerts high pressure on an already weakened gastroesophageal junction. Sleeve gastrectomy transfers the low-pressure volume stomach sack into a high-pressure system stomach tube. This will encourage the reflux of acid in the already damaged gastroesophageal sphincter mechanism in a patient with gastroesophageal reflux.

Another example illustrating medical history - patients with inflammatory bowel disease like Crohn’s or ulcerative colitis should not be offered obesity surgery that might affect the disease process or interfere with the treatment options. Therefore, I would not offer gastric bypass or mini gastric bypass to such patients.

**KEEP THE PATIENT’S THOUGHTS AND BELIEFS IN MIND**

Some of my patients come and ask specifically for only one operation. I will support offering the patient their choice as long as it will not cause them any harm. For example, some patients would like only the gastric band - and nothing but the band. They believe it is a very safe operation.

This is one of the misconceptions patients have. Problems with the gastric band will not happen in the initial years after the operation. The longer the patient lives with the band the more chance there is of having complications like band erosions and slippage. Some of those complications are life-threatening. One way around this could be to offer a gastric sleeve/bypass or mini bypass, as if a complication is to happen with those operations it will happen early. The longer the patient lives with these operations the safer they are.

It is important to me as a surgeon to listen to what patient want, however it is also important for me to point out any possible risks and give my recommendations while taking into account the patient beliefs surrounding surgery.

**FOLLOW THE SURGEONS ACT**

Some surgeons believe in only one solution for all patients. Those surgeons believe, for example, in offering only gastric sleeve to all patients, and some believe in offering a gastric bypass to all patients.

I believe that the surgeon should take all the factors above into consideration and only decide after discussing it with the patients and involving them in the decision-making process. This ensures we choose the best course of surgical treatment for the patient.

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**HOW AI WILL TRANSFORM HEALTH: AND HOW IT WON’T**

*“I never predict anything and I never will” - Paul Gascoigne*

Artificial Intelligence (AI) will be a transformative technology over the next few decades, and health looks like one of the areas where it has the most potential. Getting policy and regulation right is vital to maximise its enormous benefits while minimising the substantial risks. And to do this well we need a rough forecast about exactly how AI might be used.

Any attempt at prediction carries the risk of making a fool of oneself, and it is generally a good idea to follow the sage example of Paul Gascoigne above. This is especially true when it comes to AI, a technology that has been through huge peaks and troughs in expectations. However, the task cannot be avoided if we are to be properly prepared.

So in this article I’ll take the risk of looking like a fool a few years down the line and offer some tentative suggestions as to what most transformative effects of AI that might be in health in the next 10 years - not the biggest technical breakthroughs, but the biggest changes in our experience. This draws on our report Confronting Dr Robot.

Press coverage is, I think, a poor guide here. AI tends to get the most attention when it seems to achieve human level performance in some area - like playing go, or driving a car, or diagnosing cancer from a medical image. While this is hugely technically impressive, it is not a great guide to uptake. New innovations generally takes root where the existing approach works least well, rather than where it works best. Being better than doctors is a high bar, especially when their full range of skills is considered: spotting problems that are unrelated to the original diagnosis, helping the patient make complex trade-offs, considering psycho-social as well as medical factors etc. Healthcare is at its best when a clinician talks with a patient, and looks at their data - it is the other 99% of the time that most of the problems happen. These areas also tend to have fewer institutional and regulatory barriers to uptake.

So let us look at some of the key moments and decisions that have to be taken outside of the conversation with the appropriate clinician, and where AI can help.
THE INITIAL DECISION TO SEE MEDICAL HELP

We’ve all indulged in some frantic googling to try and work out if we need to take time off work to see a doctor - and we are not very good at it. Around 20% of people appearing GP surgeries do not need to be there. Similarly there are a large number of people who should be getting their health problems attended to, but don’t, often causing problems later.

There are a number of AI powered chatbots in the market which aim to help patients at this point, such as within Babylon’s GP at Hand product, which are already being used by thousands of people. Evidence of their efficacy in far from solid - but that hasn’t stopped their widespread availability and use.

REFERRAL

GPs do amazing work, but are generalists. When confronted with an uncommon problem, they do not find it easy to know when to refer to a consultant. Referral rates vary between two and twenty times between various GP practices, far more than can be explained by different patient characteristics.

We are seeing the emergence of AI driven referral engines. For example, Google Deepmind and Moorfields Eye Hospital recently published a study showing that AI can make a very accurate referral decision for over 50 eye conditions. C the Signs is live in the NHS today, helping GPs diagnose cancer and make the appropriate referral.

REMOTE MONITORING

One of the most remarkable studies on digital health shows that remote digital symptom monitoring for cancer patients improved survival by 8 months, far more than the average new cancer drug. Ensuring clinicians and patients can react to changes in health quickly can have huge benefits, and AI can play a significant role here. Examples such as Current Health are live in the NHS at the moment, using a mixture of wearable sensors, patient data entry, and AI analytics to monitor conditions in real time, and take action.

Apart from the efficiency and quality impacts mentioned above, AI could also shift knowledge and power into the hands of patients. AI can help patients understand what is happening with their health, be better equipped to know when to seek treatment and to know who would be best to give it. This could strengthen their ability to advocate for themselves, and engage them as more active participants in their own healthcare decision making.

So we are already seeing the emergence of AI in a number of powerful positions:

- AI as the front door - strongly influencing whether patients go to seek treatment.
- AI advising on key moments in the patient journey such as referral.
- AI analysing data to flag up patients with ongoing issues who need urgent intervention; or who can perhaps be left alone.

This future would put AI becomes influential about who seeks treatment, when they do it, and who they see. In a perfect world these algorithms would be deployed to do exactly what they are good at, with a clear understanding of their limitations, with appropriate processes to pick up mistakes, and clarity about the ultimate responsibility for decision making.

However the history of technology implementation in healthcare should not fill us with confidence. Its not enough that we properly regulate the reliability of the advice that the AI is giving - we also have to think about the clinical and institutional context in which the AI is applied. In the worst case, it is easy to draw an analogy with the replacement of bank managers by credit scoring algorithms.

- The reasoning behind decisions such as refusing a referral becomes more obscure.
- The conversation that would allow a clear picture of the whole patient to emerge does not happen, as feeding data to the AI dominates.
- Even where there are obvious special factors, it is hard to overturn the judgement of the algorithm. The ability of people to interrogate the process, appeal, and advocate for themselves is diminished.
- Those with atypical situations or symptoms, find it harder to progress and advocate for themselves, leading to widening health inequality.

All this can happen to a significant extent without AI being given explicit authority to overrule anyone; the mere fact that people are being measured against a standard is a powerful influence, and there will be a temptation over time to include the AI’s output in system management and planning discussions, making it substantially influential.

In order to get to the better of these futures a number of principles need to be in place:

CONTROL

AI should give citizens a clearer and more timely understanding of their health and what should be done, in ways that support greater citizen confidence and control.

SIMPLICITY

Well implemented AI should make it quicker and easier for patients to get a resolution to their problem. This requires clarity about the types of problem AI can deal with, and well defined boundaries beyond which human input is required, to avoid AI becoming an additional barrier.

DIALOGUE

The conversation between doctor and patient should remain central. AI should support conversations - ensuring that they are with the right people, that it happens at the right time, and providing the information that supports it. AI should not degrade conversations by over-standardising or taking up unnecessary time.

EQUITY

AI should not be used in ways that exacerbate health inequalities. AI should help all citizens, and most particularly those who face the most challenges and disadvantage in relation to their health and well-being.

ACCOUNTABILITY

It must be possible for AI to be understood, questioned and held to account, otherwise AI could fundamentally disempower users - both citizens and health professionals. Without accountability (and the transparency underpinning it), the rest of these AI principles are hard to achieve - control, simplicity, dialogue and equity all require AI that can be understood and held to account by its users.

I remain optimistic about AI and health, but there is a real need to focus the debate on how its less glamorous but most probably applications might work in real systems and to consider increasing autonomy and dialogue as objectives alongside more technical measures of AI’s reliability. Healthcare tech has often been implemented from a system management perspective, and without fully taking advantage of the opportunity to directly empower patients - a set of problems we continue to try to address at Nesta through for example our Healthier Lives Data Fund, in partnership with the Scottish Government.
The UK is well placed to research and develop geological solutions to climate change due to the excellent and well-developed knowledge base, mature understanding of the UK’s subsurface, as well as world-class universities and research centres.

The geology of the UK - and the geoscientists that have studied it - have played a vital role in the development of the UK’s economy. One of the main components of the industrial revolution was the abundance of easily accessible high-calorific coal in parts of England, Wales and Scotland - and the co-location of materials like iron-ore, limestone and coal allowed large-scale construction for the industrial revolution, such as the famous Iron Bridge in Shropshire. More recently since the 1960s offshore oil and gas has brought huge economic benefits and revenue for private industry and UK Government. Around 42 billion barrels of oil equivalent have been produced from the UK offshore so far, each year bringing around £5 billion in tax revenue, and supporting around 450000 jobs. These developments are related to coal and hydrocarbons – what we could call a process of ‘carbonisation’ of the economy - but geology and geoscientists will have a powerful and critical role in the ‘decarbonisation’ of the economy and in delivering the UK Government’s commitment to ‘net zero’ by 2050. Reports from the IPCC, the Committee on Climate Change and the Science and Technology and BEIS parliamentary select committees all outline the critical role that carbon capture, utilisation and storage (CCUS) will play in delivering net zero for the UK economy through decarbonisation of industry and power. The decarbonisation of domestic heating and air conditioning across the world is likely to need geothermal energy and a hydrogen economy will need large-scale geological storage.

DECARBONISATION TECHNOLOGIES
Three key geologically-related technologies will be needed for decarbonisation: CCUS, hydrogen as fuel and geothermal energy. The UK is well-placed to develop and deliver these technologies due to its favourable geology. The North Sea has the potential to be a major resource for a future CCUS industry, due to the concentration of highly skilled professionals and significant data and understanding that already exists about the subsurface in the North Sea. In the area of geothermal energy, there has been significant activity in the UK, primarily in Cornwall and Glasgow. In Cornwall, investigative drilling at the United Downs site is ongoing, aimed at developing a deep geothermal energy resource in Cornwall, with the potential for a further 20 sites. The British Geological Survey, as part of NERC-UKRI, is also investigating the potential for low temperature geothermal energy at their field site at the abandoned mine workings in East Glasgow as part of the UK Geo-energy Observatories project (UKGEOS). As described below, there are also a
number of hydrogen projects in development around the UK. See Figure 1.

**LINK TO UK REGIONAL DEVELOPMENT**

The nature of geological resources and materials is such that their use in decarbonisation will tend to be place-based. For example, the development of a regional ‘hydrogen economy’ – where hydrogen provides fuel for vehicles, heating houses and powering industry. Hydrogen’s mass production in the short term will be by steam methane reforming (SMR), from natural gas which produces CO$_2$, and hydrogen. The hydrogen is a zero-carbon fuel, but the CO$_2$ will have to be used, or disposed of, geologically. The key point here is that geological disposal of CO$_2$ cannot be done everywhere, because only specific geologies are suitable. Critically, there are many suitable locations with supporting infrastructure in the North Sea. It is also known that to make the hydrogen economy work, huge amounts of the gas will be needed, and therefore so will large local storage in the subsurface. In most cases, this means geological storage in underground salt layers.

A practical example is the ‘H21’ Leeds City Gate project which will convert the existing natural gas network in Leeds – used mainly for heat – to 100% hydrogen. Decarbonisation of heat is a major challenge for the UK, where fossil fuels dominate the sector, see Figure 2. In the H21 project, SMR plants on Teesside will produce the hydrogen and the waste CO$_2$ will be disposed of offshore in the rocks under the southern North Sea. Subsurface salt cavern storage in the Tees and York areas will be needed for ‘intra-day’ and ‘intra-seasonal’ swings in demand as heating is turned on and off by consumers.

The Liverpool-Manchester Hydrogen Cluster will decarbonise domestic heat, but also major industrial gas users in the oil refining, glass manufacturing, food and drink, chemicals and pulp and paper sectors. The Liverpool-Manchester area also has suitable geology: the gas fields located in the East Irish Sea off the coast of Merseyside, could be repurposed to provide CO$_2$ storage; the area is rich in salt deposits suitable for the storage needed for the roll out of hydrogen.

There is also potential for geothermal energy to play a significant role in decarbonising heating in the UK with the added potential for electricity generation. Low temperature geothermal energy in particular, typically groundwater with a temperature less than 20°C, can play a part in decarbonising heating. Huge volumes of such waters exist under the UK’s towns and cities. Former industrial areas where waters move very freely because of old coal mine workings may be...
particularly well suited to domestic heating using below-ground energy. Coal mine heat is being tested right now at the NERC-UKRI British Geological Survey test site, UKGEOS, in the former coal mining area in the east end of Glasgow. Other industrial towns based on or near coalfields, often with fuel poverty, could also benefit from coal mine heat.

The research and development associated with CCUS, geothermal and hydrogen will develop in geographical clusters around the UK that can exploit existing industrial infrastructure as well as natural geological resources and other advantages to allow local solutions. These regional hubs will concentrate the Industrial Strategy. Across the UK, local ‘energy ecologies’ – collections of energy users and producers - are beginning to work together to decarbonise. The local funding arrangements of the Government’s new Industrial Strategy will target government funding along with co-funding from industry to address market failure. The cluster concept underlines the need for industry and government to work together to decarbonise, but also the importance of the distribution of useful rock types, and ultimately the importance of geoscience knowledge and skills in decarbonisation.

The solution to net-zero will not be a ‘silver bullet’ technology but a variety of solutions, both national and local. Incorporation of geological solutions into local industrial strategies and investment in geological skills will be critical to meeting the decarbonisation challenge and stimulating economic growth across the UK.

**HOW CAN PARLIAMENTARIANS HELP…**

- Appraise and build geological solutions to climate change into local industrial strategies. For example, where there is the potential for geothermal energy in a given area, ensure that the requisite licensing regulation is developed to support technological development.
- Promote the important role of geological skills and the UK’s local geology in the development of decarbonisation technologies, both regionally and nationally, particularly when developing national policy around investment in research and development and workforce training.
- Strengthen the geoscience skills pipeline through investment in the UK’s outstanding universities sector and support the development of immigration policies that allow for the movement of international researchers and students.
ENGINEERING THE FUTURE OF THE UK

It’s well understood that the UK needs to upskill its population to stay competitive in a world economy, as well as to meet other domestic needs.¹ The engineering sector is vital to the UK’s economy, generating more than £1 in every £5 of UK turnover, employing 5.6 million people and producing the majority of UK exports.²

However, there are challenges. The current and projected annual demand is that the UK will need 59,000 more engineering graduates and technicians than we currently produce. The engineering profession also suffers from a stark gender imbalance: only 12% of engineers/technicians in industry are women who comprise 47% of the UK workforce. A similar issue affects BME engineers: 8% of engineers/technicians are BME, while BME workers form 12% of the UK workforce.

These two problems of shortfall and lack of diversity have the potential to at least somewhat offset each other. Just as importantly, UK Engineering would benefit substantially from greater diversity in its outlook.

Substantial effort and attention is being committed to these issues and progress is being made in many areas, but it is still too slow — and there is increasing awareness of the important role engineering must play in modern challenges, like climate change, and caring for an aging population.

ENGINEERING IDENTITY

Engineering suffers from an image problem. Most people are unaware of the part that engineering plays in their life in the same way that whales probably give little thought to the importance of water. The products of engineering are everywhere: the computer on which I am typing this, the seat on which I am sitting, the clothes I am wearing, the tiles under my feet, the building materials and infrastructure where I am, the roads and paths by which I travelled here.

Compounding this, engineering’s greatest accomplishments are often attributed to science alone. While the Saturn V rocket that took humans to the Moon was a product of engineering, the popular term is “rocket science” and not “rocket engineering”, the profession didn’t even get much credit for the fact that the first two humans on the Moon were engineers — which was not a coincidence. Not for nothing is the word “engineer” descended from the same Latin stem as “ingenuity”.

The contribution that engineering has made to quality of life and enhanced lifespan is also due to its direct intervention in healthcare. It takes only a small perspective change when in a hospital to become aware of just how much of the equipment and medicine that is being used and surrounds patients has been produced by engineers. This is true outside clinical settings too, for instance mobile defibrillators (first developed in Northern Ireland) can now be found in corner shops, carefully engineered to be used by untrained people.

Despite this, it is entirely possible for our most scientifically literate school students to have little or no knowledge of what engineering is, or worse, to have significant misconceptions. I can personally attest to this; my degrees are not in engineering — I am an immigrant into a profession that requires and absorbs expertise of all sorts. Fewer than a quarter of young people aged 11 to 14 reported knowing what engineers do. At this age they can already make subject choices that will make entering the engineering profession later more difficult.

Many tend to have an image of engineering that it is low-paid, low-skilled work, involving heavy labour, when none of this is true. Some of this may directly contribute to the gender issue, but some newer areas may be freer of stereotypes – the proportion of women studying biomedical engineering far exceeds that for mechanical engineering — I am an immigrant into a profession that requires and absorbs expertise of all sorts. Fewer than a quarter of young people aged 11 to 14 reported knowing what engineers do. At this age they can already make subject choices that will make entering the engineering profession later more difficult.

Some notable campaigns are helping. “Primary Engineer” – introducing primary school students to engineering and asking them what they would invent. “This is Engineering” – a campaign led by the Royal Academy of Engineering also...
seeks to overturn misconceptions and increase diversity in the profession — their videos have had over 37 million views. The Year of Engineering in 2018 – championed by Stephen Metcalfe MP have all helped to raise and change awareness. This momentum must be maintained and increased.

SUSTAINABILITY AND ETHICS

Another important shift in the engineering landscape is a dramatically increased focus on the issues of sustainability and ethics. These have long been a mandatory part of engineering courses accredited by the Engineering Council, but it’s fair to say that the prominence of these ideas has risen sharply.

It’s been sometime since Professor Raffaella Ocone first suggested that there should be some analogue of the Hippocratic Oath for engineers — certainly the work of many engineers has life or death consequences, just as in medicine. The importance of engineering ethics has probably never seen so much attention from the variously involved professional bodies. It is the subject of academic conferences, joint work by the Engineering Council and the Royal Academy of Engineering, and indeed the Engineering Professors’ Council Board has dedicated a strategic retreat to it.

Issues such as the Climate Crisis have underlined this need. The widely held opinion that the climate change is anthropogenic — and essentially driven by our technical evolution since the industrial revolution places a particular onus on engineers. Even if one takes the contrary view as to the origin of climate change, its effects still require major efforts of engineering to ameliorate. It will be engineers who produce technologies that affect CO₂ levels in our atmosphere and oceans, but it will also be engineers who will lead the effort in protecting our populations against the existing impacts and create a sustainable future.

POLICY IMPERATIVES

The UK needs to grow its world class engineering industry, driving innovation and our export economy. To do this, as engineer Nick Cooper puts it succinctly “we need more engineers and we need more people that think like engineers”. We must address the diversity issues in engineering and ensure that more people are aware of what engineering is, what it does for them and what it might offer them as a career.

Engineering education must embrace many challenges: an ever-increasing depth and breadth of scientific and mathematical background as new science is developed; the need to develop the soft skills which are just as important in industry; and a much greater focus on issues that have historically sometimes been paid lip-service — such as ethics and security.

The UK needs a mix of engineers with varied backgrounds and specialisations, both within certain discipline areas, but also to have a mix of those engineers with elite academic skills and those with more industrial focus. This can be achieved by diversity of engineering degrees and FE awards, and by effective degree apprenticeships. Degree apprenticeships are perhaps off to a shaky start, and the EPC is working with stakeholders to help ensure their success.

There are signs that not all degree courses are ideally suited to students from all academic backgrounds, and this might be expected, but it is important to consider that in some geographical areas of the UK, students at 18 may have very different (and in some cases limited) access to traditional A level academic backgrounds in subjects like Maths and Physics. As a sector, there is a need to consider more explicitly who has access to A levels, T levels, BTECs and apprenticeships. While some “conversion courses” offering degrees in engineering to other graduates exist, more of these are necessary.

The educational pipeline for engineers, and the success of UK engineering to industry is dependent on the UK’s cutting-edge science and engineering research track record. The commitment to increasing to a 2.4% spend of GDP on R&D is an important part of this, but it’s equally important to look at how some policies can produce multipliers on cash spend. For instance, the EPC’s own research⁴ estimates that access to the Horizon 2020 programme has multiplied the effect of EU-research income by 3.35. In a post-Brexit UK, it will be important to consider the net benefit we may have in access to such schemes in the future. Similar arguments can be made for the benefits of Erasmus+ which has aided student and staff mobility within the EU up to now.

Our future needs ingenious people to build it and safeguard it. We have those people, but we need more of them and we need them to come from all parts of our society.

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With colleagues at London Metropolitan University, Ian Haines established undergraduate and research collaborations with Shanghai University of Traditional Chinese Medicine which lead to the creation of a joint research facility on its new campus. He developed a longstanding joint undergraduate programme in computing with the Hong Kong Computer Institute (now the International Academy of Management).

As part of its intention to extend its international reach the Parliamentary and Scientific Committee met with a delegation from Gansu, China on 16 October 2019. The delegation included the Chen Bingdong, First Vice-President, Gansu Association for Science and Technology, Ma Zhongming, President of Gansu Academy of Agricultural Sciences and colleagues involved in agricultural science, environmental science, water conservation and forestry and international liaison as well as representation from Lanzhou University (with an interest in smart intelligent systems) and the Chinese Embassy. The meeting was hosted in Committee Room 14, in the Palace of Westminster, by Stephen Metcalfe MP, Chair of the Parliamentary & Scientific Committee and members of the P&SC Council.

Gansu Province is located in north-central China. It is a predominantly agricultural region but has a significant mining industry that includes a range of rare earth elements. Amongst several challenges it needs to develop forestry to protect soil and prevent soil erosion. The purpose of the visit was to engage with P&SC to discuss potential academic and other collaboration and exchange between Gansu and the UK.

The discussions evolved around three priority areas for collaboration and potential scientist exchanges:

- the need to increase agricultural productivity, including issues of water use and crop development for higher quality, greater yields, drought- and pest-resistance
- potential changes to future crops needing to be cultivated to account for climate change and the need for innovation in the development of ‘green agriculture’. The delegation emphasised that they regarded climate change as a global challenge and not one limited to Gansu or China
- development of intelligent agriculture, integrating AI and related technology to control the planting, cultivation and harvesting of crops.

It was agreed that as a follow up to the meeting P&SC would send further information on some UK organisations involved in aspects of agricultural science and associated technologies and funding opportunities for collaboration, between China and the UK.

Within a few weeks of the meeting the first opportunity arose to deliver on the agreement by sending
information on the Innovate UK competition for UK-China collaboration on ‘Precision for enhancing agricultural productivity’ (https://apply-for-innovation-funding.service.gov.uk/competition/482/overview).

The UK and Chinese Governments have agreed to each contribute £5 million to support this initiative. The intentions of the competition are to encourage the use of data-intensive methods for commercial farming. Bids were encouraged in areas such as monitoring, intelligent decision support leading to business-led outcomes in one or both of the autonomous technologies (sensors, systems, vehicles and robotics) and data-driven solutions to enhance productivity while reducing emissions.
ANDREW MILLER
1949-2019

Science has lost a great Parliamentary friend with the untimely death of the former Chair of the Parliamentary & Scientific Committee Andrew Miller who died on Christmas Eve 2019. He was 70.

A tribute from Dr Stephen Benn, Vice President

Andrew was involved in science ever since 1992 as MP for Ellesmere Port & Neston to which he was re-elected five times. His previous experience as an official in the Manufacturing, Science and Finance (MSF) trade union brought with it a predisposition to take an interest. He had earned a diploma in industrial relations from the London School of Economics and had worked as a laboratory technician at the then Portsmouth Polytechnic. Andrew had been born in Isleworth, west London and was educated in Malta (about whose politics he was always well informed) and later Hampshire.

Early in his Parliamentary career he took a keen interest in the development of the Parliamentary Office for Science and Technology (POST) and was a member of the Parliamentary Science and Technology Information Foundation which helped bring it into existence.

As with any MP Andrew also found himself involved with constituency issues. As a local MP he became embroiled in 1997 in a very famous and tragic case involving a young British woman who had been the carer of a baby in the USA and whose parents blamed her for the death of their child. He was an assiduous local MP and played a key role in helping to support, and bring closure, to his constituent.

He was active in many other areas too – he chaired the House of Commons Regulatory Reform Committee in the early 2000s and in 2007 he piloted the Private Members’ Bill that brought the Agency Workers Directive into UK law – but Andrew was always rightly proud that in 2010 he became the very first directly-elected Chair of the House of Commons Science and Technology Select Committee. It gave him an authority unmatched by his predecessors.

He also valued the opportunity that this gave him as a member of the Commons Liaison Committee so that he could (and did) raise science issues directly with the Prime Minister.

He set about making the Select Committee as active as possible and in combination with his Chairship of the P&SC this made Andrew the dominant voice of science in the 2010 Parliament.

There were times when the Select Committee under his guidance had to move very quickly indeed as, for example, when Pfizer gave no notice to Parliament of the closure of their important site in Sandwich. Andrew convened an emergency hearing and the Committee’s report discovered that the closure plans had been in the preparation for much longer than officially admitted.
As Chair of the Select Committee he ensured it benefitted from some very capable specialist assistants in the committee office. On one occasion he successfully used their expertise in the production of a very authoritative Select Committee report on rare earth metals.

He also nurtured and encouraged fellow Members with an interest in science and presided over a Select Committee that really made its mark in the 2010 Parliament (and has continued to do so since).

Andrew was a staunch supporter of all the major science events in the House. STEM for BRITAIN was a particular example. He worked tirelessly (as did his office) to make it the foremost example of bringing science research into the House where early career researchers presented their work and explained it to their local MP.

Voice of the Future was another. He once described it as “like no other event on the planet” and led his fellow MPs in answering Questions from young scientists and engineers.

He strongly supported Parliamentary Links Day where each year he took the lead in welcoming scientists and Parliamentarians to the House on the biggest single day for science in the Parliamentary calendar.

He presided over the P&SC’s 75th Anniversary in 2014 and welcomed the then Prime Minister Rt Hon David Cameron MP to the celebrations held in the House. He was also present at the special celebration held at Buckingham Palace hosted by HRH The Duke of Edinburgh (the longest member of the P&SC to this day).

Andrew was hard working and widely liked and admired throughout and on both sides of the House and was as familiar a face in the tearoom with fellow MPs as he was in the Stranger’s Bar with visiting scientists. His bonhomie was infectious and well-intended and as Chair of the P&SC he encouraged many interesting discussions at dinner after the formal meetings had concluded. He was always very proud of his family and sometimes referred to them in oral evidence sessions. He also took the lead in improving links with the science community in the USA.

He chose to retire from Parliament and as a result could return to visit it with his head held high – which he did from time to time. Standing down also enabled him to do other things that he had planned to do to help science – sadly not for as long as he had originally hoped.

On the 26 March 2015 – at a Parliamentary Farewell just before he left the House – no less than 20 science organisations gathered together to thank him for all his work on behalf of science.

He returned to the House in 2016 to receive a Lifetime Achievement Award for Outstanding Contribution to the Cause of Science and he was surrounded by all his many friends in the science community.

In the 2010 Parliament Andrew bestrode the House like a scientific colossus for he chaired the two major science committees (S&T Select Committee and P&SC) at one and the same time. He came to regard it as the happiest of the five Parliaments in which he served over 23 years.

He will be greatly missed and will always be remembered.
The Challenges and Opportunities for UK-Ireland Collaboration in Higher Education and Research Post-Brexit

Brexit has presented a number of challenges for the future relationships between the United Kingdom and the Republic of Ireland. The negotiations leading to the EU Withdrawal Agreement were difficult as both the UK and the EU sought to achieve their respective objectives while ensuring the avoidance of a hard border on the island of Ireland and the maintenance of the Good Friday Agreement. Post-Brexit there is an obligation on both the UK and Irish governments to find ways of supporting and reinforcing the natural and historic linkages between these islands for the benefit of the citizens of both nations. Nowhere is this more important, or more likely to yield synergistic results, than in the field of higher education (HE) and research. There are a wealth of opportunities to build upon and develop further the productive network of North-South and East-West collaborations that already exist within the island of Ireland and between Ireland and the UK. It is to be hoped that the development of this sector will be a strategic priority for the re-established Northern Ireland Executive and Assembly, and North-South Ministerial Council.

Notwithstanding the UK’s withdrawal from the EU, there is widespread support among the academic and research community in Northern Ireland (NI) for continued participation in future EU research framework programmes. EU funding schemes, both European Regional Development (Structural) Funds (ERDF) and Research Framework Funds, have been a significant source of funding for research and capacity building across all disciplines. This is particularly true for humanities and social sciences research which has played an essential role in promoting social and cultural development and understanding. It is to be hoped that any future UK funding arrangements should ensure investment across the spectrum of academic disciplines.

Opportunity and Need

There is both opportunity and need for a suite of programmes designed to support increased UK-Ireland collaboration. This includes regional specific initiatives to deal with Northern Ireland’s chronic underfunding of higher education (over £2,000 less per student fte relative to England) and the associated cap on student numbers. Science relies on the exchange of ideas and collaboration across borders. This is particularly relevant on the island of Ireland where joint research projects, collaborative degree programmes, cross-border businesses and organisations have grown and flourished within the relatively peaceful environment that has existed in recent years. It is important to reflect on this unique relationship, and to consider what future opportunities and challenges there are for scientific research and development.

High levels of North-South collaboration across all research disciplines are reported by Queen’s University Belfast and the University of Ulster. Similarly, Irish universities and institutes of technology report high levels of collaboration with researchers in Northern Ireland, England, Scotland and Wales.

- 63% of successful Northern Ireland’s projects to the EU’s Horizon 2020 research programme involve research partners in the Republic of Ireland.
- 79% of academics in an all-island survey by the Royal Irish Academy agreed that collaborations between Irish and UK higher education institutions are very important in their field of study.

Future UK funding arrangements should enable regional distribution of a significant proportion of research funding.
funding to help build specific North-South research collaborations and support the continued movement of researchers and students in both jurisdictions to access research infrastructure and skills training.

Measures to grow the pool of talented UK researchers should address regional challenges to retention as well as the attraction of international talent, including immigration measures. The proportion of researchers from outside the UK varies by region.

- 43% of Northern Ireland’s researchers are from outside the UK - the highest proportion across all UK regions 5.

The ability to attract international talent is therefore crucial to the future success of Northern Ireland research.

Retention, as well as attraction, of researchers is also a key challenge for the NI research system.

- One in six of Northern Ireland-born graduates of working age live in England and Wales, with more living in Scotland 6.
- Only a third of Northern Ireland graduates who studied in England, Scotland or Wales returned to NI to work in 2017 7.

There are emerging significant skills gaps across the region which pose challenges for R&D, innovation and industrial competitiveness. The 2018 Northern Ireland Skills Barometer published by the Department of the Economy suggested 87,000 new jobs would be created by 2026, of which around a third are expected to be filled by students and migrant workers. Retention of talent is therefore a key challenge for future research investment strategies for the region.

The delivery of a new framework for research funding across the UK should be informed by a clear understanding of the existing spatial and regional R&D investment baseline figures and a commitment to building regional capacity, addressing skills and enabling innovation. As outlined below, there is considerable disparity in regional investment in R&D with Northern Ireland operating below the UK average at present 8.

- While the UK spent £527 on R&D per capita in 2017, there were large differences between the nations. England spent £554 and Scotland £466. Northern Ireland spent £371 which is well below the UK average.
- Most of the UK R&D expenditure was carried out in England, at £30.8 billion (89%) in 2017. Scotland accounted for £2.5 billion (7%), while NI spent £744 million (2%) on performing R&D.
- The NI Department for the Economy (DfENI) investment in universities’ R&D in 2016 was £47 million, which is £25 per capita compared to the UK average of £31. The Scottish Funding Council invested £279 million in R&D which is £52 per capita, which is more than double the local per capita investment by DfENI, and well above the UK average.
- The level of investment by the Research Councils in NI in 2016 was £32 million which is £17 per capita in comparison to the UK average of £31.
- Conversely, the levels of ERDF funding between 2014-20, which is based on regional disadvantage, were £50.3 per capita in NI as compared to £24.3 for Scotland and £12.6 for England.

INWARD INVESTMENT AND INTERNATIONAL COLLABORATION

Within the UK and Ireland, higher education and research are essential factors in attracting inward investment and are a major contributor to export income through the recruitment of overseas students and international partnerships. At a regional level, universities are also engines of growth by supporting the rebalancing of the economy, by creating local jobs, by encouraging local innovation and by attracting investment and talent. Northern Ireland is particularly dependent upon the economic and social benefits of higher education as it attempts to transform its economy to develop a knowledge-based industrial sector and to encourage Foreign Direct Investment 9.

Beyond whatever agreements and funding arrangements the UK may reach relating to future participation in EU Research Framework programmes, its overall international research strategy should involve opportunities for collaborations with those countries with which it has an existing well-established and impactful scientific research history. As has been highlighted in the Smith and Reid (2019) 10 proposals for future international collaboration on research and innovation, existing bi-lateral relationships such as those that exist between national academies in Ireland and the UK offer an immediate mechanism through which to deliver scaled-up collaborative research funding schemes. Working in partnership with research funding agencies and government departments, the academies offer a well-established high prestige framework through which to support research in all disciplines.

PROPOSALS

The Royal Society and the Royal Irish Academy have jointly agreed a number of recommendations to strengthen research collaboration across the island of Ireland and between Ireland and the UK 11, including:

- Creating a bespoke suite of programmes including bilateral funding agreements to support North-South, East-West academic research mobility, innovation and skills/talent development and appropriate research infrastructure.
- Encouraging support for all-island bodies such as the Royal Irish Academy to create further opportunities for all-island and UK-Ireland dialogue, interchange and collaboration.
- Maintaining access to EU structural funding programmes (ERDF, ESF, PEACE and INTERREG) or their replacements and ensuring a strong focus on research and innovation, so that the economy of NI and the Border Region of Ireland can continue to grow and prosper. In the event of such funding no longer being provided through EU structures, it should be provided directly and ring-fenced by the UK government e.g via the Proposed UK Shared Prosperity Fund or equivalent.
- Exploring the possibility of developing and enhancing UK-Ireland bilateral research funding schemes with other countries, such as the expansion of the US-Ireland
Research and Development Programme to extend to additional thematic areas in science and engineering and to include the humanities and social sciences.

- Maintaining close collaboration and providing mechanisms for close cooperation with key European partners to continue the delivery of excellent research in Northern Ireland and the Irish Republic.
- Seeking the continuance of regulatory and standards equivalence with EU countries and promoting the continued recognition of professional qualifications between the UK and the remaining 27 EU member states.
- Promoting increased and coordinated investment in research and innovation, through government initiatives in Northern Ireland and the Irish Republic to support cross-border collaboration and innovation that will drive economic growth.

Specific required actions include:

- The development of joint North-South research centres, academic and research appointments and joint research studentships, to enhance the profile and international impact of HE and research across the island of Ireland.
- The development of regional research-enhancement funding by UK Research and Innovation to expand Northern Ireland’s research capability.
- Ring-fencing of the research component of the UK Shared Prosperity Fund and using it strategically to enhance research capability in the Northern Ireland HE sector.
- The development of all-island research-equivalent trade / study missions to build new overseas research capacity collaborations.

The recent proposal to develop a cross-border university based on existing university and institute of technology campuses in the North-West is a potentially innovative development. Such an institution could have significant advantages in terms of accessing both EU and UK research funds. Provided other major infrastructural shortcomings for the region were addressed, a new multi-campus university could provide the knowledge and skills base and platform for a North-West (North Atlantic) Ireland/Northern Ireland economic corridor to offset the infrastructural deficit in that region which has had limited investment from the various governments (Irish and NI/UK) 12.

THE SHARED GOAL?

Brexit imposes a number of challenges for future collaboration in higher education and research between Northern Ireland and the Republic of Ireland and between Ireland and the UK. However, if addressed strategically and innovatively these challenges can lead to synergistic and mutually beneficial economic and cultural outcomes and enhance the historic ties between the British and Irish nations.

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DIFFICULT COMPROMISES ON THE ROUTE TO ZERO CARBON FOR ELECTRICITY AND TRANSPORT

The world is faced with several problems that are going to have to be addressed by systems engineers and scientists working with politicians. The greatest of these is the urgent need to reduce the carbon emitted by human activities to a level that will prevent unacceptable global warming. This is proving extremely challenging and many difficult compromises will have to be made before we reach zero carbon.

The first is to accept approximations for what is happening. The modelling of how human behaviour is changing weather systems is even more difficult than modelling weather itself, and while there have been great advances in weather forecasting, accurate long-range forecasts are still beyond our capability. The problem must be tackled by what is called chaos theory. Chaos theory is a scientific theory describing erratic behaviour in certain nonlinear dynamical systems. It shows how small perturbations can result ultimately in immense phenomena and has been applied successfully to the modelling of weather. In the case of forecasting, however, many of the data sets needed to tackle the problem are incomplete, or insufficiently precise because of the limited number of sensors that can be placed in the atmosphere. The problem is also so large that precise solutions are beyond the capability of even the largest supercomputers. As a result, engineers and scientists trying to find ways to avoid global warming must work, as is often the case for engineers, where they don’t have the data or the techniques to fully understand what they are trying to do. They have no option but to compromise and live with approximations.

In this case the consequences of failing to act rapidly are so dangerous that there is no question of waiting until we really understand this complex problem. Snow and ice cover are clearly decreasing and as they do so the ground absorbs more heat and warming accelerates. Climate scientists have done their best to come up with accurate estimates of the temperature rise that are acceptable and these have to be used as a starting point. Some of the consequences of their predictions have proved optimistic and others pessimistic but in order to get on with it we need to address the worst cases and to act as quickly and strongly as social, financial, and engineering circumstances allow.

The UK has set the target of zero carbon by 2050 that should, if matched by others around the world, allow us to stay below the maximum acceptable temperature increase set by the climate scientists. Some countries have set more aggressive targets but others, including some of the largest, are yet to set any aggressive targets. Overall it has become clear that we need not only to reach the 2050 target but to minimize the total CO₂ in getting there and preferably reduce the emissions as early as possible.

There are many ways of meeting our targets. In this article I am addressing some of the key issues relating to the elimination of carbon from our power stations and our transport systems with a brief mention of heating. I will not be considering alternative fuels for internal combustion engines such as hydrogen although they may well prove valuable in lowering carbon emissions. I will not discuss the removal of carbon by planting trees or adopting the recommendation of the Intergovernmental Panel on Climate Change (IPCC) of conserving and creating areas of peatland, which are the largest
natural terrestrial carbon store and can trap carbon for centuries.

I will also not discuss the contribution of aviation to anthropogenic climate change although the IPCC has estimated that this is 3.5%. Electric powered commercial flight seems far away although there is some hope that hybrid powering of aircraft might be helpful in reducing the carbon per passenger mile, which is estimated to be higher than other forms of transport. Fossil fuels would have to be used for take-off but electric power might be able to contribute during cruising.

Despite all the unknowns there does appear to be general agreement that, ultimately, we should use electricity for most of our energy needs. The major exception is heating, which consumes about 25% of our energy, but even here one might consider using electric heat, but this would be expensive and place huge demands on generation. In the meantime, we will have to rely on heat pumps, improving the insulation of our building stock, wearing warmer clothes and perhaps building more district heating systems that use waste heat from industry and from power stations, especially from nuclear plants.

However, wherever we use electricity it will have to be carbon free before the electrification strategy is effective. This is most obvious in the case of electric vehicles. While electricity is still generated from fossil fuels, and power plants continue to emit CO\(_2\), the use of electric road vehicles will not eliminate carbon. It may be useful in cleaning the air in cities like London, but it only changes the place where the carbon is emitted. It may even be better to compromise and continue to use some of the most efficient combustion engine vehicles while we work towards zero carbon electricity. This is because a large fraction of the energy from fossil fuel power plants is lost before it ever reaches the wheels of electric vehicles.

In most fossil fuel electrical power stations chemical energy stored in natural gas is converted successively into thermal energy, mechanical energy and, finally, electrical energy. About 50% of the energy in the gas emerges as electricity. This electricity then must be distributed over the grid to the user with a further loss of 10%-15%. It is finally converted back into mechanical energy in the vehicles. Ironically, it is more efficient to put the fossil fuel in the vehicle where it can be converted in one step to mechanical energy, even though the most efficient combustion engines only have a thermal energy efficiency of about 40%.

This is especially the case with road vehicles where at present there is no way to deliver the electricity directly to them while they are moving, as it can be with trains. The electricity has first to be stored in a battery and then converted back to mechanical energy. This introduces further energy losses of about 20% in the charging system and the battery. There is also the issue of the carbon produced in manufacturing lithium batteries, which, if fossil fuel derived electricity is used in their manufacture, can be as large as that emitted by a fossil fuel car in its first 70,000 miles.

There is the benefit with electric vehicles that energy can be recovered while braking but this gain is unlikely to make up for the losses incurred in the generation, distribution and storage of electricity. Non-plugin hybrid cars make little or no contribution to reducing carbon as all the energy they use is derived from fossil fuel. However, because drivers of hybrid cars are conscious of the need to conserve energy, they are likely to drive without accelerating hard, and at reasonable speed, and probably produce less carbon than other drivers. This is a good example of how human behaviour is also going to be important in reaching our carbon goals.

In conclusion, despite the reductions in carbon we have made with renewables and nuclear, we will have to go further towards carbon free electricity before we can reach zero carbon with electric vehicles. It is no good looking at vehicles alone. The entire energy system comprising generation, delivery and use, and the manufacture of batteries, must be considered and optimized.

Another difficult compromise in trying to reduce carbon as quickly as possible arose when it was realised a few years ago that nitrous oxides were more dangerous to health than had previously been thought. This realization turned upside down the strategy of European vehicle manufacturers. Their strategy had been to place highest priority on reducing carbon emission and optimizing fuel consumption by switching to diesel engines, rather than on health. Diesel engines are inherently more efficient than conventional petrol engines because of the nature and temperature of their combustion process. Engine manufacturers had eliminated particulates and many polluting gases from diesel exhaust, but more nitrous oxides remain than in the exhaust of petrol engines. The consequence has been that the most efficient and lowest carbon fossil fuel combustion engines are now being outlawed making it even more difficult to reduce the carbon from fossil fuel cars. This emphasizes once again that we must decarbonize electricity generation as rapidly as possible to make electric propulsion zero carbon.

We can eliminate CO\(_2\) in the generation of electricity by using a combination of low carbon intermittent wind and solar sources with constant sources such as nuclear reactors or hydro-electric-power. Alternatively, we can store excess power from renewables so that it can be used, for example, when the wind is not blowing and there is no sunshine. However, this will require storage of hundreds of gigawatt-hours, which can only be approached with immense hydro-electric schemes that are rarely possible. Other means of storage are under development but will struggle to become practicable on the time scale required.

Batteries are going to be useful for short term rapid balancing on the grid but will be too expensive for long term national scale storage. It has been suggested that the batteries in cars could be used to backup renewables, but this would require everyone being prepared to randomly give up use of their cars and leave them connected to the grid. Maybe politicians can persuade people to do this, but it is going to be a challenge.

There is also the possibility of capturing the CO\(_2\) in the power station and sequestering it away under the ground, perhaps using the facilities used now for extracting fuel. It is proposed that this carbon capture and storage (CCS) can be used at national supply levels but attempts to store these massive quantities of CO\(_2\) are yet to be commercially viable. CCS is actively being developed, however, and hopefully will become available in the next...
couple of decades and allow us to continue to use fossil fuel powered power stations.

Failing the development of viable CCS, or large-scale storage, the only alternative for backing up renewable generators on a predictable timescale, is nuclear power. Fortunately, this has been realised by recent UK governments, although it is unclear that we are proceeding fast enough to have enough nuclear power in place to meet the 2050 target. Replacing and expanding our nuclear capability appears at first to be another difficult compromise because initially nuclear is going to be expensive. On re-examining this problem, however, it appears that, as with other forms of energy, there are ways of reducing the cost of nuclear.

For example, recent cost comparisons made between renewables and nuclear need reviewing. The present cost of nuclear has been elevated by extremely high borrowing costs (9%). This has led to the extraordinary fact that the financing cost of the Hinkley Point European Pressurized Reactors, EPRs, is well over 50% of their total cost. The high finance cost was evidently justified because no-one had succeeded in building the EPR reactors when the project was started, and people questioned the validity of their design. EPRs were being built in France and Finland but were yet to be completed and were over budget and years late. Regrettably this situation remains. The risk that they might not be successful was therefore relatively high. In the meantime, however, China General Nuclear completed two EPRs in Taishan, about 100 miles west of Hong Kong, and these reactors are each delivering power up to 1.66GW to the grid in China. The technical risk that EPRs might not work has therefore been removed and borrowing costs like those available to investment grade projects, about 4%, should be used for future reactors. It has also been estimated that building replicas of the first systems will further reduce cost. So far in the UK we have never built a replica of a nuclear reactor. Every new reactor has been different.

The opposite situation exists with wind power. It may be that the cost of implementing offshore wind power is being under-estimated because the high cost of connecting the thousands of wind turbines needed, for example to provide the same power as Hinkley Point, to the grid has not been taken fully into account. This could add 25% to the costs presently used for offshore wind. Another factor is lifetime. The wind energy industry and the Government base their calculations on wind turbines having a lifespan of 20 to 25 years. This is to be compared for example with the case of a new nuclear plant like Sizewell C where it has been said, “it could last for 60 years.”

Small and Modular nuclear reactors also offer the opportunity for lower costs and UK governments have been assessing their feasibility for many years. Fortunately, after endless delays, £18 million was committed last July to support a consortium led by Rolls Royce that is proposing to build SMRs with an output of 220 MW - 440 MW. These SMRs can be built with prefabricated components in a factory using robotic assembly. The reactor vessel can be shipped on a truck and the whole power station located on a site that is just one-tenth the size of large-scale reactor sites. The consortium says their SMR will cost £1.75 Bn and could be delivering power to the grid in 2029. It will last for 60 years and will supply electricity at a cost of less than £60 per 100 kWhr. The government support is very welcome although it probably does not even cover the costs already expended by the consortium. This is an exciting project that could not only help the UK reach its 2050 target but become a major source of export revenues. Several foreign governments have already written letters of intent to Rolls Royce.

When all of these factors have been taken into account, the costs of renewable and nuclear energy may be about the same, but even if they are not, we will still need nuclear to back up the intermittent renewables and keep the lights on when there is no wind or sunshine.

The UK has been relatively successful in decarbonizing its electricity supply and we are above average in terms of the actions we are taking to curb climate change. None the less we must ensure that our energy and transport strategies make numerical as well as political sense and this will involve our expert systems engineers and climate scientists working closely with government and civil service officials. One way this has been successfully achieved in the past is by harnessing the knowledge of the fellows of the Royal Academy of Engineering and the Royal Society. They should be consulted more often, and we should not continue developing strategies under wraps and treating them as being politically sensitive. The Royal Academy of Engineering has in fact scrutinized the costing of the RR Consortium SMRs.

There is a National Grid website that I recommend to readers who are interested in following the UK’s progress in decarbonizing electricity. It shows the current and historical percentages of electricity power types delivered on the UK grid http://grid.iamkate.com. You will see on this site that in 2019 the fraction of power generated by wind and solar and hydroelectric increased to 23% and nuclear was maintained at 20%, giving a total of 43% overall for very low carbon generation. This is encouraging and shows that we are on the way to realising our goal of using renewables in combination with nuclear to decarbonize our electricity.

However, there were weekly averages in 2019 where the power from wind and solar fell to below 2 GW, or a fifth of the maximum of about 10 GW when they were operating close to their nominal capacity. This suggests that a backup capability of about 80% of the maximum renewable generation will be needed. I have been unable to find an estimate of what is being assumed for the balance between nuclear and wind and solar, but for a total capability of 50 GW, it would seem to have to fall between 250GW of renewables and zero nuclear, and zero renewables and 50GW of nuclear. Perhaps 100 GW renewables and 30 GW nuclear, or 50GW renewables and 40GW nuclear would seem reasonable. Whatever is decided, a great deal of new capacity will have to be built and the complexity, cost and reliability of the grid that must deal rapidly with the endlessly varying output of the renewables is going to be a major challenge.

The most straightforward and least complicated alternative would be use 100% nuclear, but this would initially be difficult to finance and in any case is politically impossible. When thinking about this, it is interesting to note that some of the plans being made by the...
Chinese to reduce carbon include the building of 550GW of nuclear capacity, enough to supply ten times the UK’s gross electricity needs.

Another unknown is the increase in total capability needed when all our road transport is electric. We have only just started to build the charging network that will be needed and there is little detailed information about the cost and timescale for this immense project. The network will have to have far more charging points than there are petrol and diesel nozzles and be more distributed than the network of petrol stations, because it takes at least 50 times longer to deliver energy to an electric car. A diesel nozzle delivers energy at an equivalent rate of 25 megawatts compared to the largest car charging points today that are only approaching 0.25 megawatt. Most points supply between 0.005 megawatts and 0.025 megawatts. It will take hours rather than minutes to fully charge a vehicle. Partial charging will of course be faster, but there will have to be charging points in homes and work locations and anywhere else that cars will be left for a significant time. At the end of 2019 there were about 30,000 points in the UK and approaching 40 million vehicles. There is much to be done and more difficult compromises to be made before we reach our target of zero carbon in 2050, but the government seems to have the right approach in placing highest priority on renewables and nuclear, while continuing to maintain some support for the other options for generation and storage. However, the building of new nuclear will have to be accelerated if we are to succeed.

At least we are now seriously addressing climate change and are above average in setting an example to others of how progress can be made.

Finally, there is another website that is valuable in allowing us to see how the UK is performing relative to other countries. https://www.electricitymap.org/?page=map&solar=false&remote=true&wind=false

It is a world map showing in colour the real time carbon intensity of electricity generation in different countries. The map remains incomplete, but you will see, for example, that the UK is ahead of Germany, the Netherlands and Poland but cannot compete with France, where there is a large fraction of nuclear, or Scandinavia and Iceland where fossil fuels plants have been replaced by hydroelectric and geothermal energy.

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

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E-mail: florence.bullough@geolsoc.org.uk
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The Geological Society is the national learned and professional body for Earth sciences, with 12,000 Fellows (members) worldwide. The Fellowship encompasses those working in industry, academia and government, with a wide range of perspectives and views on policy-relevant science, and the Society is a leading communicator of this science to government bodies and other non-technical audiences.

Contact: Lynda Rigby, Executive Head of Marketing and Membership
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Tel: 020 7713 0214
Email: mci@ibsms.org
Twitter: @IBMSScience
Website: www.ibms.org
Advancing knowledge and setting standards in biomedical science
With over 20,000 members in 61 countries, the Institute of Biomedical Science (IBMS) is the leading professional body for scientists, support staff and students in the field of biomedical science. Since 1912 we have been dedicated to the promotion, development and delivery of excellence in biomedical science within all aspects of healthcare, and to providing the highest standards of service to patients and the public. By supporting our members in their practice, we set quality standards for the profession through training, education, assessments, examinations and continuous professional development.
The Institute of Materials Finishing

Contact: Delia Mertoiu
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We are the UK’s leading professional body for those involved in all aspects of food science and technology. We are an internationally respected independent membership body, supporting food professionals through knowledge sharing and professional recognition.

Our core aim is the advancement of food science and technology based on impartial science and knowledge sharing.

Our membership comprises individuals from a wide range of backgrounds, from students to experts, working across a wide range of disciplines within the sector.

Institute of Innovation & Knowledge Exchange

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

Institute of Measurement and Control

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Reg Charity number: 269815

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

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

Institute of Chemical Engineers

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

The Institution of Chemical Engineers

The Institution of Chemical Engineers (IChemE) advances chemical engineering’s contribution worldwide for the benefit of society. We support the development of chemical engineering professionals and provide connections to a powerful network of around 35,000 members in 100 countries.

We support our members in applying their expertise and experience to make an influential contribution to solving major global challenges, and are the only organisation to award Chartered Chemical Engineer status and Professional Process Safety Engineer registration.

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The IChemE is a world leading professional organisation, sharing and advancing knowledge to promote science, engineering and technology across the world. Dating back to 1871, the IChemE has over 163,000 members in 127 countries with offices in Europe, North America, and Asia-Pacific.

IOP Institute of Physics

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The Institute of Physics (IOP) is the professional body and learned society for physics in the UK and Ireland. The IOP’s mission is to raise public awareness and understanding of physics, inspire people to develop their knowledge, understanding and enjoyment of physics and support the development of a diverse and inclusive physics community. As a charity, the IOP seeks to ensure that physics delivers on its exceptional potential to benefit society.

Institute of Marine Engineering, Science and Technology (IMarEST)

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

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The IET is a world leading professional organisation, sharing and advancing knowledge to promote science, engineering and technology across the world. Dating back to 1871, the IET has over 163,000 members in 127 countries with offices in Europe, North America, and Asia-Pacific.
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LGC is a global leader in the life sciences tools sector, including human healthcare and applied markets (food, agbio, and the environment). LGC provides a comprehensive range of measurement tools, proficiency testing schemes, supply chain assurance standards and specialty genomics tools (oligos, PCR tools, NGS reagents), underpinned by leading analytical and measurement science capabilities. Under the Government Chemist function, LGC fulfils specific statutory duties as the referee analyst and provides advice for Government and the wider analytical community on the implications of analytical measurement for matters of policy, standards and regulation. LGC is also the UK’s National Measurement Laboratory for chemical and bio-measurement. With headquarters in Teddington, South West London, LGC has laboratories and sites across Europe, the US, China, Brazil, India, and South Africa.

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L’Oréal employs more than 3,800 researchers world-wide and dedicates over €877 million each year to research and innovation in the field of healthy skin and hair. The company supports women in science research through the L’Oréal UNESCO For Women In Science Programme and engages young people with science through the L’Oréal Young Scientist Centre at the Royal Institution. L’Oréal also collaborates with a vast number of institutions in the UK and globally.

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The MBA represents its members in providing a voice on the implications of analytical measurement to the environment on which it depends, and to maximise benefits to society. An expert provider of advice for the benefit of policy makers and wider society.

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The Institution provides politicians and civil servants with information, expertise and advice on a diverse range of subjects, focusing on manufacturing, energy, environment, transport and education policy. We regularly publish policy statements and host political briefings and policy events to establish a working relationship between the engineering profession and parliament.

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

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

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

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

The London School of Hygiene & Tropical Medicine
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The London School of Hygiene & Tropical Medicine (LSHTM) is a world-leading centre for research and postgraduate education in public and global health. LSHTM was built on world-class environmental science. Around the world, we build capacity overseas in 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.

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.

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

A Forum for Natural History

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LGC is a global leader in the life sciences tools sector, including human healthcare and applied markets (food, agbio, and the environment). LGC provides a comprehensive range of measurement tools, proficiency testing schemes, supply chain assurance standards and specialty genomics tools (oligos, PCR tools, NGS reagents), underpinned by leading analytical and measurement science capabilities. Under the Government Chemist function, LGC fulfils specific statutory duties as the referee analyst and provides advice for Government and the wider analytical community on the implications of analytical measurement for matters of policy, standards and regulation. LGC is also the UK’s National Measurement Laboratory for chemical and bio-measurement. With headquarters in Teddington, South West London, LGC has laboratories and sites across Europe, the US, China, Brazil, India, and South Africa.

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

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The Institution provides politicians and civil servants with information, expertise and advice on a diverse range of subjects, focusing on manufacturing, energy, environment, transport and education policy. We regularly publish policy statements and host political briefings and policy events to establish a working relationship between the engineering profession and parliament.

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A Forum for Natural History
We inspire people to engage with science to solve major resource scarcity.

We help enable food security, eradicate disease and manage change of our planet, life on it and can predict the impact of future change. We tackle the biggest challenges facing the world today.

We use our unique collection and unrivalled expertise to – its past, present and future – to understand and share the world’s scientific knowledge.

We work with government, business, civil society and the public to bring about positive change.

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Natural History Museum

Head of Science Policy and Communication

Contact: John Jackson

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.

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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.

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

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

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Northampton is a member.

We bring together scientists from over 60 countries, and anyone with a genuine interest in the science of human or animal nutrition can become a member.

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

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

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The Royal Society is the academy of science in the UK and the Commonwealth comprising 1400 outstanding individuals representing the sciences, engineering and medicine. The Society has played a part in some of the most fundamental, significant and life-changing discoveries in scientific history and Royal Society scientists continue to make outstanding contributions to science across the wide breadth of research areas. Through its Fellowship and permanent staff, it seeks to ensure that its contribution to shaping the future of science in the UK and beyond has a deep and enduring impact, supporting excellence in science and encouraging the development and use of science for the benefit of humanity.

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The Royal Society of Chemistry is the world’s leading chemistry community, advancing excellence in the chemical sciences. With over 50,000 members and a knowledge business that spans the globe, we are the UK’s professional body for chemical scientists; a not-for-profit organisation with 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

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SFAM utilises the expertise of its international membership to advance, for the benefit of the public, the application of microbiology to the environment, human and animal health, agriculture, and industry. Our values include equality, diversity and inclusivity; collaboration to amplify impact; scientific integrity; evidence-based decision-making and political neutrality. With Wiley-Blackwell, SFAM publishes five internationally acclaimed journals.

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Advancing the science of cosmetics is the primary objective of the SCS. Cosmetic science covers a wide range of disciplines from organic and physical chemistry to biology and photo-biology, dermatology, microbiology, physical sciences and psychology. Members are scientists and the SCS helps them progress their careers and the science of cosmetics ethically and responsibly. Services include publications, educational courses and scientific meetings.

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

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

The Welding Institute is the leading institution providing engineering solutions and knowledge transfer in all aspects of manufacturing, fabrication and whole-life integrity management. We aim to achieve a broad understanding of the humane use of animals in medical, veterinary, scientific and environmental research in the UK. We work closely with policymakers to ensure regulation is effective and are a trusted source of information for the national and international media. We are funded by our members who include universities, professional societies, trade unions, industry and charities.

Established in 1964, the University of Essex is ranked as one of the Top 20 universities in the Research Excellence Framework and is awarded Gold in the Teaching Excellence Framework. It is home to world-leading expertise in analytics and data science, with research peaks spanning the social sciences, sciences, and humanities. Pioneers of quantitative methods and artificial intelligence techniques, Essex is also in the UK top 10 for Knowledge Transfer Partnerships, and works with businesses to embed innovation into operations, through KTPs, knowledge exchange and contract research.
Please register online: www.eventbrite.co.uk/e/91301608569

The launch of Public Health Scotland in April represents a huge shift in Scotland’s approach to public health. This panel discussion at the Scottish Parliament will look to ensure we harness the opportunities for Public Health Scotland.

THE PHYSIOLOGICAL SOCIETY

Tuesday 31 March 2020

Improving Health and Wellbeing:
Opportunities for Public Health Scotland

The Royal Society of Edinburgh and The Physiological Society are jointly holding a Parliamentary Discussion and Reception, hosted by Lewis Macdonald MSP, Convener of the Scottish Parliament Health and Sport Committee, on 31 March 2020 from 5:30pm.

The launch of Public Health Scotland in April represents a huge shift in Scotland’s approach to public health. This panel discussion at the Scottish Parliament will look to ensure we harness the opportunity of this new body, and also that public health guidance is informed by the latest research.

Please register online: www.eventbrite.co.uk/e/91301608569
This year we are celebrating 10 years since the formation of the Royal Society of Biology. The Royal Society of Biology was granted its Royal Charter in 1859, and 40 years since the then Institute of Biology in its current form, and 40 years since the Royal Society of Biology in its current form, and 40 years since the formation of the Royal Society of Biology in its current form.

We're celebrating this milestone year by honouring Sir David Attenborough with a Lifetime Achievement Award and welcoming Nobel Laureate Sir Paul Nurse, Rt Hon Greg Clark MP and Stephen Metcalfe MP at our upcoming Anniversary Gala dinner, to help celebrate this.

Our vision is of a world that understands the true value of biology, and how it can contribute to improving life for all and solve some of society's global challenges.

We're also pleased to announce our Anniversary Gala dinner, which will be held on [date]. The Gala dinner will feature guest speakers and a gala dinner, with proceeds going to support the RSB's work.

Find out more about our anniversary celebrations online at anniversary.rsb.org.uk.