The Journal of the Parliamentary and Scientific Committee – All-Party Parliamentary Group

SCIENCE IN PARLIAMENT
sip
SUMMER 2020

RISING TO THE CHALLENGE – THE CRICK AND CORONAVIRUS

Some members of The Francis Crick Institute's team, who are working on its PCR testing facility

STEM for BRITAIN 2021 is scheduled to take place in the Houses of Parliament on Monday 8th March, during British Science Week

Applications are invited from Monday 14th September 2020 from early-career research scientists, engineers, technologists and mathematicians who wish to exhibit posters in one of the following five areas:

- Biological and Biomedical Sciences
- Chemistry
- Engineering
- Mathematical Sciences
- Physics

The closing date for applications is Monday 7th December.

A wide range of important scientific, engineering and mathematics institutions and organisations are lending their support to this event, including the Royal Society of Biology, The Physiological Society, the Royal Society of Chemistry, the Royal Academy of Engineering, the Council for the Mathematical Sciences, the Institute of Biomedical Science, the Clay Mathematics Institute, the Nutrition Society, the Heilbronn Institute, the Institute of Physics, Warwick Manufacturing Group, United Kingdom Research and Innovation, Dyson Ltd, Biotherapy Services Ltd, IEEE Communications Society, the Biochemical Society, and the Society of Chemical Industry.

This reflects the importance we all attach to the encouragement of researchers at this stage in their careers.

Prizes will be awarded for the posters presented in each discipline which best communicate high level science, engineering or mathematics to a lay audience.

The Westminster Medal for the overall winner will be awarded in memory of the late Dr Eric Wharton, who did so much to establish SET for Britain as a regular event in the Parliamentary calendar.

From 14th September full details of the competition and exhibition including the application form can be found on the STEM for Britain website at: www.stemforbritain.org.uk

Stephen Metcalfe MP
Chairman, Parliamentary & Scientific Committee (All-Party Parliamentary Group)

Welcome to Summer 2020 edition of Science in Parliament.

A very warm welcome to this latest issue of our quarterly journal.

The COVID-19 Pandemic resulted in the postponement of the P&SC's Discussion Meetings in the Houses of Parliament which were due to be held in March, May and June 2020.

Our first virtual meeting was held on Monday 29th June, on the topic of: 'Covid-19: The Science and the Statistics Behind Them'.

Attendance was 140, which is double the average number present for our meetings at the Palace of Westminster.

We will be continuing with our virtual meetings for the time being and plan to organise a number of Zooms each year, even after 'normal service' is resumed at Westminster!

The Programme Committee has maintained the same number of meetings as originally planned for 2020, and you will see the updated list in the Diary.

Our 2021 Programme is being arranged under the chairmanship of my colleague Carol Monaghan MP, and we will carry the full schedule for next year's discussions and events in the Autumn issue of the magazine.

We plan to broaden the membership of P&SC by introducing an additional individual category focused on academics, including early career researchers, and STEM professionals, across the UK, who would essentially prefer to follow, and participate in, our work online.

We have a 'bumper' issue for Parliamentarians and members, and I want to thank the writers of the thirteen fascinating articles submitted to the Editor, as well as the usual excellent updates from the Parliamentary Office of Science Technology and the House of Commons library, and a summary of current Select Committee Inquiries.

You will not be surprised to learn that the majority of these excellent contributions deal with a variety of issues relating to Covid-19, coupled with articles on smart energy, research data stewardship and UK R&D investment.

I am very sorry to report the passing of two long-standing members of the Committee, Edward Stansfield and Lord Rea. We thank them for their outstanding support and send our condolences to their families.

The Earl of Selborne, stepped down from the House of Lords in the Spring. I would like to thank John for his wonderfully distinguished service to the cause of science at Westminster, and particularly for all his work as President of the Parliamentary & Scientific Committee.

We wish John all the very best for the future.

Finally, I should like to extend a very warm welcome to five new members of P&SC: Liverpool Hope University, Manchester Metropolitan University, the University of Leeds, the University of Plymouth, and the Knowledge Transfer Network (KTN) each of whom joined us in recent weeks.

Wishing you a safe and enjoyable, if slightly different, Summer than the ones to which we have found familiar.

SCIENCE IN PARLIAMENT
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The Journal of the Parliamentary and Scientific Committee (All-Party Parliamentary Group).

Science in Parliament has two main objectives:

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

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The Journal of the Parliamentary and Scientific Committee (All-Party Parliamentary Group).

PUBLIC SECTOR RISK EQUITY CAPITAL TO KICK-START SCIENTIFIC VENTURES

Ian Taylor MBE was an MP 1987-2010 and Conservative Minister for Science 1994-97. He chaired the Parliamentary & Scientific Committee 2007-10. He now advises companies on S&T issues. https://ukinnovationscience seedfund.co.uk/

"Public Sector Research Establishments provide untapped potential"
Sir Patrick Vallance, CaSE lecture, January 2020

This is a decade when overall UK R&D investment could increase by almost 50%. In the 2020 budget, the Chancellor announced that public R&D investment will increase to £22 billion per year by 2024-25, as part of reaching a target of 2.4% of GDP being spent on R&D by 2027. Cross-Party political consensus on this is high, with the COVID-19 pandemic highlighting the importance of science and spurring long-term support for R&D.

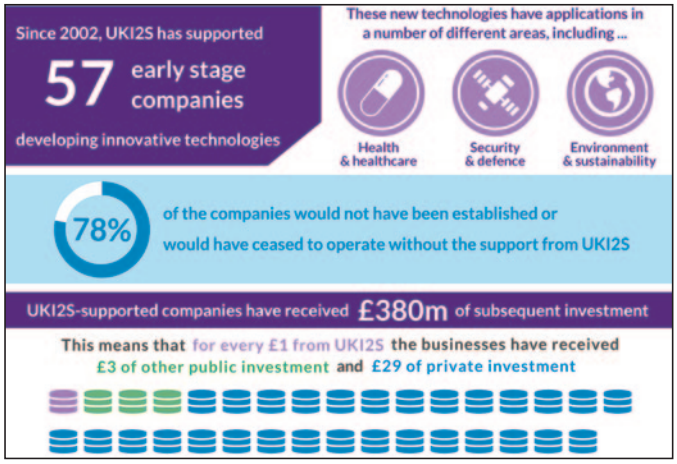
The science community has welcomed the positive signals, not least as they come against a worrying economic backdrop. In recent weeks, there have been a flurry of upbeat announcements. Support for university research; a Road Map towards the UK being 'a science superpower'; intent to unlock and embrace talent, diversity, resilience and adaptability, and to tackle our biggest challenges. Nevertheless there remain uncertainties caused by the difficult state of university finances, the relative newness of UK Research & Innovation (UKRI) as a central body delivering the majority of public funding for research and innovation, the probable loss of Horizon Europe collaboration (even if some equivalent funding is promised), an emerging crisis in charitable funding for medical research, and the potential emergence of the "ARPA" initiative, all complicating factors. Government Budget increases are welcome, yet there needs to be careful analysis as to how they are allocated and prioritised.

It has been the ambition of successive Governments, at least since my time as Minister for Science, to drive up the UK's mid-league table level of spending on R&D. The admirable challenge of reaching the target of 2.4% from the current level of 1.7% is still considerable (even whilst GDP is temporarily shrinking). This is not least because Government R&D expenditure remains stubbornly well behind the quantum of private sector investment, the level of which is itself in the current climate difficult to predict. Public funding for R&D was £9.6 billion in 2018, 26% of the total and, notwithstanding the recent announcement of a 19% increase in BEIS' research budget, across Government as a whole R&D budget growth is still sluggish.

Two things look unlikely to change, though. First, that Governments should continue to lead in the funding of basic science, on the assumption that there will be translation of the outcomes into economic/social benefit, with industry leading the way on applied R&D.

Secondly, the belief that effective translation and exploitation of this investment is essential and can lead to a transformation of our productivity, the shape of our economy and our well-being.

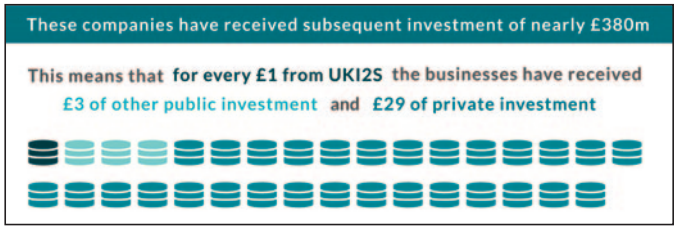
But delivering on this translation is not straightforward. Government has a difficult but key role to play in identifying and supporting those approaches that work best. Coming back to Sir Patrick's quote at the top of this piece, one benefit UK science possesses is the existence of our excellent Public Sector Research Establishments (PSREs), owned and run by public bodies such as UKRI (via STFC, BBSRC, NERC), Dstl, NPL, UKAEA and others. These combine a range of in-house research programmes, alliances with UK and international universities and



other bodies such as CERN & ITER and, increasingly, a role as economic forces in a manner that is often overlooked. There was an important recent pledge in the R&D Road Map to consider opportunities in PSREs and other publicly funded research institutes, including establishing how government can best drive innovation through these organisations.

company's life, often as founders and well before private investors usually become interested. To date the Fund has invested in 65 companies and is, I believe, clear evidence of how public funds, sensibly managed, can deliver high levels of economic return within a sustainable financial model.

One focus for UKI2S is Synthetic Biology, identified as a



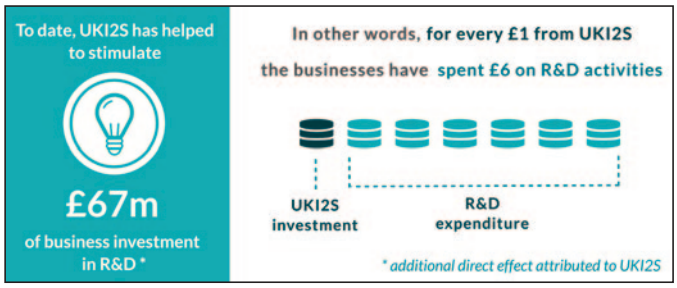
I contend that the PSREs should be a focus of greater support and attention. STFC & BBSRC, for example, have established science and technology excellence around their world leading centres, attracting high-tech companies to locate at Harwell and Babraham and, importantly, sites such as Daresbury in the North West and Norwich Research Park, both cornerstones of their local economies. Their own laboratories produce start-up companies with breakthrough technologies that compare very favourably with University spin-outs. These innovative companies are an opportunity to capture value from the public investment in science funding, to create jobs and economic growth, and we should take the opportunity to build on this with more public sector funding.

Fortunately, there is an existing and proven vehicle for public investment in the companies emerging from the labs and campuses of the PSREs. The **UK Innovation and Science Seed Fund** (UKI2S), for which I chair the advisory board, has partnered with the leading PSREs on this unique investment mandate since its creation in 2002. The Fund invests in the earliest and riskiest stages of a technology

crucial area applicable to a wide range of industries. In healthcare, SynBio has the capability to create curative, rather than palliative, therapies so we have invested in cell & gene therapy companies such as Quethera, a company with a potential breakthrough treatment for glaucoma that is now being taken to market by Astellas of Japan. In agriculture, we were an early backer of Norwich Research Park's Tropic Biosciences which has just raised £23m to use their gene-editing technology to develop bananas capable of resisting the devastating Panama fungus.

Portfolio companies have also turned their capabilities to the fight against COVID-19. Ag Plus Diagnostics and its electrochemistry technology is based on National Physical Laboratory's patented measurement invention in 2009. AgPlus has completed successful initial feasibility of a rapid IgG COVID-19 test with specificity > 98% and sensitivity > 92%. The test can be utilised in all medical settings and give results in less than 15 minutes. This adds value by establishing those that have already been exposed to virus and those that are still susceptible. The test is quasi-quantitative and can therefore help determine patients with low immune response to virus. AgPlus has been awarded 2 grants to support the COVID-19 work and are also developing a quantitative viral assay to support the test, track and trace initiative. This will allow targeted isolation and help prevent viral spread. In addition, there are two UKI2S portfolio companies collaborating under an Innovate UK-funded programme to improve the swab testing for COVID-19.

On the economic front, UKI2S has a strong record of achievement in key areas such as leverage of private investment, job creation and R&D spend. According to an independent review (SQW, March 2020) UKI2S investment of £15m has been followed by over £500m of private investment ranging from angels to VCs and large multi-national corporate investors, a great example of how public



sector funding can leverage private investment by taking the first risk! Portfolio companies generated around 700 jobs, and over 50% of the portfolio companies' total funding (i.e. over £250m) is spent on R&D. A crucial finding was the level of "additionality", that more than 75% of the companies simply would not have existed without UKI2S finance and mentoring at the earliest stages. In addition, though much of the partners' activity is located in the South East, half of companies are based outside the Golden Triangle, assisting levelling up.

The role of UKI2S in investing in early-stage ventures will become even more important during a period when private investors are likely to focus on supporting their existing investments and identifying opportunities in later stage companies recovering from the pandemic. To avoid young companies failing and the innovation pipeline coming to a halt we need to step up our investment and ensure that we can provide the finance and mentoring needed to grow and attract later, follow-on investment from VCs and angels, and deliver tangible economic impact to the UK.

Investment in science now goes beyond the immediate need for economic recovery. It is a question of national resilience to the next global pandemic or other crises. Parliamentarians from all parties agree on the essential importance of delivering a substantial increase in UK R&D investment, and as part of that, capturing the value of the great science taking place in the public sector. We in UKI2S are now examining sources to secure a step-change boost in financial capacity in order to increase the scale of the opportunity which we identify as being greater than the resources we have at present. Government can take credit for the establishment of the initial UKI2S fund and the positive results derived; it should now take the opportunity to go one step further and provide greater risk capital funding able to – as Sir Patrick puts it – realise the exciting scientific commercial potential of our public sector research establishments. □

ACCESSING ACADEMIC EXPERTISE IN TIMES OF CRISIS…AND BEYOND

Sarah Chaytor is UCL's Director of Research Strategy & Policy. Sarah established UCL's flagship academic-policy engagement initiative, UCL Public Policy, and was a co-founder of UPEN, the University Policy Engagement Network.

Dr Grant Hill-Cawthorne is a medical microbiologist and the Head of the Parliamentary Office of Science and Technology (POST). Grant continues as an adjunct Associate Professor in Global Health at the University of Sydney.

Andy Westwood is Professor of Government Practice and Vice Dean for Social Responsibility in the Faculty of Humanities at the University of Manchester. He is a Governor at the NIESR and has recently worked as a specialist adviser to a number of House of Lords Select Committees.

The Covid-19 pandemic has drawn public attention to the need for and use of scientific advice in political decision-making like never before. Minutes of previously unheard-of committees now form headline news; formerly anonymous scientists now occupy central stage in government briefings to the media. The pandemic has highlighted the need for expertise both in directly tackling and treating the coronavirus and more broadly as we start to look to recovery.

Scientific advice and academic expertise can help to underpin new policy ideas, inform debate and the development of legislation, and support Parliamentary scrutiny of Government. The unprecedented nature of this crisis and the complexity and scale of the recovery effort is likely to give rise to an unprecedented demand for expertise and evidence to inform future policy development. This is at once a challenge and an opportunity for universities and for Parliament.

We have already seen ways in which Parliament is seeking to respond to the crisis. The plethora of Select Committee inquiries on Covid-19 alone (43 at the timing of writing) illustrate the importance of using evidence to inform debate and analysis of the challenges caused by coronavirus. The Parliamentary Office of Science and Technology (POST) has created an expert database and consulted academic experts to inform horizon-scanning around crucial challenges related to Covid.

It is also clear from the level of individual academic engagement (over 5500 academics and researchers joined POST's database and 1107 fed into the horizon scan) that the academic community has great willingness to contribute their knowledge and expertise.

In the case of coronavirus, the quick action of Select Committees and POST has provided clear, well defined routes for academics to engage on a clearly defined topic upon which Parliament and the academic community are focused. As part of its 'brokerage' function POST has provided rapid syntheses of the academic contributions they have received and have written new rapid-response briefings on key coronavirus issues. Engagement was focused around a single issue upon which both academic and parliamentary communities are focused with singular urgency.

All of this has gone some way to overcome some of the barriers to engagement between the academic community and policymakers. However, what is possible in a time of unprecedented crisis – when the entire country is pivoted towards tackling the coronavirus crisis – is not necessarily sustainable in what used to be normal times. As the country moves out of crisis mode into the 'new normal', impediments to engagement may return and even increase.

The different timescales upon which Parliament and academics work are likely to reassert themselves, particularly as the urgency of the crisis lessens. Whilst much academic research has been repurposed to tackle coronavirus or to inform the response, new research projects currently starting will nevertheless take months if not years to generate results. This can be frustrating for parliamentarians and staff who will want answers 'now', and who rarely have time to digest academic research. Mutual understanding and trust is needed to recognise the nuances of how knowledge is created and used in the policy process – including how academics can respond to parliamentary need at relatively short notice.

At the same time, many other significant cultural differences persist, including some mutual impenetrability. The operation of Parliament can appear obscure, and indeed archaic, to many academics. Similarly, academic work can be highly specialist and technical, making it inaccessible to those outside academia. Research by POST and UCL has found that lack of awareness of research and insufficient understanding of how to use and appraise research evidence, as well as not having the time and ability to access research (often published in subscription-only academic journals) were all key barriers for parliamentary staff. On the academic side, a POST survey identified lack of knowledge, confidence, time and incentives for engagement as some of the main obstacles. It is by no means clear that the recovery effort will easily allow for the space and investment in the skills and relationships that are needed to overcome these barriers to understanding.

A further complication is academic concern about the 'politicisation' of research evidence, which may well be heightened at a time when both scientific advice and scientists themselves are in the spotlight. These concerns need to be handled with sensitivity and a clear understanding of the role of academics, evidence, parliamentarians and parliamentary staff throughout the engagement and policy process.

The current incentives for academic-policy engagement, within universities and within Parliament, are not strong enough to systematically overcome these difficulties. Academics generally speaking are still driven by securing grants and publishing papers. Engagement on both sides is often seen as a nice-to-have which can be outweighed by more pressing demands or sidelined due to uncertainty over engagement.

Recent years have seen increasing efforts to overcome the barriers described above, with Select committees introducing innovations in how they collect evidence and undertake scrutiny work, POST establishing its Knowledge Exchange Unit and Research Impact Hub, and an increasing number of universities developing functions to support academics and researchers to engage with public policy. This complements the longstanding work of the Parliamentary & Scientific Committee to provide routes for engagement around topics of mutual interest. A 2019 Commons Liaison Committee report on the effectiveness and influence of the select committee system also emphasised the need for "more systematic and better understood structures within which cooperation between select committees and the wider research community can be more effectively enabled and enhanced."

Our experience in this area over the past decade has shown us the importance of developing networks to foster the trust and relationships that enable rapid mobilisation of expertise to address policy problems at the right time. But this can create its own problems - giving rise to a 'usual suspects' problem rather than ensuring broad and diverse engagement with the research community (as noted by the Liaison Committee). These forms of informal engagement can also result in a lack of transparency about what evidence is informing decisions and how.

So what can we learn from efforts to harness academic expertise to inform Parliament's response to covid-19 in order to improve longer-term academic-parliamentary interaction? The crisis has certainly highlighted the importance of rapid access to scientific and research evidence and perhaps suggests new mechanisms that could be introduced to enhance this.

For example, would the creation of thematic databases of expertise increase engagement? Could existing parliamentary academic fellowships be diversified and expanded – including parliamentary staff spending time in universities, perhaps during recess? Might universities start to deliver rapid synthesis of research evidence in response to Parliamentary activity? What new opportunities for regular engagement and networking could be provided?

The truth at the moment is that we don't really know what would be most effective. It is perhaps easier to see where we want to get to, than how to get there. The challenge will be to build accessible and systematic structures that enable different forms of engagement at different points and in different modes.

A new 4-year project funded by Research England will offer new opportunities to explore this, looking at the most effective ways of building academic-policy engagement in different geographical contexts and at different points within the public policy sphere. Involving 5 universities (UCL, Cambridge Manchester, Northumbria, Nottingham) and 4 policy partners (including POST) the project will design, test and evaluate different activities to identify which work best and which can be scaled up across the university sector and the public policy sphere. We hope that this project will provide a significant opportunity to build on the work already ongoing within Parliament and to widen the scope and range of engagement between Parliamentary staff and academics.

Importantly it will also provide new learning and evidence on what works. This of course won't completely solve the complexities discussed above, but it will provide greater understanding of where efforts can best be focused and how engagement can best be shaped. It is likely that any step-change in academic-policy engagement will require sustained investment, new incentives on both sides, a significant increase in structured forms of engagement, and sustained and expanded outreach. It will require Parliament and universities to create new systems and resources to support this whilst continually striving to increase transparency and diversity. If we are really to improve the ways in which academics and Parliament engage with each other, then taking a serious look at what works is a good place to start.

CAPE: CAPE brings together the universities of Cambridge, Manchester, Nottingham, Northumbria and University College London to create a hub of academic-policy engagement expertise. Our members are dedicated to transforming the process of academic-policy engagement to support the development of evidence-based policy for public benefit. □

RISING TO THE CHALLENGE – THE CRICK AND CORONAVIRUS

Dr Sam Barrell
Chief Operating Officer
The Francis Crick Institute.

The Francis Crick Institute was set up to carry out blue-skies biomedical research – to understand the biology underlying human health and disease. It's the kind of research that expands our horizons and broadens our understanding of human diseases, but also the kind of work that can be years away from benefiting patients.

But when the world is in the grip of a pandemic that is taking hundreds of thousands of lives, it can't afford to wait years. In the face of a new and unknown virus, the science community was being looked to in an unprecedented way to help us understand and tackle it. And the answers were needed quickly.

It was a galvanising moment for Crick researchers who saw that their work and their expertise could help shed light on the SARS-Cov-2 virus. And the Crick had other unique strengths to contribute to both the national and global responses to the pandemic.

For some research groups it meant pausing their current research to respond, pivoting onto new projects to help build the world's understanding of the infection. We have seen researchers from multiple disciplines approaching complex questions in different ways and sharing their results; their exchanges sparking new ideas and new theories.

PARTNERSHIP

Though the Crick only opened 4 years ago, one of our strengths lies in our history. The institute was born of the merger of two venerable research institutes; the Medical Research Council's National Institute for Medical Research and Cancer Research UK's London Research Institute. They, together with Wellcome, UCL, Imperial College London and King's College London make up our founding partners, giving us a strong network of relationships to draw upon.

Scientific, academic, business and clinical collaborations are woven into our fabric. Those partnerships have made it easier for us to down tools, respond where we are needed and adapt fast. As part of our COVID response we have partnered across disciplines, sectors and countries.

THE CRICK COVID CONSORTIUM

Early in the pandemic, when the need for rapid and accurate testing was becoming increasingly apparent, the Crick looked at the national challenges in developing large scale testing, and saw that we could play a part. We had the right equipment, expertise, adaptability and partnerships to contribute to the national need. Working with University College London Hospitals (UCLH) NHS Foundation Trust and its diagnostic partner Health Services Laboratories (HSL), we transformed our laboratories into a high-throughput testing centre in just 11 days, with the help of hundreds of volunteer staff and students.

We have just carried out our 50,000th test, helping 10 hospitals, the London Ambulance Service, and a number of care homes to test staff and patients.

We have made our procedures publicly available, to help other laboratories set up their own testing sites. So far, we have advised 40 institutions on training and protocols.

MULTI-DISCIPLINARY

With lead researchers from the physical, biological and clinical sciences, the Crick encourages collaboration between disciplines, while supporting people at every career stage to work together. So it was natural for researchers to work across groups in collaboration with our cutting-edge science and technology platforms to answer some of the fundamental questions about the virus and how it behaves.

Crick scientists benefit from specialised facilities including high level containment labs which enable the study of the pathogen within a tightly controlled setting. We're applying expertise in virology, immunology, structural biology, and chemistry to understand the lifecycle of the virus –

how SARS-CoV-2 attaches to cell surfaces, how it enters cells, and how it replicates inside cells. By knowing more about how the virus functions, one of the things we hope to learn is how potential drugs interfere with stages of the virus lifecycle.

By drawing on years of expertise studying viruses like HIV and influenza, we are using a combination of techniques including high-resolution imaging and reverse genetics to build up a picture of how SARS-CoV-2 infects cells.

We already have long-standing partnerships with pharmaceutical companies like AstraZeneca, GSK and MSD, and industry scientists work closely alongside Crick researchers to speed up the discovery and development of new treatments. Teams across the Crick are collaborating to create methods for systematically testing many approaches, including drugs and antibodies, that might block the virus from entering cells, or limit its ability to replicate once inside the cell.

BIOMARKERS TO PREDICT DISEASE PROGRESSION

People infected with SARS-CoV-2 respond differently. Some do not develop any symptoms, some need to be hospitalised and, for some, the disease is fatal.

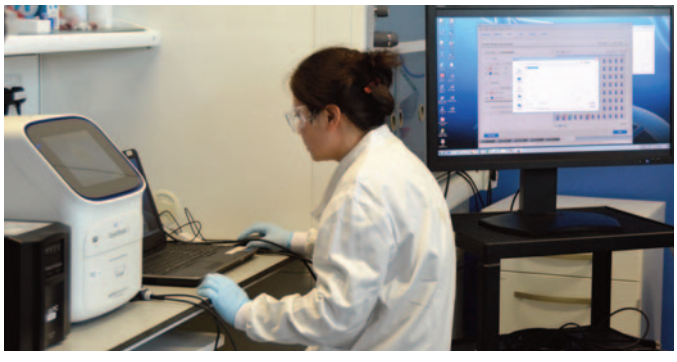
In a study by Crick research group leader, Markus Ralser, researchers found 27 potential biomarkers that are present in different levels in patients with COVID-19, depending on the severity of their symptoms.

The researchers refined an analysis method called mass spectrometry to rapidly test for the presence and quantity of various proteins in the blood plasma. This platform was developed at the Francis Crick Institute and applied to analyse serum of 31 COVID-19 patients at the Berlin University hospital Charité. Their results were further validated in 17 patients with COVID-19 at the same hospital and in 15 healthy people.

The researchers hope their findings will lead to the development of simple routine tests to check for the levels for one or some of these proteins in patients with COVID-19. The results of such tests could be used to support doctors in deciding what treatment to give.

THE CRICK'S UNIQUE MODEL

At the heart of the Crick's model is our focus on talent. We create a supportive environment to enable our researchers to develop their scientific and leadership skills, and then help them move on to the wider UK biomedical research community. Our ambition is that they will ultimately become world-class science leaders, acting as a pipeline for UK research.



Like the rest of the country, Crick researchers have had to start working in new ways. Many have been able to carry on with some of their research while working remotely. Others have been able to change their focus and work on COVID-19, like Nikhil Faulkner and Kevin Ng, who are PhD students in the Crick's Retroviral Immunology Laboratory, studying how our bodies respond to viruses. They have refocused on finding out what happens when our immune system is exposed to SARS-CoV-2. They've developed a highly sensitive test to detect antibodies that attach to the SARS-CoV-2 spike protein, which could be useful for diagnostics and research.

Enzo Poirier and Mike Buck are postdocs who, before COVID, worked on the immune system's response to cancer, but are now developing a new testing method to detect SARS-CoV-2. Their colour-change test gives a result within 25 minutes, and has just been clinically validated. They have already shared their approach with the research community so that it can be used widely.

The challenges of COVID-19 have forced the whole scientific community to think differently about how we work. At the Crick we are hoping this can help catalyse long-term improvements in research culture.

IMPACT OF COVID-19

In the last few months, the global science and research landscape has been radically transformed, but major and long-term research projects have been delayed, sometimes for years, with inevitable consequences for patients waiting for new treatments.

The large national Tracer X trial, a 10-year programme tracking lung cancer and how tumours change over time, has been paused, setting it back by as much as five years.

The pandemic has also had an immediate and profound impact on medical research funding, because of the loss of charity fundraising income. The economic impact of COVID-19 poses a real threat to the viability of charity-funded research, both now and in the future.

THE R&D ROADMAP

The COVID-19 pandemic has brought the importance of science into sharp focus and the Government has recognised, in its R&D Roadmap, the critical role that research and innovation will play in the UK's economic and social recovery from the virus' impacts.

The roadmap sets out an ambitious vision for UK science and recognises the importance of long-term investment in fundamental research and bridging the gap between discovery and application.

Scientific collaboration across countries and disciplines is critical as we look to tackle the biggest problems facing society. Maintaining the UK's position as a destination of choice for international talent will be essential, and the Government's renewed statement of ambition to participate in EU research programmes has given the sector hope. In a 2018 survey, 97% of Crick Group Leaders said they would prefer to participate in EU Framework programmes than to develop alternatives.

The Crick was set up to be agile, multi-disciplinary, collaborative. In the face of the COVID-19 pandemic, the benefits of that approach have become evident. The COVID-19 pandemic demonstrates what can be achieved through partnership and collaboration and we look forward to working with the Government to ensure that science is able to play its crucial role in the future of the UK. □

ECONOMICS IN A PUBLIC HEALTH CRISIS

Professor Jagjit S. Chadha currently serves as the Director of the National Institute of Economic and Social Research.

He is an expert on financial markets and monetary policy, as well as aspects of monetary and financial history.

> **"Q487 Mr Baker:** *I need to come to my last question, and I can see Jagjit wants to come in. Bearing in mind this is a public health crisis, what is the legitimate role of the economist in a public health crisis?"*
>
> **Professor Chadha:** *…where economists can help is that we are pretty good at understanding how to interpret numbers. More than anything else, before deciding on the kinds of policies…we need much better local measures of the reinfection rate at the granular level. We also need surveys that tell us accurately who has antibodies and who has had the virus in the past. Without these two critical parameters, it is incredibly hard to decide how lockdown should be eased at the regional level, even if that is what we wanted to do. We know that, even if the reinfection rate is 0.7 on average, there could still be many regions and areas, or even streets, in which the number is 1.1 or 1.2. It is not entirely possible to create a safe climate if there are any areas in which R is greater than 1. We need measurements. We need surveys to understand who has the disease at high frequency and surveys and estimates of the antibodies that are available. I think we have only just now discovered a test that may be reliable. Those things together would then be able to guide the policies we might want to do to ease the lockdown."*
>
> **Treasury Committee Oral Evidence 15th May 2020**

The question is often and rightly asked about what economics can teach science and, in our current circumstances, what role might it have to play in helping the country confront the covid-19 pandemic. Indeed, the question was put to me by a member of the Treasury Committee in May. Unfortunately, I really do not quite have enough time to go through all the ways economics can help. But let me try to go through some of them here and then run through in a bit more detail an issue of the importance of designing good institutions to meet social objectives and what they mean for the role of the state.

STABILITY, DATA AND ESTIMATION

Economists typically spend a large part of their time thinking about the stability of the relationships they posit or estimate. That is when a system gets shocked, under what conditions does it return to its previous steady state of or not. Understanding the dynamics of equations is the bread and butter of economic analysis from questions such as inflation to the formation of herds. The critical value in such analysis is normally 1, which by now should sound a rather familiar quantity.

Measuring the economy requires a structure to the sampling of all types of economic activity and cross-checks to ensure an absence of double counting or missing elements. The increasing digitisation of the economy has introduced a particular concern that much activity may be under-reported and/or over-priced, meaning that we might be understating real national income. The lockdown has introduced its own concerns about the accuracy with which we can measure activity.

From the theory and the measurement, we quickly move to a branch that is concerned with estimation. How we can place any confidence on the parameters we estimate about inter-relationships when they result from observations that are jointly determined? For example, unemployment is not the fundamental cause of Covid-19 deaths but they are rising together. What about sample sizes for safe inference but then what if samples start to overlap with different regimes or behaviour?

The uncertainty of numerical estimates and also in our understanding of whether estimated economic relationships are robust, mean that we have to treat any estimated parameters with great care and cannot treat them as a final answer on which to base policy. Obviously, this limits the safe space for policy responses. But without the right policy responses the economic systems will be unstable, but

also with the wrong types of responses they will also display instability.

INSTITUTIONS AND RULES

How do economists confront the issue that data relationships are so inherently unknowable, but that policy must act to stabilise the economy? By recourse to rules, institutions and managing expectations. One possible condition of policy success depends on getting people to behave in line with the policy objectives. It is then the case that objectives must be credible. For example, the objectives for the provision of public goods such as health, transport and education should relate to advice on experts and the extent which they match the choice that society could make if it could speak. This requires complex interactions between knowledge, public opinion and political direction.

So how did policymakers then deal with the economic hit to Britain's economy? First identify the shock: the coronavirus has affected nearly all economies and exposed them to the risk that globalisation, which dominates modern economic production, will not only be disrupted but may also have to change in radical ways. This means the shock is not only about the incidence of the virus and the mortality rate but also imparts disruptive news about future patterns of production. In this case, the macroeconomic policy playbook gives some clear guidance on what to do: shore up demand and allow the economy to adjust slowly to its new level of productive capacity. If you provide people with a clear signal as to that level of support then the damage and the costs of change will tend to be substantially mitigated.

In terms of demand management, so far so good. Much has been done to foster confidence. The crisis triggered a co-ordinated response by monetary, financial and fiscal policies. On Budget day we had a £50 billion emergency cut in bank rate, a new SME term funding scheme and a relaxation of the counter-cyclical buffer. On the following Tuesday, the Chancellor moved even further away from his arbitrary fiscal rules and announced support to business worth some 15 per cent of GDP and nearly 70 per cent of outstanding business loans. And the following day the Bank of England engineered a further emergency cut in Bank Rate to 0.1 per cent and re-ignited the quantitative easing programme, with a further £200bn or nearly 10 per cent of GDP. Subsequently both arms of policy have been further flexed.

Even that may not be enough and requests for state support from firms - what economists call the supply side - may start to come thick and fast. And these may be hard to resist from the travel, tourist and hospitality sectors, as well as supporting key workers distributing and carrying in the gig economy. The key here is the co-ordination of the various policy arms to the same objective of shoring up demand and helping the supply side adjust. But note all these interventions mean that the state has ratcheted up in size with more public debt, to around the size of one year's national output, with even more of it held by the Bank of England along with directed lending to firms and an insurance network that will resemble industrial policy on a scale not seen since the 1970s.

DID WE ASK FOR A BIGGER STATE?

The uncertainty tab has been picked by the state. And socially we may see much more of the same. How we manage an infectious health crisis when there are substantial herding effects to confront may also lead to more direct state control. One initial strategy was to allow the spontaneous spread of the virus to build up so-called 'herd immunity'. The herd would eventually act as a barrier to the spread of the virus. The argument ran that even though this might lead to more deaths in the short run, it would limit deaths in the longer run. The alternate strategy of imposing a quarantine, it was argued, would lead to lower deaths now but not allow herd immunity to develop which would lead to more deaths in the future. In economic terms, we had to choose a point on the trade-off.

But confronting the actions of the herd is about actually creating a groupthink that pushes the group in the right direction. Individuals will tend to place a significant weight on what they think others will do in response to a policy, rather than simply following the policy signal. The success of any policy thus depends on which endpoint the herd latches onto. That will require clearer signalling, explanation and direction by the state.

In order to decide on the best policy strategy to limit the health impact of the virus, we need to understand how the outcomes are affected by the way that individuals and families interact with each other's responses rather than just the policy intervention itself, where what also matters is the likely consistency, or credibility, of the policy treatment.

So if I think individuals are not interested in taking the personal risk of developing herd immunity and/or that the government is unlikely to carry out its plan consistently when the deaths mount, I will cancel plans to attend gatherings and self-impose my own travel restrictions. In February and March as people decided to act in accordance with their view of what everyone else will do rather than what the government suggested, the more liberal policy floundered. Instead the government had to follow the popular lead and order bars, restaurants, theatres and museums to close their doors because the herd had decided to stay at home. But now when we open those same bars and restaurants, if people do not believe they are safe or are concerned that may yet lose their jobs, the economy may still not recover that much. The interaction of policy with data and beliefs is key to the outcomes.

And so here again in order to confront the choices of the herd, more direct state involvement may occur with the possible requisition of businesses or premises that may otherwise be redundant in the face of the virus, whose assets could prove valuable in handling the consequences of a large increase in the numbers of infected people. Hotels could be converted into hospitals or care centres and restaurants could be hubs for food delivery.

We may have witnessed the point at which government actions will tend to enlarge the reach of the state into everyday lives. Co-ordinated economic policy actions also suggest more direct state involvement in the market economy. The state is being ratcheted up. This not only implies more tax to support the larger state, but it is a way of confronting and corralling the herd in the internet age. The new era of an enlarged state taking back control may only just be beginning. □

CONTACT TRACING APPS FOR COVID-19

Dr Susie Wright is a physical sciences and IT adviser at the Parliamentary Office of Science and Technology (POST). More content from POST on COVID-19 can be found on their website, https://post.parliament.uk/category/analysis/covid-19/.

There has been much discussion of the role digital contact tracing might play in helping to reduce the risk of further COVID-19 outbreaks as lockdown restrictions are eased. Contact tracing is the process of identifying people who have come into contact with an infected individual so they can be warned that they may be at risk of illness.

Digital contact tracing using mobile phone apps can automate this process by detecting when people come into close contact and notifying users that they may be at risk. This is a new and relatively untested technology, but potentially allows for quicker and more precise tracing than traditional, manual contract tracing that uses interviews with infected individuals to understand who they have been in contact with. However, for apps to work effectively, numerous challenges must be overcome, including accurately measuring distance between contacts, ensuring users' privacy and encouraging widespread uptake of any app. Many countries have released digital contact tracing apps but, so far, there is limited evidence that they have been able to effectively overcome these challenges. Singapore was one of the first nations to release an app in March. Since then, Australia, Norway, France and Germany, amongst others, have launched their own apps.

On 12 April, the Government announced that NHSx, a unit of the NHS responsible for digital innovation, was developing a contact tracing app for the UK. After early testing at RAF Leeming in Yorkshire, a trial of this app began on the Isle of Wight on 5 May and the app's source code was published. A national roll-out was expected to follow this trial before the end of May but the app was never released. However, on 18 June the Government announced that they would be changing the trialled app to make use of a software interface released by Apple and Google in May. The release of the UK app is now not expected until the autumn at the earliest. On 22 June, the House of Lords was told that the cost of the app to date was £11.8 million.

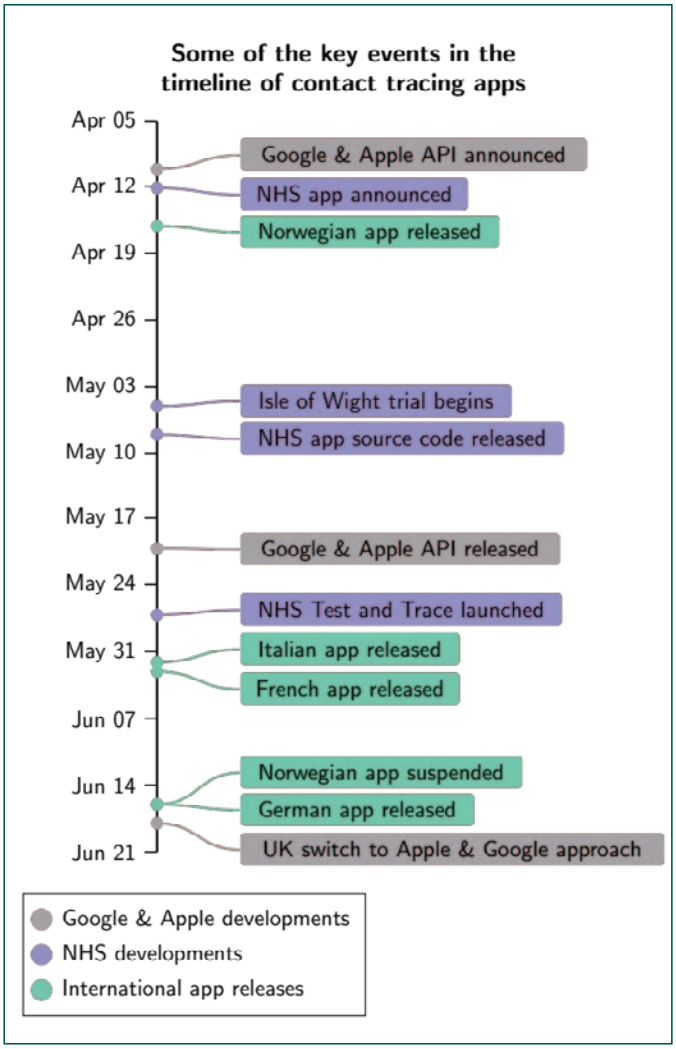
HOW DO CONTACT TRACING APPS WORK?

Contact tracing apps work by digitally tracking who an individual has come into contact with. When two people come within a certain distance of each other, their phones exchange 'tokens' (unique identifying numbers) that have been allocated to each phone. It is generally agreed that, to protect an individual's privacy, the tokens should be anonymised, generated randomly and changed regularly. The app stores a list of the tokens belonging to all contacts made over a given period. If an individual begins to show symptoms of COVID-19, or tests positive, the app is notified. It can then alert other users that they may be at risk of infection if the infected person's token is stored in their phone. When designing an app to carry out this process, different technical specifications can be chosen to meet certain standards of accuracy, security and user privacy.

Most contact tracing apps currently in circulation use Bluetooth to measure contact proximity. In principle, a phone can estimate the distance to another Bluetooth device by measuring the signal strength received from that device. Norway is one of the exceptions to this in Europe as their app collected users' location data via GPS. However, Norway's Institute of Public Health suspended use of this app on 16 June after the country's data protection agency raised concerns that the app's use of location data was unnecessarily invasive to privacy. Bluetooth provides some privacy protection as the proximity of other devices, but not their absolute location, is measured, so less identifiable personal data are collected. However, the accuracy of Bluetooth over the 1–2 metre length scales needed to measure risk of infection has been questioned. For example, research has found that Bluetooth signal strength can be affected by factors such as

whether a phone is indoors or outdoors and how deeply it is placed in a bag. Furthermore, some smartphones, particularly older models, do not support the type of Bluetooth used by most apps. Estimates reported by the BBC suggest 12% of phones in active use in the UK may not support it. Singapore is now distributing wearable Bluetooth devices with the same functionality as their app in an attempt to circumvent some of the problems with using Bluetooth on mobile phones.

Another issue that has dominated the debate surrounding contact tracing apps is whether app developers should use a decentralised model, where data are managed locally on a user's device and data sharing is minimised, or a centralised model, where data are shared with a central computer managed by the app administrator. Decentralised apps involve less data sharing so are thought to provide better privacy protection.



In part, this debate around centralisation arose as many countries, including the UK, initially pursued a centralised approach which would allow them to collect data to research the spread of the virus but Apple and Google, as well as some academic groups, supported a decentralised model. The Application Programming Interface (API) released by Apple and Google in May allows contact tracing apps to access additional functionality, such as the ability to run as a background process, which is usually denied to apps for security reasons. Apple and Google have stated that only apps developed by public health authorities will be able to use the API and these apps must meet certain security, privacy and data control standards. Some of the countries that initially planned to use a centralised approach, including Germany and Italy, switched to a decentralised model before their apps were released to allow them to make use of the API.

Other countries, including Norway and France, have opted to follow a centralised approach. The Australian app has been described as 'hybrid-centralised' as data are stored on a user's phone but their identity is revealed to the health ministry if they are at risk of infection. The app that the UK Government tested on the Isle of Wight was built on a centralised model but the announcement on 18 June that the Government are now looking to work with Apple and Google suggests a switch to the decentralised approach followed by those companies. A concern that has arisen from countries using different approaches is that their apps may not be compatible with each other and so contacts from other countries may not be recognised.

Another area where many countries have faced difficulties is encouraging a sufficiently large proportion of the population to download the apps. An Oxford University study estimated that uptake by 80% of UK smartphone users would be required for an app to suppress the epidemic (although lower uptake could still help slow the spread of disease). Reports suggest that, as of mid-May, 40% of the population of Iceland, around 25% of the population of Singapore and about 20% of the population of Norway had downloaded the apps released in those countries. Since 2 June, the French app has been downloaded by 1.8 million people but subsequently deleted by 460,000 of them. Concerns have been raised that individuals without smartphone access, particularly the elderly who at higher risk of severe illness from COVID-19, may be excluded from any benefits offered by an app. The Government have maintained that any app would be used alongside manual contact tracing to support those without smartphones.

NHS TEST AND TRACE

On 28 May, the Government's manual Test and Trace programme was launched. This programme aims to identify the contacts of anyone who tests positive for COVID-19 via interviews with the infected person. The Health Secretary has since argued the importance of receiving information from a human rather than an app to reassure the public during the contact tracing process and in June the Common's Science and Technology committee was told that the app wasn't a Government priority at that time. However, critics have commented that the manual contact tracing programme offered by NHS Test and Trace would not be able to identify contact between strangers and could be too slow, meaning those exposed to the virus could unwittingly spread it before being told to self-isolate. The Royal Society's Data Evaluation and Learning for Viral Epidemics group estimate that testing, tracing and informing contacts needs to take place within 3 days to reduce the number of new infections generated by 15%. □

MODELLING THE SPREAD OF COVID-19 USING NON-STANDARD MEASURES OF POPULATION DENSITY

Professor Oliver Johnson

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Since the start of the coronavirus pandemic, there has been considerable interest in comparing the response of different countries, using numbers of deaths or positive tests to measure the effectiveness of their policy and healthcare response. While such calculations are tempting, they need to be performed carefully, and with certain caveats in mind.

First, there are issues of timing and reporting. Not all countries are at a comparable stage of their own epidemic, and standards vary hugely in terms of how and when deaths are reported, and which individuals are included in national figures. For this reason, it is premature to compare countries too early in the pandemic: in the absence of a vaccine, it may well be that final death tolls will be fairly similar overall when viewed as a proportion of the population.

Second, and more importantly, not all countries are alike. For example, it was relatively easy for New Zealand to follow a strategy of isolation and elimination, due to its geographical isolation. It is far from clear that, given the presence of a major international hub airport and large numbers of international visitors including students, this would have been a realistic option for the UK.

Further, there are other factors that affect the severity of the virus which mean that not all countries should expect the same number of deaths. For example, fatality rates are significantly higher among the old, so one might expect that countries with a higher average age or a larger proportion of over 70s would expect to see more COVID casualties. This might suggest why fatality rates are so much worse in South American than in Africa at the time of writing. Similarly, levels of obesity or diabetes are also associated with worse healthcare outcomes for coronavirus, so should be taken account of when assessing international casualty figures.

One particular demographic factor that appears natural in this context is population density. We will refer to the usual calculation of total people per square kilometre in a region as the *standard population density*, to distinguish it from another measure we discuss later. Having seen the severity of the outbreak in New York City and other densely populated regions, it is natural to hypothesise that the higher the standard population density, the faster the virus should spread. In more crowded areas, it seems inevitable that

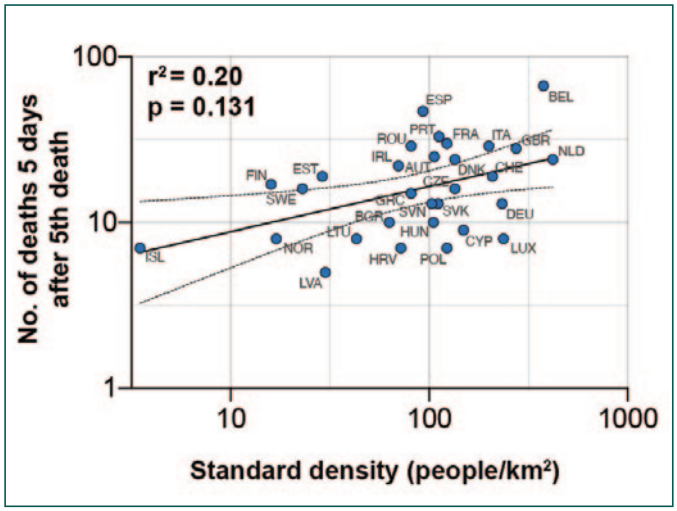

Figure 1: relationship between standard population density and rate of spread of COVID-19 for a number of European countries.

people will have more close contact with others, so an infected individual will transmit the coronavirus to more people, and the outbreak will grow at a faster rate.

This is a hypothesis that is relatively easy to test. National population data is readily available, and a number of websites aggregate coronavirus casualties. Hence, we can calculate the standard population density for each country, and plot it against the rate of spread early in the epidemic. For example, we might look at how many deaths took place in the 5 days following the casualty figures reaching 5 deaths per day.

As we see from Figure 1, there is surprisingly little correlation between standard population density and the rate of spread, when comparing European countries. In general, countries with larger standard population densities typically have faster spread of the virus, but there are many exceptions, and the trend is not statistically significant. We can perhaps understand why by looking at Spain. Although the virus spread very fast there, taken as a whole the country has a very low standard population density of 93 people per square kilometre. However, this low figure reflects the fact that the country contains many empty regions where nobody at all lives, as well as many of the highest density neighbourhoods in Europe, in Barcelona and Madrid.

We can see a similar phenomenon in New York State, another hotspot for the virus. Again, the standard population density is very low (163 people per square kilometre), but this is made up of a combination of relatively empty areas of land upstate and the extremely high density areas of New York City itself.

This helps us to understand why the standard population density is not the right measure in this context. One way to see this is to understand what it means: the standard population density tells us "how many people we expect to be living next to a randomly chosen point in the country?". In that sense, the large empty spaces of upstate New York count for more than the relatively small area of Manhattan. However, we need to think from a different point of view: that of the virus.

The virus does not pick a random point in space: it effectively picks a random person. For example, we can imagine that an initial outbreak will be seeded by an international traveller arriving from outside the region. In that case, the right question to ask is "how many people we expect to be living next to a randomly chosen person?". It is perhaps not obvious that this is a different question to the one above. However, it is clear that sampling in this way will weight Manhattan much more highly in the calculation, since a randomly chosen person is more likely to live there. This leads us to use the *quadratic population-weighted density* as an alternative to the standard population density. Thanks to data provided by the WorldPop project in Southampton, we have access to population data on the scale of a square kilometre grid, so can calculate this relatively easily.

It turns out that Spain has a particularly high value of this population-weighted density (3273 people per square kilometre), as does New York State (6163 people per square kilometre). We can plot this population-weighted density against the rate of spread. We find that the population-weighted density does a better job of explaining the rate of spread than the standard density when comparing European countries (see Figure 2), explaining roughly half the variation observed between countries.

Making this comparison allows us to see which countries are performing particularly well or badly, through having a faster or slower rate of spread respectively than their population-weighted density suggests. In particular, given the large amount of media interest comparing the epidemic in the UK and Germany, it is interesting to notice that neither country stands out as an outlier in that sense. Indeed, it may be somewhat surprising to find that Germany has a population-weighted density of only 885 people per square kilometre – lower than Sweden or Ireland – reflecting the fact that its population is fairly evenly distributed across the country, making the virus slower to spread. In fact, the country which stands out for having a slower spread than expected is not Germany but Greece, which locked down early to very positive effect.

Of course, the population density is not the only factor that explains the spread of the virus, but we argue it must be taken into account when comparing outcomes between different countries. However, we emphasise that any such comparisons must be performed carefully and rigorously, and only at the end of the pandemic.

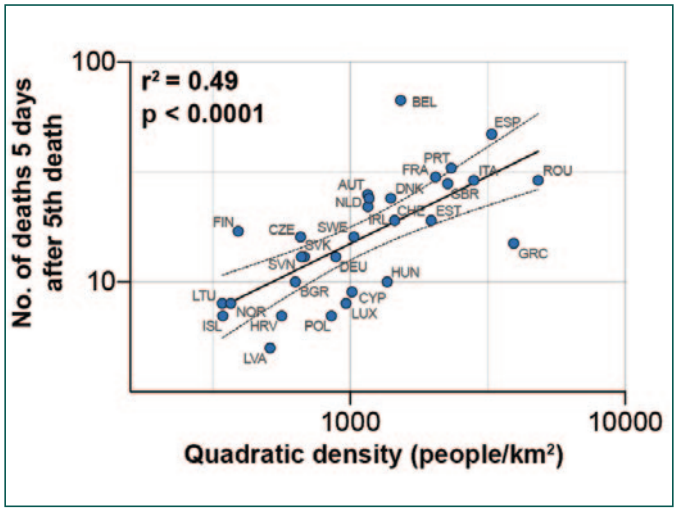

Figure 2: relationship between population-weighted density and rate of spread of COVID-19 for a number of European countries.

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THE BENEFITS OF LONG-TERM STEWARDSHIP OF RESEARCH DATA

Dr Matthew Addis is Co-founder and CTO of Arkivum. Matthew previously worked at the University of Southampton IT Innovation Centre. Over the last fifteen years, Matthew has worked with a wide range of organisations in the UK, Europe and US on solving the challenges of long-term data retention and access.

There is substantial value in making research data open and accessible [1]. Benefits include: science that is higher quality and more productive; faster development of new products and services; and increased impact for research when addressing societal challenges. Substantial benefits can be derived from making other forms of data open too: for example, the Open Data Institute reports [2] on the potential held by data from the public sector. From an economic standpoint, the value of making data open is estimated to be as high as 4 per cent of GDP [3]. Or, as a McKinsey report [4] put it, "Open data – public information and shared data from private sources – can help create $3 trillion a year of value in seven areas of the global economy."

Nowhere are these benefits more apparent than in the response to the current COVID-19 pandemic and in the efforts of the international community to rapidly share data in an open and trusted way. The Research Data Alliance COVID-19 working group is at the forefront of establishing guidelines to ensure that open data on COVID-19 engenders the maximum benefit both today and in the future too.

THE NEED TO PLAY FAIR

These benefits can only be fully realised if research data is Findable, Accessible, Interoperable and Reusable – otherwise known as FAIR [5]. It is not enough simply to put data online and hope for the best. FAIR encourages and supports high-quality research that follows good research practice which produces results that are repeatable, verifiable and re-usable. Only under these circumstances can research data be used with confidence and exploited to its full potential. These drivers for FAIR data are embodied at an international level in statements made by the G8 science ministers in 2013 and last year in the Beijing Declaration from the Committee on Data of the International Science Council (CODATA).

There are substantial costs if good practice is not followed and data is not made available in a FAIR way. A recent PwC report containing a cost-benefit analysis of FAIR data stated that: *"We estimate the annual cost of not having FAIR data to be a minimum of €10.2bn per year. The actual cost is likely to be much higher due to unquantifiable elements such as the value of improved research quality and other indirect positive spill-over effects of FAIR research data."*

Crucially, FAIR data also needs to be made available in a trusted and reliable way for the long term, often many decades – only then will the value of open access to be fully realised. For example, a study [6] shows that academic and industrial innovators cite biological data resources in their patents decades after the data was originally published.

IT'S A MATTER OF TRUST

The need for long-term trustworthy research data is embodied in the TRUST principles, namely that stewards of research data should consistently consider Transparency, Responsibility, User Focus, Sustainability and Technology. Or, as the TRUST article in Nature [7] puts it: *"to make data FAIR whilst preserving them over time requires trustworthy digital repositories (TDRs) with sustainable governance and organizational frameworks, reliable infrastructure, and comprehensive policies supporting community-agreed practices"*. The article goes on to point out that *"Consensus on 'good' data management practice is beginning to form, but there is still insufficient implementation in some scientific domains."* This is where there is much work still to be done – work to ensure not only that research data is made available today, but that it is also properly managed and stewarded and made available for those who can, should and will benefit from it in the future.

THE UK LEADS THE WORLD

The long-term stewardship of research data is an area in which the UK is well placed when it comes to cementing and extending its current position as a world leader.

The European Bioinformatics Institute at Hinxton in Cambridge

presents an excellent example. For decades, the EBI has been providing access to a wide range of life-sciences data. An independent report [8] found that "EMBL-EBI services contributed to the wider realisation of future research impacts conservatively estimated to be worth some £920 million annually, or £6.9 billion over 30 years in net present value." As the report notes, this is equivalent to 20 times the operational cost of running the EBI. Furthermore, the report findings note that "45% of survey respondents stated that they could neither have created/collected the last data they used themselves, nor obtained it elsewhere."

UK institutions such as the EBI already lead the field in providing long-term open access to research data, but the UK is also home to world leaders in important and related fields. For example:

- The Digital Curation Centre (DCC), the Digital Preservation Coalition (DPC) and the Open Preservation Foundation (OPF) provide expertise in digital curation and digital preservation.
- Memory institutions such as the British Library and The National Archives, and of course the Parliamentary Archives, continue to break new ground in digital preservation put into practice.
- The Jisc Open Research Hub is a new innovation in hosted and service-oriented solutions for research data management.
- Arkivum's digital preservation and data archiving solution is an example of new commercial services for long-term data management.

Together this means that the UK punches well above its weight and is ideally placed to create and deliver new solutions and new commercial services for the long-term stewardship of research data – and to offer these solutions on the international stage.

EOSC: RESEARCH DATA AT AN UNPRECEDENTED SCALE

A major multi-national initiative is the European Open Science Cloud (EOSC) [9], which exemplifies the scale of the challenge and the opportunity. EOSC seeks to store, share and re-use research data across European borders and scientific disciplines, and to provide access to an array of related services, bringing together institutional, national and European initiatives and developing a shared pool of scientific knowledge underpinned by FAIR data. To put that in context, EOSC targets 1.7 million European researchers and 70 million professionals in science, technology, the humanities and social sciences. The scale is huge – and so are the volumes of data being produced.

Whilst EOSC has embraced FAIR, challenges still need to be addressed when it comes to ensuring that the initiative's FAIR data is properly stewarded and managed for the long term. Even the largest organisations in EOSC, such as CERN and the EBI, recognise that stewarding data on the scale required by EOSC needs new approaches and solutions.

ARCHIVER

ARCHIVER [10] is a new €4.8m European Commission-supported project, led by CERN, which will start addressing this challenge. ARCHIVER recognises that commercial services for digital preservation now need to be reliably and certifiably scaled to the "petabyte region and beyond" in order to address the specific complex data requirements of many scientific disciplines. The ARCHIVER project aims to introduce radical improvements in the area of archiving and digital preservation services by combining multiple ICT technologies – including extreme data-scaling, network connectivity, service inter-operability and business models – in a hybrid cloud environment. Its aim is to deliver end-to-end archival and preservation services that cover the full research lifecycle.

Arkivum, in partnership with Google Cloud, has been chosen as one of five consortia for the design phase of the three-year ARCHIVER project, which launched in June. Spun out from the University of Southampton nearly a decade ago, Arkivum now provides specialist software and services for long-term data management and digital preservation to major institutions and commercial organisations in a diversity of sectors, including life sciences and pharmaceuticals, research and higher education, and culture and heritage. Arkivum and Google together will be tackling the challenges that the ARCHIVER buyer group (which in addition to CERN and EMBL-EBI includes DESY in Germany and PIC in Spain) has laid down. The end goal is providing new services for long-term data archiving and digital preservation to the whole EOSC community.

The vast volumes of data that are now being produced around the world, in so many areas of endeavour, hold major long-term opportunities for producing substantial economic, scientific and societal benefits. ARCHIVER is just one example of the opportunity for the UK to consolidate and extend its position as a world leader in the long-term stewardship of research data – all the way from new governance and policy-making through to the development and commercialisation of innovative new services and infrastructures.

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COVID-19: STATISTICS IN ACTION

Prof Sylvia Richardson CBE
Director
MRC Biostatistics Unit
Cambridge Institute of Public Health
University of Cambridge

President-Elect
Royal Statistical Society

Little was known about the epidemiology of infection by COVID-19 in early February 2020, but some of the characteristics of the SARS-CoV-2 transmission that had been described in China, namely high infectivity with early estimates of R in the order of 3 and suspicion that transmission could take place before the development of symptoms, were already an early warning of the potential for worldwide spread. Even less was known about the disease presentation and clinical management of the fraction of COVID-19 infected individuals who became severely ill with complications requiring intensive care treatment, and at significant risk of mortality. From the outset, it became apparent that the combination of epidemiological characteristics and clinical manifestations of COVID-19 could lead to a pandemic and required an unprecedented and urgent scientific collaborative effort.

There were - and still are - many unanswered questions regarding COVID-19. Statistics is contributing to provide evidence on many aspects of COVID-19, evidence which in turn provides a sound basis for policy decisions. The range of questions that are tackled straddles from basic science to public health, from understanding the immune and inflammation response to the virus to quantifying the overall disease burden. Progress is being made by matching each scientific question with appropriate data sources, purposely designed or routinely collected, and by using statistical approaches which are tailored to the type of data and question. To illustrate the productive melding of statistics and science that has taken place at pace since March 2020, I will draw on the experience of the MRC Biostatistics Unit (BSU) and the breadth of COVID-19 related projects that the BSU COVID-19 Working Group is engaged in.

MELDING OF STATISTICS AND SCIENCE TO TACKLE COVID-19

Engagement of statisticians has been most effective when it has been able to build on an existing network of trusted collaborations. Not only this has facilitated rapid access to relevant data sources, but it has also ensured that the much-needed dialog between analysts and scientific researchers can flow immediately. Through our long-standing collaboration with Public Health England (PHE) led by Daniela De Angelis, we were able to set-up quickly an agreement enabling the BSU Covid-19 Working Group to have access to hospital records of infected patients from the hospital surveillance systems. Crucially, we were able to report back on data quality, missing data and inconsistencies, and to discuss the interpretation of any results so that these were as robust as possible. Without an established network of collaboration, detailed understanding and critical appraisal of the data collection are difficult.

Existing collaborations have also been the basis for setting up new data collection protocols at speed. Our collaboration with clinical teams in Intensive Care Units (ICU) at Addenbrooke's and our previous work on understanding Electronic Care Records (ECR) were the basis of a COVID-19 ICU project, aimed at understanding how to target care to patients in most need. This project was approved quickly in March, and first ECR data were extracted within a month. Despite this fast start, full access to ECR data on a safe haven where powerful data science tools could be deployed was only operational mid-June as there were many regulatory barriers to satisfy. Finding an adequate balance between the much-needed rapid access to data and the importance of data protection has been raised by the current crisis and a fruitful topic for further discussion.

The breadth of questions raised simultaneously by this unprecedented pandemic is reflected in the diversity of statistical approaches that are being utilised to try to answer them. Much progress has been made recently on multidimensional methods for precision medicine, going away from one-at-a-time analyses of each biomarker towards integrative analyses of whole panels of biomarkers to get a deeper understanding of coordinated responses to external stimulus. Such integrative analyses will be key to understand the observed heterogeneity of the immune

Acknowledgment: I would like to acknowledge the BSU COVID-19 Working Group for many stimulating discussions and for their stellar and dedicated work.

BSU COVID-19 Working Group: Daniela De Angelis, Thomas Jaki, Sylvia Richardson, Brian Tom; Joshua Blake, Paul Birrell, Robert Goudie, Christopher Jackson, Peter Kirwan, Kevin Kunzmann, Anne Presanis, Pantelis Samartsidis, Shaun Seaman, Helene Ruffieux, Martin Wiegand.

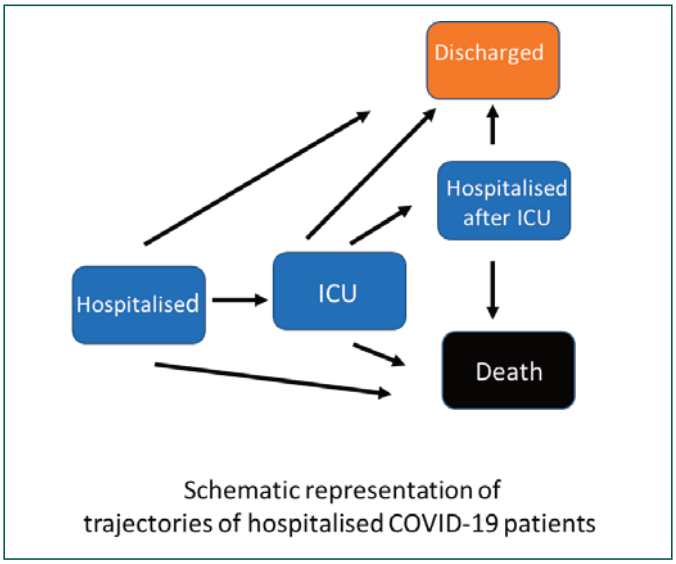
response to COVID-19. In collaboration with colleagues in the Cambridge Institute of Therapeutic Immunology & Infectious Disease, we are involved in a study of the different phases of the immune and inflammation responses to infection by SARS-CoV-2. We will use clustering and other integrative analysis tools to find coordinated modules of dysregulation in severe patients. Characterising subgroups of patients with similar immune responses is the prelude to better target treatment for each patient.

One important challenge since the beginning of the epidemic has been robust treatment evaluation since there was no known treatment for COVID-19 infections. Early on, there were many reports from small studies with inadequate designs, which created confusion. A recommendation from WHO and UK NERVTAG to evaluate whether existing treatments could be repurposed to treat COVID-19 was the impetus for the community to set-up a large Randomised Clinical Trial (RCT) with multiple arms and flexible design. The RECOVERY trial was conceived with chief investigators from Oxford University, and supported by a steering group which includes a BSU Lead. In view of the urgency and the much-needed flexibility, an adaptive design was chosen. Adaptive design is a framework that goes beyond classical RCT designs involving two groups, treated versus control. It includes features such as the ability to compare several arms to a common control arm, to introduce new treatments and secondary randomisation during the trial, to stop treatment at interim analyses, and to carry out dose finding. Crucially, this increased flexibility is not at the cost of the integrity and the validity of the results which is maintained. Such methodological underpinning had been previously developed by researchers at the BSU, working together with a network of trial methodologists to establish statistical properties of a variety of adaptive designs. Thanks to its design, the RECOVERY trial, which started on the 19th March, has already being able to report on three interim analyses with immediate impact on the clinical care of patients.

For a minority of infected individuals, the viral phase is followed by an excessive inflammatory response, which can have severe consequences in particular on the lung, creating pneumonia and acute respiratory distress syndrome, with fatal outcome for some. It is important to study the trajectory of hospitalised patients to better understand the severity burden that COVID-19 imposes on the health system and to inform the general population. After hospital admission, patients can follow a number of trajectories (see diagram) including admission to ICU, readmission to a ward after ICU, discharge or death. It is particularly useful to estimate the probabilities of transition between these different states as well as the length of stay in ICU or other wards. This can be done through the framework of multistate models.

Typically, such analyses are carried out using hospital records data, which has been collected for different purposes such as hospital management or audit. Currently, the main sources of data are the COVID-19 Hospitalisation in England Surveillance System (CHESS), which has been set up by PHE, and the Covid-19 Clinical Information Network (CO-CIN). As these observational data sources are not purpose built, it is important to consider carefully issues related to inconsistencies, missing data, censoring, and population selection as these will influence the results and their interpretation. As is good practice in any analysis of observational data, care must be taken to assess the sensitivity of the analyses to these issues.

A final and beautiful example of melding between statistics and science on COVID-19 is the modelling work carried out by Daniela De Angelis and her BSU-PHE team to reconstruct the evolution of the pandemic in the UK. This is fully detailed in a separate article to which I refer the readers.



Schematic representation of trajectories of hospitalised COVID-19 patients

THE ROLE OF STATISTICS

In summary, as statisticians, our role is to produce evidence from data and quantify uncertainty. This needs to be done in a principled, transparent and interpretable way so that policy makers are fully aware of the assumptions underpinning the analyses and can make informed decisions. Having access to good-quality data is paramount and greatly facilitated by long-term multi-disciplinary collaborations. There has been a huge mobilisation of the scientific community on Covid-19; statisticians are involved in the whole spectrum of projects, making use of a large portfolio of statistical methods.

Exploiting and repurposing routine data collection are certainly useful. The UK is internationally known for its strength in health data science made possible through initiatives like Health Data Research UK, and this has been of major benefit to the current crisis. But observational data comes with its limitations and needs careful analysis as well as consideration of potential sources of biases. The latter can be avoided by having purposely designed and well-conducted studies. Hence, being nimble in setting-up quickly such studies to tackle emerging health threats is essential.

Significant strides have been made but lessons can be learnt to better prepare for the future. These include planning comprehensive, well-designed and aligned data streams covering multi-facet surveillance and involving all the relevant disciplines, designing methods for triangulating evidence in the context of surveillance, and carrying out a constant evaluation of operational systems and policies. □

NATIONAL LABS ARE CRITICAL DURING A CRISIS AND BEYOND…

Dr JT Janssen is Chief Scientist at the National Physical Laboratory, the UK's National Metrology Institute that specialises in measurement science. JT is responsible for the quality of science and engineering research undertaken at the laboratory as well as strategic engagement with external scientific research institutions, universities and government. He heads the National Graphene Metrology Centre (NGMC), whose role it is to develop metrology and standardisation for the nascent graphene industry. JT is also a Scientific Co-Director of the Quantum Metrology Institute (QMI), which covers all of NPL's leading-edge quantum science and metrology research and provides the expertise and facilities needed for academia and industry to test, validate and ultimately commercialise new quantum research and technologies.

We are here to say "**if there is more we can do, we are here and we want to help**".
Our focus now is to help industry restart. NPL will continue to offer direct support to businesses, we will be developing the digital metrology, virtual testing and validation to reduce the time it takes to get products to market and offer the data quality infrastructure to help businesses make good decisions, based on reliable data.

NPL National Physical Laboratory

The National Physical Laboratory (NPL) is 120 years young this year – providing science and engineering expertise for the UK for over a century and as such we have weathered our fair share of crises. From wars to recession and now through a pandemic, the science and engineering community have always risen to the challenge and supported society to get back on its feet.

NPL is the UK's National Metrology Institute, we look after the measurement standards and measurement infrastructure for the UK. It may not be immediately apparent why this is important but having confidence in your measurements really is crucial during a crisis.

NPL never closed, we have remained open throughout the pandemic, but of course have had to operate under different conditions. Certain services that we provide must keep going no matter the circumstances, this includes:

- **Healthcare services –** calibrations allowing for the delivery of cancer treatments, sterilisation of medical equipment, and assurance of radio-pharmaceuticals.
- **Timing –** we maintain UK's National Time Scale (UTC)NPL. Our atomic clock is accurate to within 1 second in 158 million years and contributes to Coordinated Universal Time (UTC) the global timescale. Accurate timing is essential for navigation, telecommunications, data transfer, fair financial trading
- **Environmental monitoring –** running air quality networks in England and Wales and calibrating the networks in Scotland, to ensure that we continue to meet clean air regulations
- **Nuclear safety –** calibrations of neutron detectors to allow continued safe operations in nuclear power stations.

Then of course we wanted to offer our expertise where we could in response to COVID-19. We asked our scientists and engineers to engage with industry and healthcare contacts to identify where we could offer the most benefit.

SUPPORTING THE IMMEDIATE HEALTH CRISIS

We offered free access to our engineering expertise for organisations working on development of new ventilators, offering testing and validation to quality assure the products and ensure that they met safety and quality standards as well as additional measurement support to enable them to scale up production.

Alongside this, our own engineers have been working on designing new prototype ventilators for use in developing economies. A project conceived by one of our engineers, Jean Morris, who as part of a multidisciplinary team from across NPL - rapidly iterated several concepts to develop an affordable ventilator design. One of the final designs, the PocketVent, costs approximately £1k, a factor of 10 less than a commercial ventilator unit and has been designed by a team of engineers including Jean, and her colleagues Joshua Schofield, Joshua Bayfield, Chris Bull and Arthur Vie – three of whom are early in their career having completed their training through the NPL apprenticeship.

The ventilators were designed to be simple-to use, portable and lightweight and maintain key functionality as well a control panel and detailed data display. All the parts for the ventilator are either made with common machine tools, are easily-sourced off the shelf components, or can be shipped by multiple global suppliers. Design decisions were driven by consultation with several clinicians, with a focus on patient safety and indispensable functionality. We tested our prototypes on a lung emulator which mimics the response of different types of patient's lungs and produces detailed information about the

performance of the devices tested, allowing them to be comprehensively evaluated. We are now actively looking at the further development of this ventilator with partners to make sure it meets the needs of developing economies and their health care systems.

We have been supporting the testing and validation of personal protective equipment for use in NHS and care home settings and have been working closely with a community project, Protecting Heroes. The Protecting Heroes team specialise in industrial engineering and design, they have worked to develop face shields for deployment to the NHS front line. NPL have been delighted to support them throughout the process from initial evaluation, revisions to designs, to ensuring that the face shields passed quality and safety standards, receiving CE certification. NPL have also assisted by delivering advice on the supply chain and safe assembly of the face shields, ensuring confidence in the quality of the product at all stages of the process. We have set up a temporary hub at the NPL sports club where volunteers from NPL put together and pack the face shields ready for distribution. Protecting Heroes are now making 1800 face shields a day and produced over 30,000 so far.

We have a great data science team at NPL and during the pandemic they have been supporting the Royal College of GPs to boost their team's resilience and ensure that health data reports for Public Health England can continue to be delivered.

Our socially distanced engineering team who worked on the PocketVent- from Left to Right: Jean Morris, Chris Bull, top right screen – Joshua Bayfield, bottom right screen – Arthur Vie, Joshua Schofield

Now as lockdown is lifted, UK companies need to operate differently, to accommodate social distancing, to adjust to disruptions in their supply chains and to deal with the demand shocks of the pandemic.

We have asked UK businesses to #TellNPL what they need from us, as the science and engineering community needs to pull together to **make sure that businesses can access our support, expertise and facilities to enable economic recovery.**

INCREASING PRODUCTIVITY

The UK's measurement infrastructure provides vital support for business, enabling access to the research, tools and techniques, standards and facilities to test products in the lab and within real world environments. This means customers can be confident in the performance, safety and security of what they are purchasing. Better measurement can help improve the technical performance of instruments and process control equipment, which in turn enables the creation of appropriate protocols for testing safety and performance, and the **faster commercialisation and adoption of new technologies.**

We will keep offering **direct support to business to help industry restart.**

DIGITAL TRANSFORMATION

Discussions with the manufacturing sector suggest we can expect a change in attitude and behaviour towards research and development activity. Instead of research moving forward in incremental steps, manufacturers are expecting to go for major step changes – in other words, moving straight to the next generation of technology. We are seeing more companies looking at how they can automate processes and benefit from AI and Machine Learning to boost their productivity. COVID-19 is going to be a catalyst for an even faster move to industry 4.0.

We will be **working directly with industry** enabling the development of data quality standards and frameworks so they can have **confidence in the data** they are collecting and **confidence in the decisions** that they are making based upon it.

GETTING PRODUCTS TO MARKET SOONER

The Coronavirus crisis has shown how difficult it can be to get products to market quickly, having tested and certified that they meet the required standards.

NPL are experts in physical testing but to make processes across all industrial and manufacturing sectors more agile in the recovery phase and beyond, we also need to **develop the UK's virtual testing capabilities**, making use of digital technologies to **get novel products to new markets faster.**

Instead of having to send people to test items in situ or send products to NPL, we will work through the National Measurement System programme to develop a combined digital and physical test programme. Virtual testing can take place at both the design and production stage, reducing potential errors earlier on in the process.

Protecting Heroes face shield in use!

CONCLUSION

NPL and other Public Sector Research Establishments are often called upon in times of crisis. As National Laboratories we work all year round for the benefit of society. However, in the Government Office for Science 2019 report "Realising our ambition through science"[1] it states our PSREs are underutilised and more can be done to exploit them.

Reference

1 Government Office for Science (2019) Realising our ambition through science: Government Science Capability Review https://www.gov.uk/government/publications/government-science-capability-review

SCIENCE UNDER LOCKDOWN

"We will be guided by the science" **has been a recurring mantra throughout the Covid-19 crisis. But how does science keep going under lockdown? Caroline Wood explores how the measures taken by the Science and Technology Facilities Council (STFC, part of UK Research and Innovation, UKRI) have allowed vital research to continue.**

THE CENTRAL LASER FACILITY – SHINING A LIGHT ON THE CORONAVIRUS

Professor John Collier leads the UK's Central Laser Facility (CLF), based at STFC's Rutherford Appleton Laboratory in Harwell, Oxfordshire. The facility has 200 staff and boasts some of the world's most impressive lasers, capable of imaging detail at the single molecule scale.

Professor John Collier is Director of the Central Laser Facility.

For John, there was never any question of whether CLF should remain open in some capacity when the lockdown was imposed. With their unique facilities, he knew that they could help to discover valuable knowledge about the coronavirus. Within days, CLF issued a Rapid Access Call for research relevant to the SARS-CoV-2 virus and Covid-19, using the facility's high-resolution microscopy suite called Octopus. But this was only possible thanks to advance planning and the fact that much of the facility can operate with a very low level of staff. "The main reason we have been able to keep going is that many of our lasers can be operated by only one or two trained scientists" John says. This means that CLF now has a very different environment to 'business as usual', due to the complete absence of the wider scientific community from the site. "Normally we would have three to four university groups on Octopus at any time, who would participate in the experimental procedures" John says. "We are now having to reconfigure everything so that external users can participate remotely in real time. It's not ideal – we'd rather be helping these groups to design and run their own experiments."

Even so, this has facilitated several clinically-relevant experiments including an investigation into the cellular response to a potential drug treatment designed to reduce the inflammatory response in the lungs (often the cause of death in Covid-19 cases). "With colleagues on the Campus at the Diamond Light Source, the electron Bio-Imaging Centre and the Rosalind Franklin Institute, we have also been working on projects to map in high resolution where the coronavirus goes once it enters a cell and which cellular components it interacts with" John says. A further experiment is exploring whether anti-viral nanoparticles could target reservoirs of coronavirus in brain neural tissue. It is unusual for such a high proportion of CLF's work to have a virology basis, and there have been some challenges in handling the experimental samples. "Normally, users would bring living samples to us, but now we are having to establish delivery chains to make sure cell samples arrive intact" John says.

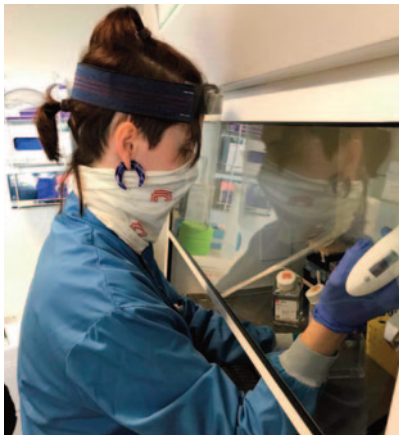
ADVANCE PLANNING

Since a large part of scientific research involves troubleshooting problems, it is not surprising to learn that John was already convening daily coronavirus-focused business continuity meetings several weeks before the lockdown. It was clear that reducing on-site staff numbers to the bare minimum required to remain operational meant that most would have to work from home. "We realised that half the department was not set up for home working, so we immediately began sourcing laptops, cameras and WiFi dongles. This meant that by the time the lockdown was imposed, our staff could get set up for remote working very quickly." Besides this foresight and preparation, some fortuitous timing also helped the community to adapt. CLF are involved with several projects currently in the design and modelling stage, including the Extreme Photonics Application Centre. "This has given us a lot of computer-based design and modelling work to do, so we are still being productive" says John. "For other researchers, it's been a chance to finally work through a backlog of data – I expect a lot of papers will be written during this time!"

But ultimately, science needs a continual flow of data and John's challenge has been to work out how the rest of the facility can safely reopen. "The larger facilities, such as the Vulcan Laser, will be easier as there is more space for people to move around, and much of it is automated" he says. The smaller laboratories used by multiple groups will be more problematic. Approaches adopted have included assigning individuals or groups specific zones; alternating between different groups each week and introducing a Monday-Thursday working week, to allow any traces of the virus to die off over the weekend should it be present. But even with these measures in place, John worries about the long-term repercussions for early-career researchers, particularly since 50-60% of the facility's users are PhD students at a critical part of their research training.

Elsewhere, other STFC labs and facilities have also been trying to keep work as 'business as usual' as possible and to contribute to the effort against coronavirus. STFC's Scientific Computing Department, for instance, are continuing to develop software for determining the 3D-structure of proteins from crystallography and electron microscopy data. This is now being used to understand how the coronavirus spike protein enables it to gain entry into human cells.

Meanwhile, STFC's ISIS Neutron and Muon Source facility is working to be operational again in the autumn, whilst at the same time continuing to publish numerous new scientific findings and running various online webinars for its large research community. STFC has also run its 3D printing capability 24/7 to produce PPE for local NHS Trusts and hospitals, including face shields and headbands. □



Researchers working under social distancing guidelines at STFC's Central Laser Facility. © Central Laser Facility

RESEARCH COMPLEX AT HARWELL – BUILDING UP CAPACITY

Materials chemist Dr David Payne is Interim Director of the Research Complex at Harwell, located on the Harwell Campus. Although the Campus closed when lockdown was introduced, the Research Complex remained open. David and the core team he leads swiftly brought in new measures that allowed them to continue their safe working capacity, whilst launching new projects on tackling Covid-19. At the time of writing, 40 researchers can work in the building at any time.

Dr David Payne is Interim Director of the Research Complex at Harwell. He is also a Reader of Photoelectron Spectroscopy of Materials at Imperial College London.

"It's been a while since I was a PhD student and spending all my time at the bench" David says. "So my initial action was to 'think' my way through the laboratory buildings and assess, to the highest detail, every possible source of potential infection and the areas where social distancing cannot be easily maintained." According to David, the core team have done "an incredible job" in making the Research Complex Covid-secure. One of their first steps was to get rid of any pen and paper sign-in sheets for out-of-hours working and replace these with a swipe card system, so that the Security Officers would be aware when users left. Using the floor plans, the building was divided into zones which could safely contain researchers, with a variety of different access points. "We had been looking into introducing an online system for hot-desking, so it has been relatively easy to modify this for the labs themselves, so that scientists could 'check in' remotely in advance." says David. "What is important for us is how to find the balance between individual research autonomy against needing to manage occupancy and use of space. Our system allows researchers to plan their work better, and allows others to see this in advance and accommodate their work around others." Using this system, they hope to further increase the number of researchers allowed in the building at any one time.

According to David, sharing best practice has been invaluable, including his work as part of STFC's Bronze Business Continuity team. "This made me aware of what colleagues in other facilities were doing, besides the vital services that support research" he says. "Everyone has stepped up to the challenge and we've all worked hard with a common purpose to come up with solutions." Aware of the need to prioritise PPE, David and his team have been keen to embrace innovative alternatives.

They have installed new door handles that dispense alcohol hand gel besides replacing exit push-buttons with motion activated ones, thereby removing a common touch point. "All these small cumulative changes have enabled our vital research into coronavirus to continue, and now accelerate, with one of our groups at the Research Complex recently submitting a research article on Covid-19 for Peer Review" he says.

"The real challenge though is that science is an inherently social activity. There are certain activities you just can't do in isolation, even with Zoom meetings" David says. One of the things he misses most is the chance to discuss the latest research findings with scientists from across the world. "This must be the first time in many years when I am not flying overseas for a conference, and in many ways that is a good thing. My carbon footprint is much better now, which I'd like to maintain even after things have gone back to normal." Like John, he is also worried about the long-term repercussions on PhD students and other early-career researchers. "How can we safely train the next generation of scientists? At the moment, we are only looking at the immediate crisis in front of us but if this goes on, there will be impacts we won't see until many years down the line." □

Interviews conducted by:
Dr Caroline Wood
Parliamentary Affairs Officer
Science and Technology Facilities Council (STFC)

UKRI Science and Technology Facilities Council

FROM LOCAL TO THE FUTURE: HOW ENERGY SYSTEMS ARE BEING TRANSFORMED

OR HOW WE CAN ENSURE OUR ENERGY SYSTEM IS NOT MESSED UP

Professor Malcolm McCullough

Associate Professor in Engineering Science and Group Leader of the Energy and Power Group at the University of Oxford

Did you know that by the end of this parliament, projections show that power capacity from all the connected electric vehicles in the country will be greater than all our nuclear power stations?

Our energy systems are changing fast. When a system evolves slowly, the challenges are well known and increasingly focused efforts are needed to eek out extra value. However, when a system changes rapidly, the challenges are not yet discovered and we need a broad, adaptive perspective to understand what the new societal value will be.

SO WHAT?

The question above shows three ways in which the system is changing rapidly:

Decentralisation

Firstly, the power system is transforming from being largely centralized to largely decentralized. The assets that create energy, and hence societal value, used to be large centralised power stations. In the new system *energy storage* will be a significant provider of value, as it will be distributed across the many local contexts where people live. Our challenge is how can we effectively meet national goals and take account of local opportunities and constraints.

Rate of change

Secondly, for the first time in over 50 years, the rate of change for the power sector is faster than political timescales. It takes at least 10 years to build a large fossil fuel power station – over which time the political regime can change several times, with changing priorities that create risk to the developer. Now technology is changing at a much faster rate – and bringing dramatic cost reductions for renewable technologies. For instance in 2008, the cost of solar modules started to fall dramatically, undermining the economic forecast models developed for the Feed in Tariff for solar PV. Looking forward, the emergence of long-life batteries from Tesla for example, will mean reduced battery degradation, and costs, enabling Vehicle to Grid (V2G) services.

It's not just about the power sector

Thirdly, there is a rapidly approaching potential collision between the transport and power sectors. The rapidly developing coupling between the two sectors has already started to have unexpected consequences. A large motor vehicle manufacturer recently obtained electricity generating licences in multiple jurisdictions. This new actor could well have market dominance in the power sector in a few years. The transport sector could also look to provide radically different service offerings to customers, where V2G services cross-subsidise mobility.

Space heating is also being electrified, implying a further potential collision between the building sector and power sector. The arbitrage of thermal comfort and power will lead to innovative business models, both for new housing developers but also for retrofit.

TIME TO CHANGE!

When a system evolves slowly, the challenges are well known and increasingly focused efforts are needed to eek out extra value. However, when the system changes rapidly, many of the challenges are unknown and we need a broad, adaptive perspective to uncover the challenges and to effectively unlock the new value.

Most of the existing relevant

institutions to regulate and operate the power system take a centralised, siloed, slow and methodical approach, which is no longer fit for purpose. As a nation we risk missing the once in a lifetime opportunity to maximise the rewards from this exciting transformation.

NEW TRIAL TO DISCOVER THE UNKNOWN UNKNOWNS

It is impossible to follow the usual evidence based policy route when the evidence is not fit for purpose. Therefore, we are trialling a new process – the **lean ecosystem approach** – that can efficiently manage a system which is rapidly evolving and will exhibit unexpected outcomes along the way. We are building on the core principles of the scientific method – *hypothesis, test and measure, evaluate, repeat until measurements yield data that is explained by the hypothesis* – with an approach to effectively manage change and the Rumsfeldian challenge of unknown unknowns. You may recognise that this iterative technique has familiar counterparts from complex IT projects – *agile* – to rapid product development – *lean startup* and *minimum viable product* (MVP). We add a systems flavour to make it more appropriate.

The lean systems approach was developed to enable rapid, effective, development of a Local Energy system in Oxfordshire, (Project LEO), one of the four demonstrator projects of the Innovate UK funded Industrial Strategy Challenge Fund *"Prospering from the Energy Revolution".*

The approach has five key steps, with built in feedback loops to ensure a clear outcome, see Figure 1.

A) Defining the Societal Goals

In our analogy to the scientific method the first step is to set up the hypothesis.

All systems exhibit a purpose, and this is the most important characteristic of a system. Step A explicitly brings together key stakeholders, including political and civic, to converge and prioritise the key goals that need to be achieved by the system. This process enables a clarity of purpose across all the stakeholders, and minimises the negative effects of any bounded rationality by different actors.

The goals could (should) go beyond the usual energy trilemma – ie *clean, affordable and secure* – to include aspects such as an equitable or, better still, a just, outcome for all, jobs creation, levelling up, and national leadership.

Whatever the goals and priorities, it is important that there is transparency to ensure that all participants are aware of, and agree on, the goals, and are all broadly working towards them. Prioritising the goals enables a clear process of decision making. And because this is an adaptive process, if the goals become no longer appropriate, there is a clear process as to how they can be changed.

B) Theory of Change (TOC)

In our analogy to the scientific method, this is the description of the proposed experimental approach.

This step could also be described as 'pathway' and 'back casting'. The key essence is to build a conceptual understanding of how we will journey from now to meet the goals. Like all models, it will be imperfect. The TOC is useful as it makes explicit the assumptions of how the proposed interventions will influence the system and achieve a desired outcome. It is also used to identify key performance indicators, both leading and lagging. →

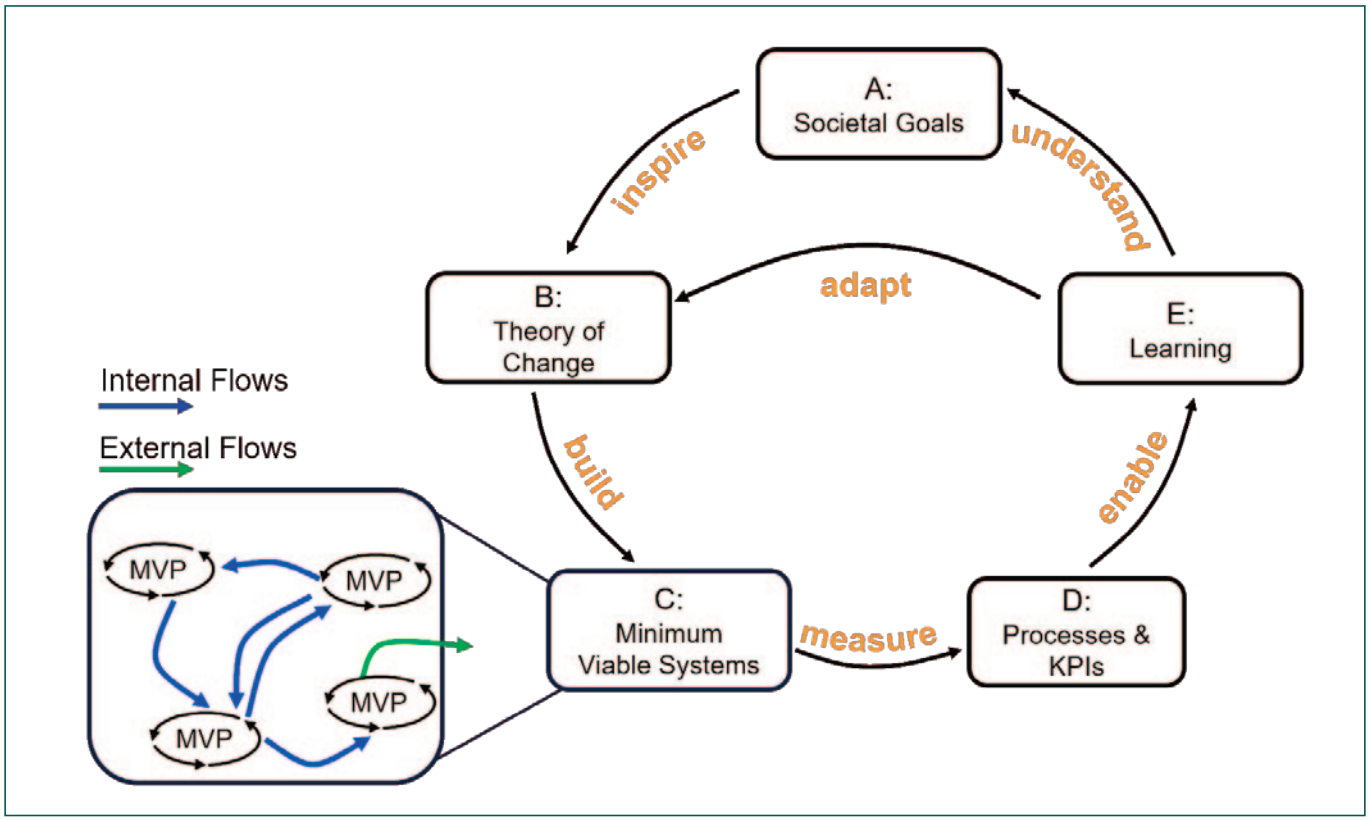


Figure 1 Overview of the Lean Ecosystem Approach

C) Minimum Viable System

In our analogy to the scientific method, this step is the experiment.

The next most important intervention in the TOC is identified, as is the minimum number of actors. A minimum viable system is created to test if the intervention does as expected.

An MVS consists of a group of two or more actors that interact to achieve a specific outcome. The process helps to identify the required actors, processes and interactions between the actors to achieve the desired outcome, and whether it is achieved as expected. The MVS ensures that mechanisms are in place to record the relevant Key Performance Indicators (KPIs, identified in the TOC and from the output required) and process maturity.

At the start, the processes can be done manually, or by using proxy methods. It is usual that each actor has a different level of maturity of their particular competence and interface with other actors. Part of the learning is for each actor to identify where effort should be deployed to maximise value. This leads to an effective and efficient co-development of the system across multiple actors.

D) Measure KPI and process maturity

In the analogy to the scientific method these are the measurements.

The actors run a trial and collect the relevant data from the KPIs and process maturity. The data should be formally recorded and shared with all partners. This approach allows for evidence to be gathered and used to adapt in-flight.

E) Learn and adapt

In the analogy to the scientific method, this is the assessment of the measurements against those predicted by the hypothesis.

The data is used both to determine if the processes are sufficient and to identify any unexpected behaviours. Having learned from the data, there are then three opportunities to adapt. First is to improve the particular MVS processes or to share learning across other MVS that are in operation. The second is to update the TOC to better reflect the actual impacts and outcomes of interventions, and to possibly improve the intervention based on the evidence gathered. The third is to reflect on the societal goals, which may need changing, not only from the evidence of the trials, but also from wider societal changes and incidents.

This process allows for a self correcting system that can effectively manage both the unknown unknowns, but also the different timescales of technology, market, and political change.

OUR TRIAL: THE LOCAL ENERGY OXFORDSHIRE (LEO) DEMONSTRATOR

LEO started in April 2019, and brings together key stakeholders from local government, three innovative SMEs, including a V2G provider, the local DNO, one of the Big Six energy companies, a community energy provider and two local Universities.

The challenge: develop a local energy system that can be readily replicated throughout the UK.

In a workshop with all the stakeholders – including those beyond the core partners – two Societal Goals were identified:

1. Maximise asset utilization by balancing local energy as best possible given wider constraints; and
2. Provide equitable energy for all.

We realised Goal 2 was dependent on Goal 1, so Goal 1 was prioritised first.

We developed a TOC which identified that a flexibility market was key to unlock value from the assets. Secondly, a strategic local energy plan would be used to understand and shape the land use of a decarbonised electricity system. A third success factor is multi-organisational collaboration.

Within six months of starting, project LEO ran its first MVS trial (it has now run more than 10). At the start many of the processes were manual, yet revealed that large batteries may have to be reconfigured for providing flexible services and that issues of non-delivery are more complex than anticipated. The trial highlighted valuable issues to resolve such as who validates, what measurements are needed, what about partial delivery, impact of reliability of assets, what nature of contract needs to be put in place and more.

So far, LEO has demonstrated flexibility delivered by storage (via a bus depot battery), generation (a run of river hydropower scheme) and reduced energy demand (via changed settings in a library HVAC system). Each has yielded much learning, which each partner is rapidly incorporating into their practices.

WHAT'S NEXT?

In the runup to COP 26, the world's eyes will be on us. Now is the opportunity for the UK to take on a global leadership role in the energy transition. Energy systems are operating at both the national and the local scale. Now we have the opportunity to align our energy transition to our societal goals to maximise the benefits for all.

Our first step as leaders is to articulate our national societal goals for a clean energy transition which could include job creation, a levelling-up agenda, equitable and just provision of energy for all.

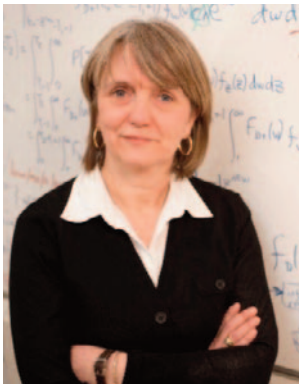
The legacy we leave to the next generation will be judged not on whether it was expedient but rather that it was right and effective, for the long term.

Links to evidence that Nissan has entered the power sector

"Nissan Wins License to Trade in Japanese Power Market" https://www.bloomberg.com/news/articles/2013-04-02/nissan-wins-license-to-trade-in-japan-electricity-market

"Nissan LEAF V2G Qualifies as a "Power Station" in Germany" https://v2g.co.uk/2018/10/nissan-leaf-v2g-qualifies-as-a-power-station-in-germany/ □

REAL-TIME NOWCASTING AND FORECASTING OF COVID-19 IN THE UK: THE FIRST WAVE?



Professor Daniela De Angelis
Professor of Statistical Science for Health
Deputy Director and Programme Leader
MRC Biostatistics Unit
University of Cambridge

During the first wave of the COVID-19 pandemic in the UK, the recurrent message has been that policy was being based on scientific evidence. But how did the interaction between policy-makers and science work and what type of contribution did scientists make to the decision process?

As of the 28th of June, over 300,000 individuals have been confirmed to have acquired infection with the SARS-CoV-2 virus. Amongst these over 40,000 have died. Over the last months we have learnt that the UK COVID-19 pandemic has three contexts: community, hospitals and care homes. A lock-down was introduced on the 23rd of March and we are gradually easing it, desperately trying to go back to normal life. Behind this knowledge and its input to policy, lies the work of many individuals: epidemiologists, mathematicians, statisticians and behavioural scientists who became members of relevant advisory groups. Figure 1 explains the structure of this interaction involving the Civil Contingencies Committee (COBR), the Scientific Advisory Group for Emergencies (SAGE), the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG), and the Scientific Pandemic Influenza Groups on Modelling (SPI-M-O) and Behaviours (SPI-B).

SPI-M-O is the committee providing quantitative evidence to SAGE, particularly on the dynamics of SARS-CoV-2 transmission. Constituted during the H1N1 Pandemic in 2009, it has been maintained over the years to ensure preparedness in the event of an influenza pandemic and recently extended to deal with other emerging diseases. Members come from a number of research institutions who freely accepted the invitation to contribute to the work. Regular commissions are received from Cabinet Office →

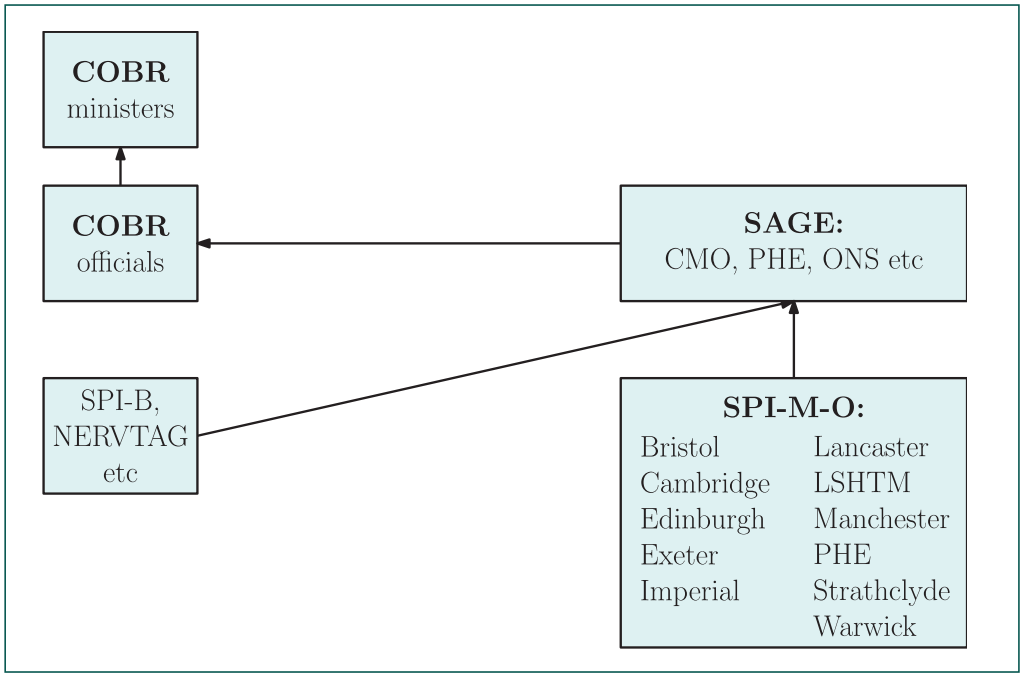


Figure 1

and answers are provided swiftly (24/48 hours!) from the various groups. Results are discussed at a SPI-M-O meeting and a consensus is reached. This consensus is communicated to SAGE and further discussed. The evidence provided may or may be considered in the final deliberations.

The questions posed throughout the pandemic have varied. During the containment phase, when the plan was to use tracing of contacts of symptomatic confirmed infected individuals, the need was to understand the potential of the pandemic. Then the questions asked were: how many people will get infected? When is the peak occurring? What is the likely duration? What age groups/geographical locations will be worst affected? In the mitigation phase, when the need was to mitigate the impact on the NHS by 'flattening the curve' there was a need to understand what non-pharmaceutical interventions would be most effective (e.g. Closing schools? Isolating symptomatic individuals? Banning big gatherings?). Once the lockdown was introduced, in the suppression phase, the questions were: how is the pandemic progressing after the lock-down? When would it be safe to re-instate social networks?

All these questions can be addressed through the use of models of SARS-CoV-2 transmission. These are mathematical constructs built to approximate the unobserved process of epidemic spread, i.e. the process of interaction of infected individuals into a (totally) susceptible population, spreading infection through

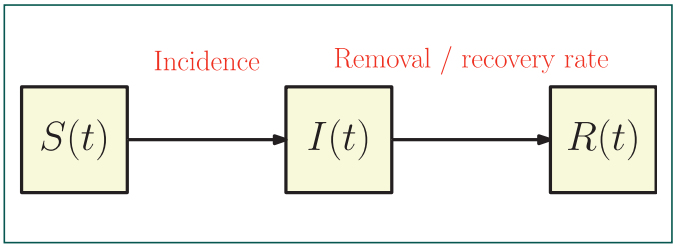


Figure 2

contact with these susceptible individuals. The infection spread will depend on how infectious the infected individuals are and the level of contacts they have with those susceptible. Figure 2 provides the simplest example of such models, referred to as the Susceptible, Infected, Recovered (SIR) model. As time progresses, more individuals become infected if no intervention is introduced, until the pool of susceptible individuals is depleted. People might then die or recover and no longer take part in the generation of infections, unless, after recovery, their immunity wanes and they become susceptible again. The quantity of interest here is the movement from the susceptible compartment to the infectious compartment, i.e. the number of new infections. These movements will depend on unknown quantities (parameters) reflecting the infectiousness of the virus and the likelihood of an infection given a contact. These unknown quantities involve the basic reproduction number, R_0, the average number of infections generated by a typical infected individual throughout their infectious period in a totally susceptible population. A value of R_0 higher than 1 indicates ongoing transmission.

The models adopted by the groups contributing to SPI-M-O have a much more complex structure than the simple SIR model in Figure 2. They typically include a higher number of compartments and further stratify the population by age groups, geography and contexts (e.g. workplace, schools etc..). The interaction between susceptible and infected individuals in the different population strata, expressed as the average numbers of daily contacts, drives disease transmission and generates new infections until there are no longer susceptible individuals, or an intervention that reduces this interaction is introduced. In this more realistic context, the aim is to monitor the pandemic evolution over time by estimating the level of transmission, the number of new infections and predict future burden, in different age groups and regions.

In the last four months, the Medical Research Council Biostatistics Unit (MRC-BSU) at Cambridge University, has contributed, in collaboration with Public Health England (PHE), to SPI-M-O by providing regular updates on the state of the pandemic in England from a transmission model. The population is subdivided into four categories: susceptible, infected but not infectious, infected and infectious, recovered. We further stratify by age groups (< 1, 1–4, 5–14, 15–24, 25–44, 45–64, 65–74, 75+ years old) and by the seven National Health Service regions. The transmission between groups is informed by the POLYMOD study (Mossong et al, 2008), giving the mean number of contacts between the different age groups and contexts, updated throughout the pandemic to account for changes in behaviour (E. van Leeuwen, F. Sandmann, 2020); literature from the Chinese pandemic provides information on the natural history of SARS-CoV-2 (Li et al, 2020; Verity et al, 2020) ; and sequential serological surveys from testing blood donors over time and in different regions provide information on the proportion of the population that has already been infected (https://www.gov.uk/government/publications/national-covid-19-surveillance-reports/sero-surveillance-of-covid-19). All these data sources are then combined with data on daily numbers of age and region-specific deaths in individuals with laboratory confirmed SARS-CoV-2 to reconstruct the underlying number of infections and characterise transmission nationally and in the different regions. Death data, although a lagged signal of infection, provide information on the shape of the epidemic curve; and data from serological studies, giving information on the proportion of the population in different age group with antibodies, inform the magnitude of the pandemic. The typical output, produced regularly (https://www.mrc-bsu.cam.ac.uk/now-casting/), included: the reconstructed number of infections over time; trends in R_t, the *effective* reproduction number (now referring to a population not totally susceptible), an indicator of ongoing transmission; and

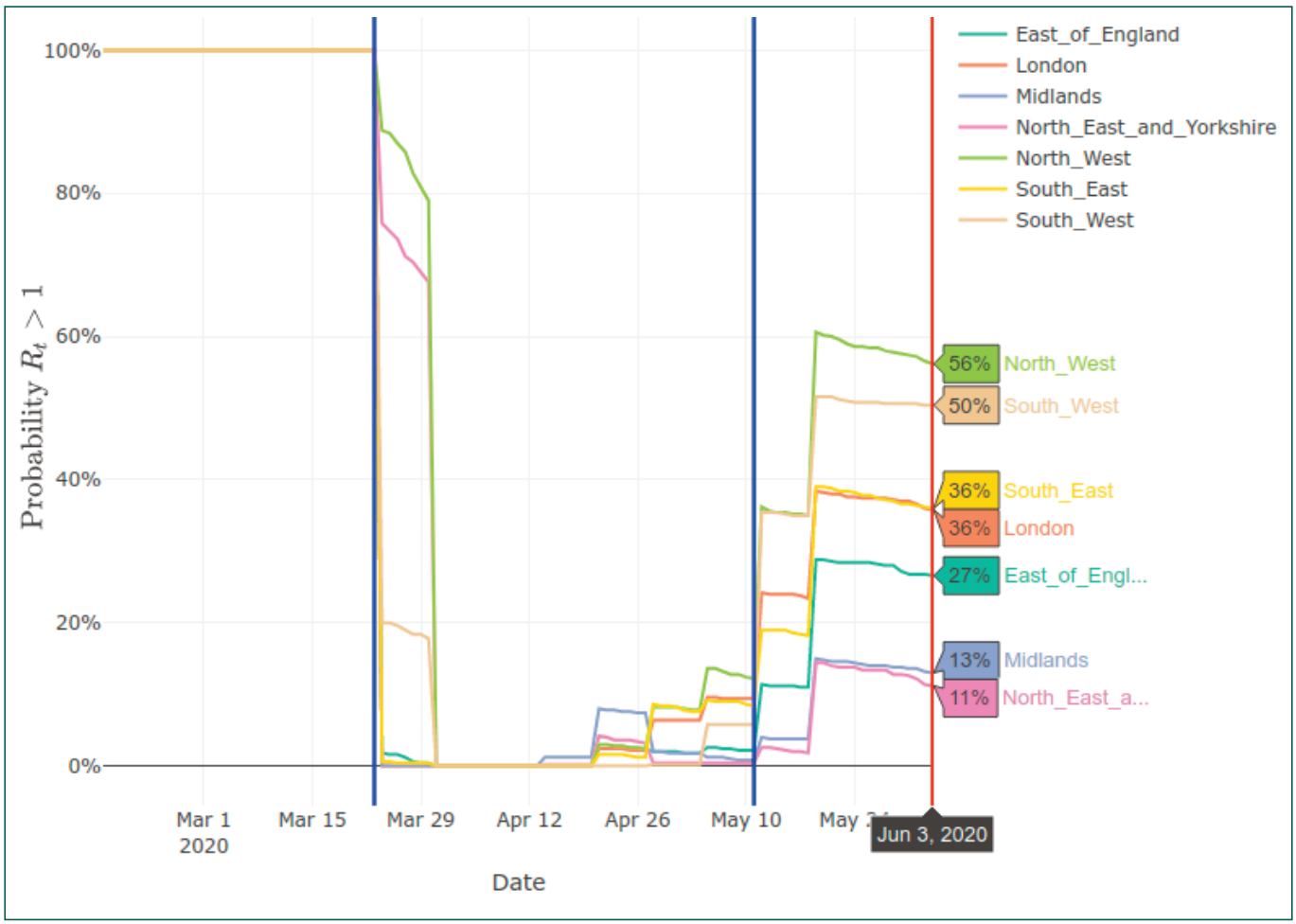


Figure 3

short-term predictions for the number of deaths. Figure 3 gives an example of these outputs, portraying the probability of R_t being above the value of 1 in the different regions at the beginning of June.

It this type of quantification, provided by the different groups, that gave evidence to policy makers to monitor levels of transmission and inform decisions.

Currently, transmission appears to be slowing down in all regions of England and the number of daily infections is decreasing over time. The estimated proportions of already infected individuals in the various age groups and regions are, however, low, alerting to the possibility of a second wave of infection. So, continued monitoring remains essential. The approach taken until now will need to be complemented by more granular surveillance tools aimed at identifying and managing local outbreaks.

These interesting times offer plenty of exciting professional experience to a statistician studying disease transmission like me!

J. Mossong, N. Hens, M. Jit, P. Beutels, K. Auranen, R. Mikolajczyk, M. Massari, S. Salmaso, G. S. Tomba, J. Wallinga, J. Heijne, M. Sadkowska-Todys, M. Rosinska, W. J. Edmunds, Social contacts and mixing patterns relevant to the spread of infectious diseases. PLOS Medicine. 5, e74 (2008).

E. van Leeuwen, F. Sandmann, Augmenting contact matrices with time-use data for fine-grained intervention modelling of disease dynamics: a modelling analysis (2020), doi:10.1101/2020.06.03.20067793.

R. Verity, L. C. Okell, I. Dorigatti, P. Winskill, C. Whittaker, N. Imai, G. Cuomo-Dannenburg, H. Thompson, P. G. T. Walker, H. Fu, A. Dighe, J. T. Griffin, M. Baguelin, S. Bhatia, A. Boonyasiri, A. Cori, Z. Cucunubá, R. FitzJohn, K. Gaythorpe, W. Green, A. Hamlet, W. Hinsley, D. Laydon, G. Nedjati-Gilani, S. Riley, S. van Elsland, E. Volz, H. Wang, Y. Wang, X. Xi, C. A. Donnelly, A. C. Ghani, N. M. Ferguson, Estimates of the severity of coronavirus disease 2019: a model-based analysis. The Lancet Infectious Diseases. 20, 669–677 (2020). □

CHANGE AND CHALLENGE ARE UPON US: PATHOLOGY, COVID-19 AND THE FUTURE

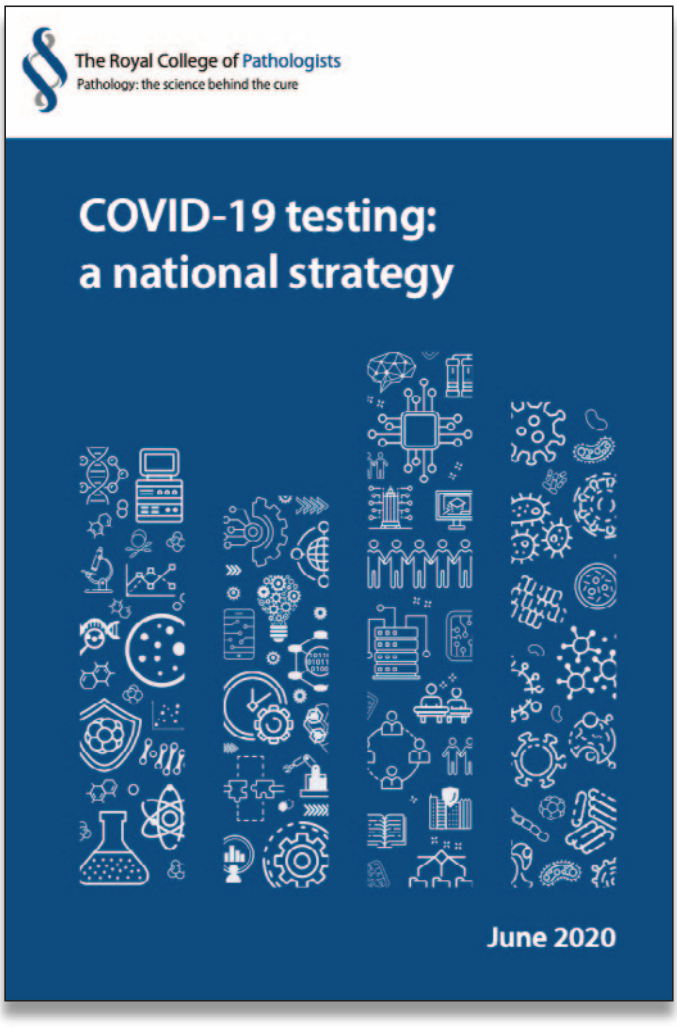
Professor Jo Martin is Professor of Pathology at Queen Mary University of London and honorary consultant at Barts Health NHS Trust.
She is currently President of the Royal College of Pathologists.

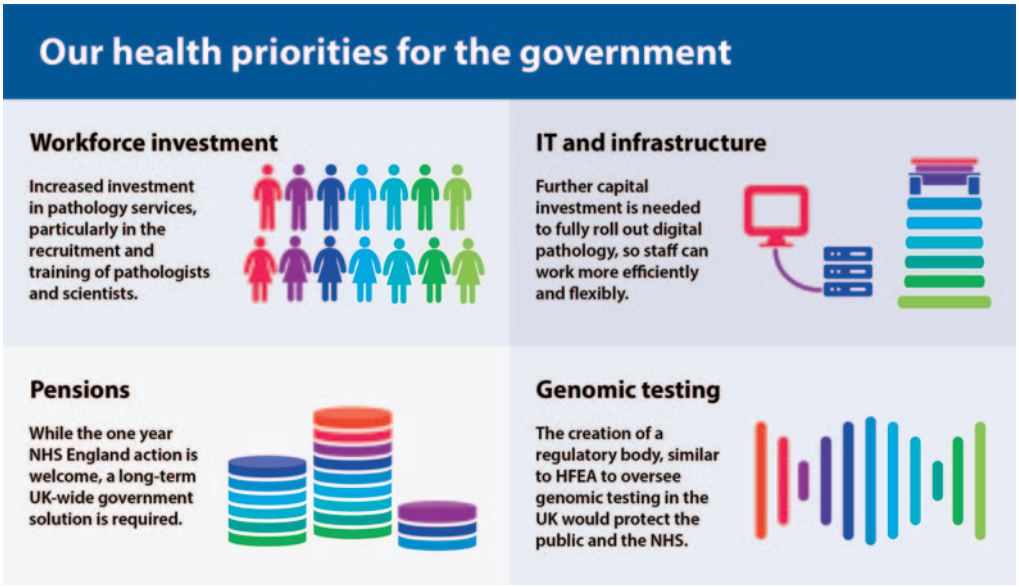
It has been a time of enormous change for everyone, all over the world. We have changed what we do and how we do it, including the services in which we work, in an incredibly short period of time and at a rapid pace with considerable personal effort. We have done this at a time when there has been huge change in our own circumstances in the face of personal loss or significant difficulties. We are grateful to everyone working in heath and social care for their continued efforts for patients and for the profession. Pathology has been vital in this huge transformation and the incredible skill, determination and dedication of our medical and scientist pathologists has been unwavering and inspiring.

Pathology covers 17 different specialty areas, and our work covers from before birth (reproductive sciences), thoughout life (haematology, clinical biochemistry), and after death (cellular pathology and forensic pathology). For some of our disciplines, especially virology, microbiology and immunology, developing, deploying and advising about testing and control, we have been at the very heart of the battle against COVID-19.

COVID-19 TESTING STRATEGY

In recent months, the College has carried out a huge amount of work on the development of a national strategy for COVID-19 testing. With the support of 22 organisations, we have brought the focus back to the purpose of testing, the skills for interpretation and quality control, and the key infrastructure and data connectivity that is needed, rather than just numbers of tests being performed.





The strategy looks past the peak of the epidemic for both viral and antibody testing and has been developed to help build robust process and structures that will work for the future. It sets out a vision for a future strategy with which clinical, scientific and policy stakeholders, including patient advocacy groups, can align. It forms the basis for a roadmap to delivery. It applies equally to all settings in which care is delivered, across all our population, and all age groups.

The implementation of this strategy needs to be planned and executed with the same energy and sense of urgency with which the initial response was handled. Testing is not something that is just done and counted. It is a process with clinical purposes for individual patients, for those who care for them and for the population at large. It is a conscious and targeted use of valuable materials and highly skilled professionals within the context of a pathway and purpose.

Our pathology professionals, working with partners in industry, the health service and public health bodies, have done exceptional work and deserve immense credit for the vast amount they have already achieved. Pathology training and professionalism has stood healthcare in good stead in recent times, and will do so for the future – through the pandemic and well beyond. The profession needs the appropriate resources to continue its vital work.

CROWDSOURCING NEW IDEAS

As part of forward-facing efforts, the College has been heavily involved in the development and championing of an innovative crowdsourcing platform Testing Methods 2020, working in partnership with the Department of Health & Social Care, the UK Bioindustry Association and BIVDA. This project has posed COVID-19 specific challenges for our community of pathologists, laboratory professionals and industry. Examples have included extraction-free rtPCR methods, alternatives to swab methods and multiplexing. A new challenge has also just been launched on 'greener testing' that is being championed by Dr Esther Youd, our Assistant Registrar, who is also our RCPath Trustee Board sustainability champion. This has suggestions on plastic-free swabs, and we are looking forward to ways in which we might be able to reduce our plastic use for the transport of samples.

WORKFORCE AND TRAINING

As we move into the next phase of dealing with the COVID-19 epidemic, and as we try to build back up to some form of normality in our health services, I am acutely aware that many of the problems around lack of workforce, especially in transfusion and histopathology, are still there. With the requirement to isolate for 14 days if 'tracked and traced', I have highlighted the specific risks around transfusion staffing and have asked all chief executives of acute trusts to urgently risk assess their own service. During my pre-pandemic lab tours, I saw several labs with only three people providing a 24-hour service. This is not sustainable.

Increased investment into pathology services to train and recruit more scientist and medical pathologists must be a priority during this parliamentary term.

I am acutely aware that many within pathology (and of course the entire health and social care service) have been operating flat out for many months. We are proud of what has been achieved, but very conscious of the challenges ahead. This epidemic will continue for the foreseeable future, and it has already seen some regional resurgences. Support must be provided to the workforce to ensure they are having adequate rest time, taking breaks and annual leave where possible.

YOU ARE WELCOME!

You will always be welcome for a visit in your local labs...meet those amazing professionals who are doing so much in the struggle against COVID-19. While you are there, also take the opportunity to see all the other pathology expertise in action, and talk with those who make transplants possible, those who see that you have blood when you need it, those who diagnose and guide treatments for cancer, and those in both human and veterinary pathology who do so much to control antimicrobial resistance. We are amazing! □

P&SC ONLINE DISCUSSION MEETING REPORT

Covid 19 – the statistics and the science underlying them, 29th June 2020

Charlotte Hall
Parliamentary & Scientific Committee

Covid-19 has altered almost all aspects of life as we know it. The virus, which was declared to be a global pandemic by the World Health Organisation in March, has caused significant disruption to work, social and family life. There have been over 11 million confirmed cases of Covid and tragically over 500,000 lives have been lost worldwide, with 44,000 of those being in the UK. However, behind the statistics and figures which have saturated the news lies a complex system of data collection and analysis.

On the 29th June 2020 a Parliamentary and Scientific Committee discussion meeting was held which not only discussed the statistics behind Covid, but also made history. For the first time ever a P&SC meeting was held online. Our guest speakers, Professor Sylvia Richardson CBE, Professor Daniela DE Angelis, Professor Oliver Johnson and Professor Jo Martin, presented to 140 attendees from the comfort of their own homes via Zoom, followed by a virtual Q&A. Despite the change in circumstances and not being able to meet in person, the quality and outcome of the meeting did not suffer. The compelling presentations and thought-provoking questions from attendees allowed for not only a greater understanding of the topic, but also much food for thought.

Data collection and analysis has been instrumental in the fight against Covid, however in the early stages there was little knowledge surrounding the virus and the rate of transmission. Statistical models were put into place to predict the spread of the virus, but as more data became available and as the stages of the pandemic progressed so the models were adapted. However, even with all the data and resources there is still a level of uncertainty. In order to move forward and improve estimations made by predictive models, their accuracy needs to be analysed and the high-quality models can be combined to present more accurate predictions.

Countries have approached data collection in different ways with varying standards. This brings the question, how can we compare the virus management globally with such differing statistical approaches? To address this challenge there are many other considerations to take into account such as population densities, availability of healthcare, geographical factors and more. It must also be noted that different countries will not all be at the same stage of the virus, but it is vital that every nation ensures that all data acquisition is both consistent and transparent in its communication. One specific point raised was should the inclusion of indirect Covid deaths be recorded, and the simple answer was yes. All causes of death should be represented and the data should be secondarily segmented.

A major concern highlighted was the lack of knowledge surrounding the asymptomatic viral transmission of Covid. The simple reasoning behind this is that people who are asymptomatic are not being tested and it was suggested that areas which have large Covid outbreaks take part in mass testing. The results of expanding the testing could lead to the reduction of cases caused by asymptomatic carriers.

All data collated has been analysed by large teams of STEM workers and Parliamentarians. Given that the Government's stated that their response to Covid would be 'led by Science', we are left with the question - is the data being utilised efficiently?

As the country continues to adapt and move forward from the effects of this devastating pandemic, so does the P&SC. We have taken an initial step by successfully holding our first virtual meeting. Whilst the future of our return to Portcullis House is unknown, the advancement of our online resources alongside support from our members has made the continuation of our meetings a certainty. □

Professor Sylvia Richardson

Professor Oliver Johnson

Professor Daniela De Angelis

Professor Jo Martin

Stephen Metcalfe MP

HOUSE OF COMMONS SELECT COMMITTEES

BUSINESS, ENERGY AND INDUSTRIAL STRATEGY COMMITTEE

The Business, Energy and Industrial Strategy Committee scrutinises the policy, spending and administration of the Department for Business, Energy and Industrial Strategy and its public bodies, including Ofgem, the Financial Reporting Council and the Committee on Climate Change. It is chaired by Darren Jones MP, who was elected in succession to Rachel Reeves MP on 6th May 2020.

The Committee regularly holds accountability evidence hearings with Government Ministers and with bodies such as the Financial Reporting Council, the Committee on Climate Change and Ofgem. The BEIS Committee also hears from a range of stakeholders in the course of its work, receiving evidence from academics, business groups, NGOs and charities to its inquiries.

Current Inquiries:

- Post Office and Horizon - Opened 4 March 2020
- My BEIS inquiry - Opened 5 March 2020
- Net zero and UN climate summits - Opened 6 March 2020
- The impact of coronavirus on businesses and workers - Opened 13 March 2020
  Deadline 31 August 2020
- Delivering audit reform - Opened 18 March 2020. Deadline 31 July 2020
- Work of the Department and Government Response to coronavirus - Opened 14 April 2020
- Post-pandemic economic growth - Opened 3 June 2020. Deadline 17 July 2020

For further details: Tel: 020 7219 5777 Email: beiscom@parliament.uk

ENVIRONMENTAL AUDIT COMMITTEE

The remit of the Environmental Audit Committee is to consider the extent to which the policies and programmes of government departments and non-departmental public bodies contribute to environmental protection and sustainable development, and to audit their performance against sustainable development and environmental protection targets.

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

From its beginning in 1997, in carrying out its environmental 'audit' role the Committee has had extensive support from the National Audit Office, providing seconded staff and research and briefing papers.

Current Inquiries

- Electronic Waste and the Circular Economy - Opened 13 March 2020
- Technological Innovations and Climate Change: Offshore Wind - Opened 6 April 2020
- Technological Innovations and Climate Change: Hydrogen - Opened 7 May 2020
- Greening the post-Covid Recovery - Opened 13 May 2020. Deadline 14 August 2020
- Energy Efficiency of Existing Homes - Opened 18 May 2020. Deadline 13 July 2020

For further details: Tel: 020 7219 5776 Email: eacom@parliament.uk

SCIENCE AND TECHNOLOGY COMMITTEE

For further details: Tel: 020 7219 2793
Email: scitechcom@parliament.uk

The work of many Government departments makes use of — or has implications for — science, engineering, technology and research. The Science and Technology Committee exists to ensure that Government policies and decision-making are based on solid scientific evidence and advice. It is chaired by Greg Clark MP.

The Committee has a similarly broad remit and can examine the activities of government departments that make use of science, engineering, technology and research (otherwise known as science for policy). In addition, the Committee scrutinises policies that affect the science and technology sectors, such as research funding and skills (often referred to policy for science).

Current Inquiries

- UK Science, Research and Technology Capability and Influence in Global Disease Outbreaks
  Opened 20 March 2020. Deadline 31 July 2020
- Commercial genomics - Opened 9 April 2020
- UK telecommunications infrastructure and the UK's domestic capability - Opened 9 April 2020

HEALTH AND SOCIAL CARE COMMITTEE

The Committee scrutinises government and in particular the work of the Department of Health and Social Care. It is chaired by Jeremy Hunt MP.

The Committee also scrutinises the work of public bodies in the health system in England, such as NHS England and Improvement, Public Health England and the Care Quality Commission, and professional regulators such as the General Medical Council and the Nursing and Midwifery Council. They do so by holding inquiries on specific topics and accountability hearings with the Secretary of State, and Chief Executives of relevant public bodies.

Current Inquiries

- Management of the Coronavirus Outbreak - Opened 3 March 2020
- Pre-appointment hearing for the role of Chair of NICE - Opened 4 March 2020
- Social care: funding and workforce Opened 10 March 2020.
  Deadline 31 July 2020
- Delivering Core NHS and Care Services during the Pandemic and Beyond - Opened 22 April 2020. Deadline 31 July 2020

For further details: Tel: 020 7219 6182 Email: hsccom@parliament.uk →

MEMBERSHIP OF HOUSE OF COMMONS SELECT COMMITTEES

BUSINESS, ENERGY AND INDUSTRIAL STRATEGY COMMITTEE

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Alan Brown MP, Scottish National Party
Judith Cummins MP, Labour
Richard Fuller MP, Conservative
Nusrat Ghani MP, Conservative
Paul Howell MP, Conservative
Mark Jenkinson MP, Conservative
Ruth Jones MP, Labour
Charlotte Nichols MP, Labour
Mark Pawsey MP, Conservative
Alexander Stafford MP, Conservative

ENVIRONMENTAL AUDIT COMMITTEE

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Duncan Baker MP, Conservative
Sir Christopher Chope MP, Conservative
Feryal Clark MP, Labour
Barry Gardiner MP, Labour
Rt Hon Robert Goodwill MP, Conservative
Ian Levy MP, Conservative
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Caroline Lucas MP, Green Party
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John McNally MP, Scottish National Party
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Alex Sobel MP, Labour
Shailesh Vara MP, Conservative
Claudia Webbe MP, Labour
Nadia Whittome MP, Labour

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Amy Callaghan MP, Labour
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Dr Luke Evans MP, Conservative
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Taiwo Owatemi MP, Labour
Sarah Owen MP, Labour
Dean Russell MP, Conservative
Laura Trott MP, Conservative

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Aaron Bell MP, Conservative
Dawn Butler MP, Labour
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Katherine Fletcher MP, Conservative
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Mark Logan MP, Conservative
Carol Monaghan MP, Scottish National Party
Graham Stringer MP, Labour
Zarah Sultana MP, Labour

HOUSE OF LORDS SELECT COMMITTEES

SCIENCE AND TECHNOLOGY COMMITTEE

The Science and Technology Committee has a broad remit "to consider science and technology". It is chaired by Lord Patel

The Committee scrutinises Government policy by undertaking cross-departmental inquiries into a range of different activities. These include:

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

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

Current Inquiries

- Ageing: Science, Technology and Healthy Living - Opened 25 July 2019
- The science of COVID-19 Opened 7 May 2020. Deadline 3 July 2020

HOUSE OF LORDS SCIENCE AND TECHNOLOGY COMMITTEE

The Lord Patel KT, Crossbench, Chair
The Baroness Blackwood of North Oxford, Conservative
The Lord Borwick, Conservative
The Rt Hon. the Lord Browne of Ladyton, Labour
The Baroness Hilton of Eggardon, QPM Labour
The Lord Hollick, Labour
The Rt Hon. the Lord Kakkar, Crossbench
The Lord Mair CBE, Crossbench
The Baroness Manningham-Buller LG DCB, Crossbench
The Viscount Ridley DL, Conservative
The Baroness Rock, Conservative
The Baroness Sheehan, Liberal Democrat
The Baroness Walmsley, Liberal Democrat
The Baroness Young of Old Scone, Labour

For further details: Tel: 020 7219 5750
Email: hlscience@parliament.uk □

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (POST)

POST is a bicameral body that bridges research and policy, providing reliable and up-to-date research evidence for the UK Parliament. It is overseen by a Board of MPs, Peers and external experts.

POST briefings are impartial, non-partisan, and peer-reviewed. Timely and forward thinking, they are designed to make scientific research accessible to the UK Parliament.

POSTnotes are four-page summaries of public policy issues based on reviews of the research literature and interviews with stakeholders from across academia, industry, government and the third sector. They are peer reviewed by external experts.

POSTnotes are often produced proactively, so that parliamentarians have advance knowledge of key issues before they reach the top of the political agenda.

And those produced in 2019 and 2020 were:

629: Cloud computing
628: Remote sensing and machine learning
627: Managing land uses for environmental benefits
626: A resilient UK food system
625: Marine renewables
624: Food fraud
623: Natural mitigation of flood risk
622: Online extremism
621: Infrastructure and climate change
620: 3D bioprinting in medicine
619: UK insect decline and extinctions
618: Bioenergy with carbon capture and storage (BECCS)
617: Climate change-biodiversity interactions
616: Low-carbon aviation fuels
615: Climate change and aviation
614: Brain computer interfaces
613: Non-custodial sentences
612: Autism
611: Human Germline Genome Editing
610: Misuse of Civilian Drones
609: Access to Critical Materials
608: Online Safety Education
607: Improving Witness Testimony
606: Compostable Food Packaging
605: Plastic Food Packaging Waste
604: Climate Change and Fisheries
603: Climate Change and UK Wildfire
602: Developments in Wind Power
601: Sustaining the Soil Microbiome
600: Climate Change and Agriculture
599: Early Interventions to Reduce Violent Crime
598: Advances in Cancer Treatment
597: Climate Change & Vector-Borne Disease in Humans in the UK
596: Chemical Weapons
595: Reservoirs of Antimicrobial Resistance
594: Limiting Global Warming to 1.5°C
593: Cyber Security of Consumer Devices

POSTbriefs are responsive policy briefings based on mini-literature reviews and peer reviews. Those produced in 2019 and 2020 were:

38: Understanding research evidence
37: Key EU space programmes
36: Understanding insect decline: data and drivers
35: Evaluating the integration of health and social care
34: Net Gain
33: Research for Parliament: Preparing for a changing world
32: 5G technology
31: Evaluating UK natural hazards: the national risk assessment

POST has also introduced some new short briefings that summarise the research around COVID-19:

COVID-19: Current understanding
COVID-19: Behavioural and social interventions
COVID-19: Insights from behavioural science
COVID-19: School closures and mass gatherings
Vaccines for COVID-19
Models of COVID-19: Part 1
Models of COVID-19: Part 2
Vaccines for COVID-19
COVID-19 misinformation
Face masks, face coverings and COVID-19
Models of COVID-19: Part 3
COVID-19 therapies
Mental health and well-being during the COVID-19 outbreak
Light switches and clusters: social distancing strategies for COVID-19
Contact tracing apps for COVID-19
COVID-19 and international approaches to exiting lockdown
COVID-19 in children
Immunity to COVID-19
Antibody tests for COVID-19
COVID-19 and social distancing: the 2 metre advice →

POST has also recently asked its COVID-19 Expert Database of 5500 experts what their main short-, medium- and long-term concerns are related to COVID-19 and what data they want to see the Government release. 17 articles covering different sectors are all available on the POST website here: https://post.parliament.uk/category/horizon-scanning/2020/

Ongoing and future projects approved by the POST Board.

BIOLOGY AND HEALTH

In production

Outward medical tourism

Disorders of consciousness

Researching gambling

Influence of industry on public health policy

Scheduled

Reformulation of food products

Testosterone and sports performance

Mental health impacts of COVID-19

Mental health impacts of COVID-19 on healthcare workers and carers

Living organ donation

Developments in vaccine technologies

ENERGY AND ENVIRONMENT

In production

Food waste

Global deal for nature

Heat networks

Plant genetic resources for food and agriculture

Scheduled

Sustainable cooling

Effective biodiversity indicators

Reforestation

Hydrogen

Regulating product sustainability

PHYSICAL AND DIGITAL SCIENCES

In production

Algorithms and accountability

Scheduled

Smart cities

AI and healthcare

SOCIAL SCIENCES

Scheduled

Screen time in young people

Distance learning

The POST Board oversees POST's objectives, outputs and future work programme. It meets quarterly.

Officers

- Chair: Adam Afriyie MP
- Vice-Chair: Professor the Lord Winston, FmedSci, FRSA, FRCP, FRCOG, FREng
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- Lord Haskel
- Lord Patel KT, FMedSci, FRSE

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- Paul Martynenko, FBCS
- Professor Sir Bernard Silverman, FRS, FAcSS
- Professor Dame Sarah Whatmore, FBA

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- Dr Grant Hill-Cawthorne, Head of the Parliamentary Office of Science and Technology
- Penny Young, House of Commons Librarian and Managing Director of Research & Information
- James Rhys, Principal Clerk, Committee Office, House of Commons
- Edward Potton, Head of Science and Environment Section, House of Commons Library
- Nicolas Besly, Clerk of Select Committees, House of Lords

Head of POST

- Dr Grant Hill-Cawthorne: 020 7219 2952

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

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For further information please go to POST's new website: https://post.parliament.uk/), its special COVID-19 briefings: https://post.parliament.uk/category/analysis/covid-19/, and for COVID-19 related expert analyses on the policy challenges that COVID-19 presents: https://post.parliament.uk/category/horizon-scanning/2020/ □

HOUSE OF COMMONS LIBRARY

The House of Commons Library is an independent research and information unit. It provides impartial information for Members of Parliament of all parties and their staff. This service supports MPs in their work scrutinising Government and legislation, and supporting constituents.

The Library provides confidential, impartial and bespoke briefing to Members of the House of Commons and their offices on a daily basis supporting the full range of parliamentary work, from policy development to constituency issues.

The Commons Library publishes a range of products including research briefings, shorter insight articles and briefings for non-legislative debates, all of which are available online for MPs and the general public. These briefings include in-depth and impartial analysis of all major pieces of legislation. The briefings also cover areas of policy, frequently asked questions and topical issues. You can find the briefings on the Commons Library website (https://commonslibrary.parliament.uk) where you can also sign up for personalised alerts for new or updated briefings in subject areas.

A recent focus of briefing has been the Coronavirus and a webpage provides access to all the relevant material published by the Commons Library as well as the Lords Library and POST (see https://commonslibrary.parliament.uk/coronavirus/).

In June 2020 it published a series of Climate Change Explainers (https://commonslibrary.parliament.uk/insights/climate-change-explainers/) covering a range of topics, including the basic science, UK and global emission trends, the history of global climate change negotiations, climate activism, green finance and possible solutions within nature and technology.

The Library has produced many research briefings around the debate on Brexit (see https://commonslibrary.parliament.uk/category/brexit/). These include most recently:

The UK-EU future relationship negotiations: Level playing field

Published 19 June 2020, CBP-8852

Brexit legislation: What has passed and what is yet to come?

Published 9 June 2020 (insight article)

The Science and Environment Section (SES) is one of eight teams in the Research Service in the House of Commons Library. In 2020 they have published, and continue to update, briefings on issues as varied as:

Fisheries: UK-EU future relationship negotiations

Published 19 June 2020, CBP-8927

This paper covers the future relationship negotiations with the EU around fisheries, including the positions of the UK Government and EU.

Brexit: energy and climate change

Published 19 June 2020, CBP-8394

A paper discussing key energy and climate change policies in relation to the negotiations on the future relationship between the EU and UK.

Medicines and Medical Devices Bill 2019-20

Published 19 June 2020, CBP-8699

This paper covers the progress of the Bill through the Commons. It seeks to provide the power to enable the existing regulatory frameworks to be updated at the end of the Transition Period.

Covid-19 and Black, Asian and minority ethnic communities

Published 17 June 2020, CDP-2020-74

A briefing for the debate on Thursday 18 June 2020 on the effect of Covid-19 on Black, Asian and minority ethnic (BAME) communities.

Economic regulation of the water industry in England and Wales

Published 4 June 2020, CBP-8931

The paper provides an overview of the price review process that sets customer bills and water company service targets every 5 years. It includes a summary of the 2019 price review that followed increasing public scrutiny of the sector.

Coronavirus: Testing for Covid-19

Published 19 May 2020, CBP-8897

An overview of testing for Covid-19 in England. It covers the different types of test that are in use and in development, as well as testing capacity and the criteria for being tested.

Agriculture Bill 2019-21

Published 11 May 2020, CBP-8702

This paper covers the progress of the Bill through the Commons, with remaining stages on 13 May.

Brexit and chemicals regulation (REACH)

Published 1 May 2020, CBP-8403

A paper discussing the EU REACH regulation for chemicals, the impact of Brexit on the chemicals industry and UK Government plans for a separate UK REACH regime after the end of the transition period. □

UK Research and Innovation

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UK Research and Innovation

Arts and Humanities Research Council | Biotechnology and Biological Sciences Research Council | Economic and Social Research Council
Engineering and Physical Sciences Research Council | Innovate UK | Medical Research Council
Natural Environment Research Council | Research England | Science and Technology Facilities Council

Website: www.ukri.org

Big challenges demand big thinkers - those who can unlock the answers and further our understanding of the important issues of our time. Our work encompasses everything from the physical, biological and social sciences, to innovation, engineering, medicine, the environment and the cultural impact of the arts and humanities. In all of these areas, our role is to bring together the people who can innovate and change the world for the better. We work with the government to invest over £7 billion a year in research and innovation by partnering with academia and industry to make the impossible, possible. Through the UK's nine leading academic and industrial funding councils, we create knowledge with impact.

Arts and Humanities Research Council

Website: www.ahrc.ukri.org

AHRC funds outstanding original research across the whole range of the arts and humanities. This research provides economic, social and cultural benefits to the UK, and contributes to the culture and welfare of societies around the globe.

Biotechnology and Biological Sciences Research Council

Website: www.bbsrc.ukri.org

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

Economic and Social Research Council

Website: www.esrc.ukri.org

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

Engineering and Physical Sciences Research Council

Website: www.epsrc.ukri.org

EPSRC invests in world-leading research and postgraduate training across the engineering and physical sciences. This research builds the knowledge and skills base needed to address scientific and technological challenges and provides a platform for future UK prosperity by contributing to a healthy, connected, resilient, productive nation.

Innovate UK

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

Innovate UK drives productivity and economic growth by supporting businesses to develop and realise the potential of new ideas, including those from the UK's world-class research base. They connect businesses to the partners, customers and investors that can help them turn these ideas into commercially successful products and services, and business growth.

Medical Research Council

Website: www.mrc.ukri.org

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

Natural Environment Research Council

Website: www.nerc.ukri.org

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

Research England

Website: www.re.ukri.org

Research England creates and sustains the conditions for a healthy and dynamic research and knowledge exchange system in English universities. Working to understand their strategies, capabilities and capacity; supporting and challenging universities to create new knowledge, strengthen the economy, and enrich society.

Science and Technology Facilities Council

Website: www.stfc.ukri.org

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

Association of the British Pharmaceutical Industry

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

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

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

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Website: www.amps-tradeunion.com

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

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

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

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

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

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

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

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

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

British In Vitro Diagnostics Association (BIVDA)

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

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

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

SCIENCE DIRECTORY

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

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

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

BSAC has members in 40 nations and active learners in more than 135 countries.

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

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

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

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

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

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

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

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

Cavendish Laboratory

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

The research programme covers the breadth of contemporary physics

Extreme Universe: Astrophysics, cosmology and high energy physics

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

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

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

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

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Our vision is integrated design to improve life, wellbeing and performance through science, engineering, technology and psychology. The Institute is one of the largest in the world representing the discipline and profession of Human Factors and Ergonomics. We have sector groups in most industries from defence to aviation and pharmaceuticals that provide expert advice to industry and government. We accredit university courses and consultancy practices and work closely with allied learned societies.

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

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We bring school students and their teachers

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- Primary; our local **Meet-a-Medic Programme** since 2005

Clifton Scientific Trust Ltd is registered charity in England and Wales 1086933

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The Council for the Mathematical Sciences is an authoritative and objective body that works to develop, influence and respond to UK policy issues affecting mathematical sciences in higher education and research, and therefore the UK economy and society by:

- providing expert advice;
- engaging with government, funding agencies and other decision makers;
- raising public awareness; and
- facilitating communication between the mathematical sciences community and other stakeholders

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The Francis Crick Institute is a biomedical discovery institute dedicated to understanding the fundamental biology underlying health and disease. Its work is helping to understand why disease develops and to translate discoveries into new ways to prevent, diagnose and treat illnesses such as cancer, heart disease, stroke, infections, and neurodegenerative diseases.

The Crick was formed in 2015, and in 2016 it moved into a brand new state-of-the-art building in central London which brings together 1500 scientists and support staff working collaboratively across disciplines.

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

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The Energy Institute (EI) is the chartered professional membership body bringing together expertise for urgent global challenges. Our ambition is that energy, and its critical role in our world, is better understood, managed and valued. We're a unique network with insight spanning the world of energy, from conventional oil and gas to the most innovative renewable and energy efficient technologies. We gather and share essential knowledge about energy, the skills that are helping us all use it more wisely, and the good practice needed to keep it safe and secure. We articulate the voice of energy experts, taking the know-how of around 20,000 members and 200 companies from 120 countries to the heart of the public debate. And we're an independent, not-for-profit, safe space for evidence-based collaboration, an honest broker between industry, academia and policy makers.

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EngineeringUK is an independent organisation that promotes the vital role of engineers, engineering and technology in our society. EngineeringUK partners business and industry, Government and the wider science and technology community: producing evidence on the state of engineering; sharing knowledge within engineering, and inspiring young people to choose a career in engineering, matching employers' demand for skills.

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

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

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

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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.

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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.

Institute of Food Science + Technology

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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.

IKE Institute of Innovation & Knowledge Exchange

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www. InnovationInstitute.org.uk

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

Institute of Marine Engineering, Science and Technology (IMarEST)

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

The Institute of Materials Finishing

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Tel : 0121 622 7387

The Institute of Materials Finishing is the premier technical organisation representing industry, academia and individual professionals in both the UK's and global surface engineering and materials finishing sector.

We actively promote continual education and knowledge dissemination by providing both distance learning and tutored training courses, as well as a technical support service. We also provide bespoke courses that are tailored to an employer's specific needs. The Institute also publishes *Transactions of the Institute of Materials Finishing* and a bimonthly newsletter (*IMFormation*), as well as holding regular regional and international technical meetings, symposia and conferences.

Institute of Measurement and Control

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Reg Charity number: 269815

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

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

IOP Institute of Physics

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The Institute of Physics (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.

IPEM Institute of Physics and Engineering in Medicine

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

IChemE ADVANCING CHEMICAL ENGINEERING WORLDWIDE

The Institution of Chemical Engineers

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

IET The Institution of Engineering and Technology

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

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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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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

London School of Hygiene & Tropical Medicine
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www.lshtm.ac.uk

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

Marine Biological Association

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

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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 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.

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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.

SCIENCE DIRECTORY

The Royal Institution
Science Lives Here

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www.richannel.org
Twitter: ri_science

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

THE ROYAL SOCIETY

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

Royal Society of Biology

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The Royal Society of Biology is a single unified voice, representing a diverse membership of individuals, learned societies and other organisations. We are committed to ensuring that we provide Government and other policy makers – including funders of biological education and research – with a distinct point of access to authoritative, independent, and evidence-based opinion, representative of the widest range of bioscience disciplines. Our vision is of a world that understands the true value of biology and how it can contribute to improving life for all.

ROYAL SOCIETY OF CHEMISTRY

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

society for applied sfam microbiology

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*Sf*AM 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, *Sf*AM publishes five internationally acclaimed journals.

Society for Underwater Technology

SUT Society for Underwater Technology

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

Society of Chemical Industry

SCI: where science meets business

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

We deliver our charitable objective by:

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

Society of Cosmetic Scientists

SCS SOCIETY OF COSMETIC SCIENTISTS

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

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

Society of Maritime Industries

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The Society of Maritime Industries (SMI) is the voice of the UK's maritime engineering and business sector. Promoting and supporting companies in Commercial Marine, Maritime Defence & Security, Ports & Terminals Infrastructure, Marine Science & Technology, Maritime Autonomous Systems and Digital Technology.

SCIENCE DIARY

PARLIAMENTARY AND SCIENTIFIC COMMITTEE – ALL-PARTY PARLIAMENTARY GROUP

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www.scienceinparliament.org.uk
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Monday 14th September 2020
Discussion Meeting on 'Non-Tumour Cancers and Precision Medicine and Genome Mapping'
5:30pm – 7:00pm Virtual Meeting

Monday 12th October 2020
Discussion Meeting on 'Systemic Racism in the UK Science Community'
5:30pm – 7:00pm Virtual Meeting

Monday 26th October 2020
Discussion Meeting on 'Sources, health benefits and global challenges of protein'
Sponsored by kind permission of the Nutrition Society
5:30pm – 7:00pm Virtual Meeting

Monday 9th November 2020
Discussion Meeting on 'How will COVID-19 impact on the Government's 'Ageing Society' Grand Challenge mission?'
Sponsored by kind permission of The Physiological Society
5:30pm – 7:00pm Virtual Meeting (unless otherwise advised)

Tuesday 24th November 2020
Annual Lunch, House of Lords 12:30pm

Monday 7th December 2020
Discussion Meeting on 'Autonomous Transport'
Palace of Westminster, 9:30am – 12:30pm including Christmas Refreshments

ROYAL SOCIETY

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

THE ROYAL INSTITUTION

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

ROYAL SOCIETY OF BIOLOGY

For further details please contact Karen Patel or Dr Stephen Benn at events@rsb.org

ROYAL SOCIETY OF CHEMISTRY

For further details please contact Events@rsc.org

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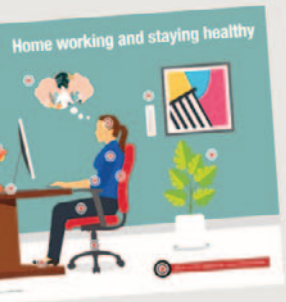
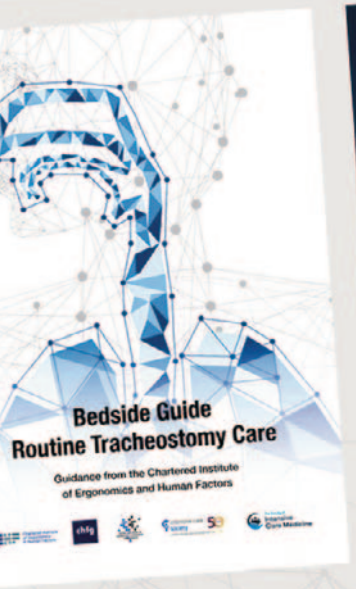
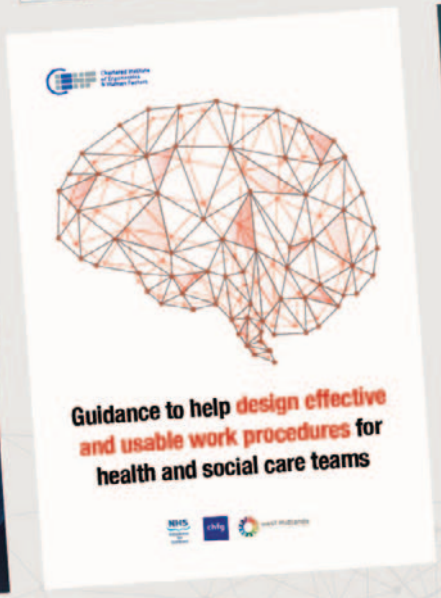
THE HUMAN FACTORS RESPONSE TO COVID-19

Human Factors is a science that combines, physiology, psychology, engineering and technology for improving life, wellbeing and performance.







Visit our website for a range of free infographics and publications in response to COVID-19

Chartered Institute of Ergonomics & Human Factors

covid19.ergonomics.org.uk

Download our latest White Paper about human factors perspectives on investigations and learning from adverse events.

www.ergonomics.org.uk