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The Government-funded UK Autodrive project, completed in 2018, saw industry come together to trial connected and automated vehicles on Milton Keynes and Coventry.

On Page 2, Transport Minister, Rachel Maclean MP, writes about the UK's self-driving vehicle revolution.



ASK THE EXPERTS BRIEFING ON COVID-19

DISCUSSION MEETING 15 MARCH 2021

The COVID-19 pandemic has changed all our lives dramatically over the past year. In this fast changing time, this briefing offered people the opportunity to hear from experts from a variety of fields about the current situation. There were four experts presenting and taking questions in this 15th March evening discussion, which was organised in partnership with the National Academies. Dr Shaun Fitzgerald from the Royal Academy of Engineering discussed how we can make spaces COVID-safe and what we have learnt about ventilation during this pandemic. Professor Melinda Mills was an author of the Royal Society's report on vaccine passports, and she discussed this reports conclusions and how these are important considerations for government policy. Professor Charles Bangham from Imperial College London discussed long-COVID and how we can best deal with this syndrome. Professor Judith Breuer from University College London discussed the emergence of new variants and what threats these pose to our current situation. There was a varied and extensive Q&A around these topics.

A lot of discussion was centred around the vaccine rollout. If the government wishes to follow the path of other countries and issue vaccine passports, there are many ethical questions to be considered. Some are concerned about the risk of creating a two-tiered society between those who are vaccinated and those who can't or won't access the vaccine. Although willingness to take the vaccine is high in the UK, the government must consider what role a vaccine passport will play in accessing many areas of life, from public spaces to social care jobs. As the vaccine rollout continues and restrictions decrease in the UK, we

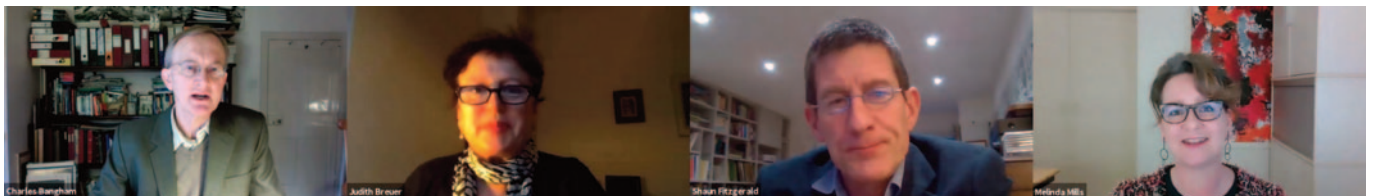
also heard how it's vital that the vaccine passports meet an international standard, to allow for international travel.

We also heard about how new variants pose a potential threat to immunity. The new variants which have been identified are associated with a decreased level of immunity, although evidence suggests the current vaccines still prevent severe illness. The UK has seen an expansion of its genomics industry since the pandemic started and this will be a crucial monitoring tool as we go forward. New variants will have an impact on decisions about the need for an annual vaccination programme or an expiry date on vaccine passports, and so this knowledge will be vital.

As we see levels of COVID-19 decrease in the UK, many are still suffering the effects from having the disease. Long-COVID is associated with a variety of symptoms, most commonly fatigue. Professor Bangham explained that the mechanism of post-viral fatigue is poorly understood and so currently treatment is focused on relieving symptoms. As businesses start to operate again, it's key that employers recognise the syndrome and support their employees who are suffering from this condition.

Since the pandemic started, we have learnt a lot about how viruses spread throughout society. Aerosol transmission was under recognised at the beginning of the outbreak, but we now know that this is a key cause of infection. Looking forward, making sure that all building meets the requirements for ventilation will reduce this mode of transmission for future outbreaks.

By Alfie Hoar, Parliamentary & Scientific Committee



L-R: Professor Charles Bangham, Imperial College London; Professor Judith Breuer, University College London; Dr Shaun Fitzgerald, the Royal Academy of Engineering and Professor Melinda Mills, University of Oxford.



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

A very warm welcome to the Spring 2021 edition of our journal, and my sincere thanks to the Parliamentary Science & Technology Information Foundation for its valued support.

In this, issue we have, in addition to our usual features a great range of articles which are listed below in the Contents section.

I want to thank each of our first class contributors, and particularly want to welcome to these pages, Rachel Maclean MP, Parliamentary Under-Secretary of State for Transport, who writes on the UK Government's autonomous vehicles policy.

As members will be aware, the Earl of Selborne sadly passed away on the 12th February. John, one of the longest-serving members in Parliament, was twice Chair of the House of Lords Science and Technology Committee and a former President of the Parliamentary & Scientific

Committee. He was a delight to know and work with. P&SC has lost a wonderful friend, supporter and adviser. John will be very sadly missed. An appreciation, by Dr Stephen Benn, will appear in the next issue.

Inevitably, our successful discussion programme has continued online, drawing a high level of interest from members and guests across the United Kingdom.

Since the last edition of *Science in Parliament*, I have had the pleasure of chairing four excellent meetings: 'UK Telecommunications and Infrastructure' on the 18th January; 'What does the UK-EU deal mean for science?', in partnership with The Royal Society, on the 1st February, which drew a record to date attendance of 150; This was followed on 15th February when the theme was, 'Sector Deals for SMEs' and on 15th March, 'Ask the experts briefing, Covid-19' in cooperation with the National Academies.

My thanks to all the distinguished speakers who contributed to these discussions and answered a large number of questions.

All our meetings are recorded on YouTube should you wish to catch-up or view again.

On 8th March I hosted the annual STEM for BRITAIN awards ceremony online.

My congratulations to our 17 worthy early career researcher winners who are featured in this issue, and grateful thanks to all

who made this 'different' event such a success, including our sponsors and supporters, the panel judges, the STEM organising team, and the parliamentary colleagues who assisted me in chairing the presentations for each category: the Father of the House, Sir Peter Bottomley MP, Chi Onwurah MP and Carol Monaghan MP. I also wish to thank other colleagues, whose constituents were finalists, for looking in on the various judging sessions and at the announcement event.

My thanks to Commander Barry Brooks who has stepped down as a member of the P&SC Council. His contribution is much appreciated.

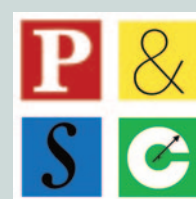
At the recent AGM, we were pleased to welcome Professor Narender Ramnani, Professor of Neuroscience, Royal Holloway University and a Trustee of the British Neuroscience Association, to Council.

Finally, I am also delighted to welcome to P&SC, parliamentary colleagues **Baroness Young of Old Scone; Lord Taylor of Holbeach CBE and Lord Sterling of Plaistow**, together with new organisational and individual members: **Pembrokeshire Coastal Forum; bit-bio; Dr Elizabeth Rollinson**, former CEO of the Linnean Society and **Dr Ashley Thomas Lenihan**, Senior Policy Adviser, Academy of Social Sciences.

With best wishes.



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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FROM CALIFORNIA TO COVENTRY, MICHIGAN TO MILTON KEYNES: WHY THE EYES OF THE WORLD ARE ON THE UK'S OWN SELF-DRIVING VEHICLE REVOLUTION



Rachel Maclean MP, Parliamentary Under Secretary of State at the Department for Transport

One of the great privileges of being a Minister is the opportunity to experience the unfamiliar. This thought loomed large as I was being driven through the Milton Keynes countryside last autumn. If I closed my eyes, I wouldn't have been able to tell that the car was in fact not being driven by a human, but by a computer.

The weather may not have been as sunny as in California, but my remarkably comfortable journey in the Government-supported Nissan HumanDrive vehicle showed me that UK-based companies are going toe-to-toe with those in The Golden State, which is synonymous with Silicon Valley self-driving start-ups. In fact, you may be surprised to hear that nowadays you're just as likely to find the next big connected and automated vehicle (CAV) start-up in Oxford, Milton Keynes or Coventry as you are in the USA's hubs for automotive and tech innovation such as California and Michigan.

The Government has had a strong hand in making this the case. The UK is currently ranked second in the G7 for automated vehicle readiness overall after the USA, but first in the world for policy and legislation. As we look to build back better following COVID-19, we cannot afford to ignore the UK CAV sector's potential to make transport greener, safer, easier and more reliable.

My Department is supporting the development and deployment of CAV because we know that the potential

economic and social benefits of the technology in the UK are vast.

A report by the Connected Places Catapult in January found that CAV could be worth £42 billion to the UK by 2035 as the technology becomes increasingly commercially available. It could create 38,000 new skilled and well-paying jobs in areas like agile vehicle design, coding, cyber security and fleet management. As MP for Redditch, I know how important the automotive industry is to the West Midlands. To remain globally competitive, we must look to the future and the next generation of mobility technologies. Just as we are supporting the UK automotive companies in their transition to zero-emission, we are helping the sector and the wider emerging CAV industry to get ahead in the global race to harness self-driving technology.

CAV has the potential to smooth traffic flow and reduce emissions per vehicle mile, improving air quality and helping the UK to meet its ambitious Net Zero goals: an issue that is front of mind for us all, especially as the UK looks forward to hosting COP26 this year. It could also

improve access to transport for people with mobility issues as well as reducing the cost and improving the reliability of transport services, helping to level-up access to transport in historically disconnected and rural areas.

Crucially though, CAV could save lives. In 2018, 85% of road collisions in Great Britain that resulted in personal injury involved human error. Even at relatively low levels of automation the technology could reduce this number. At higher levels it could massively improve safety on our roads by eliminating human mistakes altogether. Indeed, the Society of Motor Manufacturers and Traders (SMMT) estimates that CAV tech could save 3,900 lives and prevent 47,000 serious accidents between 2019 and 2030.

To take advantage of these opportunities the Government set up the Centre for Connected and Autonomous Vehicles (CCAV) in 2015, a joint DfT and BEIS unit that is shaping the safe and secure emergence of CAV, making the UK the best place in the world to develop and deploy the technology and ensuring that we can all benefit from its effects.



The Government-backed HumanDrive project, led by Nissan, developed an advanced, automated vehicle system that emulates the natural driving style of a human at the wheel. The project culminated in a successful 230-mile fully self-driving demonstration from Cranfield to Sunderland in 2019.

The Government's pioneering CAVPASS project is developing the world's first comprehensive safety and security assurance process for CAVs and the UK also offers an enabling regulatory framework for safe CAV technology innovation. Our Code of Practice for testing automated vehicles on public roads, for example, is recognised as one of the most flexible in the world.

Government and industry are working in partnership to invest in homegrown CAV innovation, with over £400 million invested in more than 90 CAV projects involving over 200 organisations. From highly automated logistics trials to self-driving buses and advanced accident-avoidance systems, these projects led by UK businesses and academia are setting the global standard for CAV innovation. Nearly £200m has also been committed alongside industry to establish a globally unique testing and proving ground ecosystem that is attracting companies from around the world to develop their technology here in the UK. With six core facilities, CAM (connected and automated mobility) Testbed UK offers a unique set of environments and capabilities for the testing and development of CAV technologies. It is the only place worldwide with the capability to take ideas from concept to development both virtually and

physically, all within a three-hour drive. These facilities are genuinely world-leading, with unique abilities to collaborate across organisational borders to share safety cases, data and learning.

The UK should be proud of its thriving CAV sector. UK SMEs with an interest in this field such as Five AI, Oxbotica and Arrival are attracting funding from global investors. Interest from across the Atlantic is particularly strong, with US tech companies acquiring UK SMEs such as Latent Logic and Blue Vision. Global automotive and tech companies are also choosing the UK as a location for CAV innovation, with Nissan opting for the UK as one of a small number of locations to undertake R&D on automation, and Israeli company REE



The Government-backed Endeavour project is trialling highly automated vehicles in London, Oxford and Birmingham. The world-leading project is demonstrating automated driving in a variety of urban and city environments and will develop engagement models with local authorities and communities to help them prepare for the future launch of self-driving vehicle services.

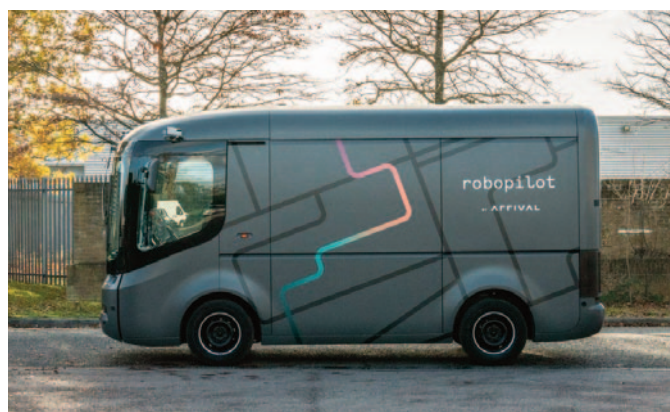
recently setting up base at HORIBA MIRA in the West Midlands – one of the leading CAM Testbed UK facilities.

The future is bright for homegrown CAV companies, but we must not become complacent given fierce competition from around the world. I want to help UK companies attract even more private investment, securing the UK's reputation as a scientific and tech superpower and leading to more well-paid, skilled jobs across the country.

My Department is also rapidly scaling up its work on CAV regulation. The Law Commission of England and Wales and the Scottish Law Commission are coming to the end of the Government-commissioned three-year review into UK law. They will publish landmark proposals later this year for the

world's first comprehensive legal framework to ensure the safety of self-driving vehicles on our roads. We are also currently consulting on exciting new Automated Lane Keeping System (ALKS) technology, and establishing whether it will be legally defined as the first automated vehicle technology on British roads, ahead of its introduction to the market in late 2021. For the first time ever, this would mean that a driver of an ALKS-enabled vehicle would legally be able to hand over total control of the driving task – in some conditions – to the on-board self-driving system.

The coming years will prove to be crucial for CAV innovation in the UK, determining not only whether we can take advantage of its potential environmental and societal benefits, but also ensuring that associated



The Government-backed Robopilot project is led by UK-based electric vehicle company, Arrival, to develop self-driving capabilities for its electric van, which could then be adapted for its planned future rollout of larger electric trucks and buses.

economic benefits are brought to UK shores. The Transport Secretary and I are determined that we take full advantage of the opportunity CAV presents the UK as we continue our efforts to build back better following the COVID-19 pandemic.

If you would like to discuss Government's work on CAV, please contact my team at enquiries@ccav.gov.uk. □

WHAT DOES THE UK-EU DEAL MEAN FOR SCIENCE?



Sir Richard Catlow FRS, vice-president and Foreign Secretary of the Royal Society and Becky Purvis, Head of Public Affairs at the Royal Society

The 2016 referendum heralded the beginning of a period of uncertainty for scientists. The value of international scientific collaboration and participation in Horizon 2020, the most ambitious multilateral funding scheme in the world, had been recognised by all sides in the debate. But the result put the UK's future participation into question.

That is why the news on 24 December 2020 that a deal had been struck, including agreeing the terms for UK association to Horizon Europe, the successor to Horizon 2020, was excellent news. The deal also allows the UK access to Euratom Research and Training programme, the fusion test facility ITER, Copernicus and the EU's Satellite Surveillance & Tracking (SST) services. It should bring about an end to the uncertainty and sets out a path for an ongoing and close scientific partnership between the UK and EU, representing a new chapter in a key scientific relationship.

The UK's considerable financial commitment to associate and remain a central partner in European research and innovation demonstrates the value that the government places on this international collaboration. It is a huge opportunity for researchers and innovators in the UK to strengthen and build new partnerships and access valuable, world-class programmes, such as the European Research Council and the vitally important multilateral collaborations that Horizon Europe will enable.

It is important that the association agreement is quickly ratified.

The past few years of

uncertainty and passionate debate about the UK's future relationship with the EU have damaged confidence and dented relationships and so speedy ratification of the association deal is really important. Even ahead of this however, we can begin to rebuild valuable partnerships with colleagues working across the EU and further afield. All of us in the science community have a role to play in reaching out to our colleagues overseas and forging new relationships and partnerships going forward. Association secures us access to the programme, but it is now our job to go out there, build collaborations and partnerships and apply for the money that will support research and innovation in the UK, and collaborations with researchers and innovators around the world.

The UK must continue to be a welcoming magnet for talent from all over the world.

While association to Horizon Europe is hugely welcome, we must recognise that the UK has left the EU, which does have some practical consequences that will impact directly on science. The end of free movement means that most EU researchers and innovators who want to come and work in the UK will now need to navigate the visas and immigration

system, which adds extra impetus to the important work that is underway to ensure that the UK is an attractive destination for international talent. This includes the cheaper and more flexible Global Talent visa, which the Royal Society was involved in delivering and administers on behalf of the Home Office.

But there is more to be done. Currently the upfront costs of work and study visas for researchers and innovators considering coming to the UK are up to six times higher than the average across leading science nations. The UK must reduce these costs in line with our international competitors. It may also be valuable to review the list of permitted activities that visiting scientists and academics can undertake on short-term trips to the UK. The newly created Office for Talent in Downing Street offers a valuable opportunity to drive this work.

The end of UK association to Erasmus+ is a sad casualty of the deal. Personal experience is very important and can underpin future relationships. Throughout my career I have travelled widely and over the past four years I have had the honour to be the society's Foreign Secretary. In that role I have visited many countries and have seen first-hand the value of scientific

relationships and their role in building international links. We must ensure that the UK remains an attractive destination for people from around the world to study, train and gain experience. We all benefit from this.

Realising the UK's global ambitions as a responsible and visionary global science superpower.

Science is increasingly global with 55% of UK academic publications the result of international collaboration in 2018, compared with 26% in 1998. The past year has highlighted the benefits of international scientific cooperation: without it, many more people would have died in

the pandemic and we would not have vaccines now being delivered. It will also be crucial to addressing future challenges such as climate change, biodiversity loss and new pandemics.

The EU Framework Programmes are the most ambitious multilateral funding schemes in the world, and participation is increasingly global, which provides a perfect platform for building additional scientific collaborations across the globe. The UK can be an active participant in European science as well as being ambitious in creating new bilateral and multilateral deals with leading and established science nations.

To realise this end, UK participation in international scientific collaborations must be a core component of a successful domestic research and innovation strategy. We must maintain the UK's excellence in cutting edge basic science as well as fostering innovation, replacing valuable programmes that the UK can no longer access such as the EU Structural funds. The new UK Shared Prosperity Fund for instance, which will replace EU structural funds, can play a valuable role in supporting the UK's innovation landscape in the future. And we must seek ambitious new deals with established and emerging science nations around the world, as well as continue to

foster the growth of scientific expertise in the developing world.

Finally, the costs of association to Horizon Europe must be covered by additional funding to that already committed to building the UK's domestic and global strength in research and innovation. The government's commitment to increase public funding for R&D to £22 billion per year by 2024 to 2025 is crucial to delivering growth and productivity across the UK, upon which we build our international collaboration. To secure the long-term health of the research and innovation system, the UK should be seeking to increase overall investment in R&D to 3% of GDP. □

NOW THAT WE HAVE THE EU-UK TCA, WHAT NEEDS TO BE DONE TO ENSURE UK HIGHER EDUCATION AND RESEARCH CAN THRIVE?



Anne-May Janssen
Head of European Engagement
Universities UK International

When the EU-UK Trade and Cooperation Agreement was announced on Christmas Eve, everyone at Universities UK International (UUKi) gave a collective sigh of relief. Naturally, the days and weeks that followed were focussed on getting a better understanding of the text and the implications for the UK higher education sector. It will come as no surprise that although the deal was welcomed by our sector, there were disappointments too, but negotiations are exactly that – negotiations – and neither side gets everything they want. Now that the dust around the TCA is starting to settle, we are forming a clearer picture of what the

future of the UK higher education sector looks like, where there is still work to be done, and how the UK government can help.

In the years immediately after the referendum, Team Europe at UUKi embarked on relationship building exercise to let our European friends know that, come what may, we would find a way to continue to work together. Something that became apparent early on was that there was a lot of misunderstanding among our European partners around Brexit and the implications for the sector. We also became acutely aware of the lack of understanding among many UK

stakeholders of what a 'no deal' would mean while helping them prepare for the 'no deal cliff edge' moments. In the most recent Brexit webinar that we hosted with the Science and Innovation Network, almost 1,000 sector professionals from across Europe and the UK tuned in live to hear about the deal, and we were inundated with questions afterwards. These ranged from technical questions about Erasmus+, to whether or not UK academic degrees will continue to be recognised in the EU. (Answer: yes they do! Academic degree recognition is part of the Bologna Process which is voluntary and intergovernmental, rather than

EU legislation, and the UK remains part of the process.)

What does this reality mean for our work – and that of the government – going forward? One of the first priorities should be to communicate implications of the deal to a wide audience, including our European partners. The best example, and most prominent one, would be the message that the UK will fully associate to Horizon Europe and that our European partners should have no qualms about working with our researchers. As you probably know, the UK's success rate in Horizon 2020 went down from 16% around the time of the referendum to 9%, which was due to the uncertainty that Brexit created. We as a sector body are delighted that the UK will associate to Horizon Europe, but we need to make it work and drive the UK's participation back up to pre-referendum levels. Part of that equation is making sure that the right information reaches the right people, so that researchers based in the EU feel confident in working with researchers based in the UK, but also so that researchers in the UK see Horizon Europe as a fundamental part of the UK science landscape.

A more detailed issue that needs addressing is international PhD recruitment in the UK, which has been dropping for several years, despite the positive step by UK Research and Innovation (UKRI) last year to open their studentships to more international students. EU students make up a substantial proportion of PhD students in areas like physical sciences, engineering, and technology, which means that we need to find ways to mitigate the impact of higher fees and immigration costs and bureaucracy to avoid destabilising our academic talent pipeline in these areas.

Another big topic that requires a lot of attention going forward is the Turing Scheme. We are very grateful that, in the current economic climate, the UK government is committed to student mobility. The sector and government need to work together to make this new scheme a success and to ensure a multi-annual financial commitment. We are aware that there continues to be quite a bit of disappointment around not associating to Erasmus+, but we have to make the Turing Scheme a success or risk losing it. The sector needs to rally behind this scheme to make it work and help the Department for Education (DfE) further develop the scheme over the coming years. The first year is a pilot year and DfE have indicated that they are open to tweaking the scheme in the future to match the needs of the sector. UUKi will, for example, be making the case to include staff mobility and shorting the mobility period below the current minimum of four weeks. Our research has shown that students from disadvantaged backgrounds often go on shorter placements abroad initially, which help increase their confidence and leads to longer study placements abroad afterwards.

Another crucial issue that needs to be addressed to make sure the UK remains an attractive destination for students who want to study in the UK for a short time as part of their degree, is to create a dedicated immigration route for inbound students on study and work placements for up to a year. At the moment, the new points-based immigration system does not have an immigration route that fits the needs of these incoming students. In fact, two of the three available routes will most likely act as deterrents. Students wanting to come to the

UK for a work placement must go through Tier 5 and students who want to study in the UK for a period between six and twelve months have to go through the Student route. Both are admin-heavy routes and very expensive for what are essentially very short stays. Not only that, but the Student route also includes an English language requirement, which is counterproductive as improving the level of English often is one of the key reasons students want to come to the UK for their mobility placement. We are hoping that this year the Home Office and DfE will work with us to develop an immigration route that will solve these issues to ensure the UK remains an attractive destination. If we do not, we run a real risk of not only decreasing the diverse and international nature of our university campuses, but also lose out on the huge economic contribution (£420 million annually) these students make to the UK. These are large and detrimental consequences, for an issue that has a practical solution.

Then the last topic I would like to mention is Transnational Education (TNE). Pre-departure, UK TNE delivery in EU Member States was regulated through the EU Services Directive. The TCA agreement includes provisions that offer other, more limited, access for privately funded UK education services to EU member states. For existing and future TNE provision, the agreement establishes that any limitations need to be consistent with those applied to local and/or third country providers. In practice, this means that depending on the specific member state, conditions could be imposed on legal form, licencing or national accreditation, student numbers, access to government support or qualification of students for benefits or financial assistance,

among others. We have compiled a summary of existing measures that can be taken (that we are aware of) which you can find on our website. We will be closely monitoring the developments in EU Member States around the provision of UK TNE delivery, because although the agreed deal means that there are more barriers for UK TNE providers, TNE could potentially play an important role for those EU students who wish to obtain a degree from a UK provider, but cannot due to the rise in tuition fees.

Naturally, there is more detail to all of this and there are other topics that impact universities which need our attention the coming years, such as the recognition of professional qualification. For those interested I would recommend having a look at our briefing on the TCA and its implications for UK higher education on our website.

The coming months, and years I dare say, we will continue to work not only on making the deal work for UK higher education, but also to strengthen our relationships with our international partners. The deal may be done, but there are many resulting issues that need addressing and we should tackle these together. □

NUCLEAR ENERGY'S WIDER ROLE IN A LOW CARBON FUTURE



Paul Davies is a Senior Policy Advisor at the Royal Society and leads the Low Carbon Energy programme. Before entering the world of policy and public affairs, Paul was a Chartered engineer, developing the manufacture of high tech products for a number of multinational companies.



Professor Robin Grimes is the Steele Chair of Energy Materials at Imperial College and Chief Scientific Adviser (nuclear) to the Ministry of Defence. He is a Fellow of the Royal Society and the Royal Academy of Engineering.

NUCLEAR POWER IN A RENEWABLE ENERGY WORLD

In the UK nuclear energy currently delivers stable baseload low carbon electricity at scale. In other words, once operational a reactor provides a large, constant amount of electricity 24/7 until it requires refuelling (after about 18 months). Whilst nuclear will continue to generate base load electricity, it must be more flexible if it is to contribute an important fraction of UK total energy. This is because future nuclear must integrate within an energy system dominated by intermittent renewables. To understand how nuclear can contribute, it is important to remember that solar and wind

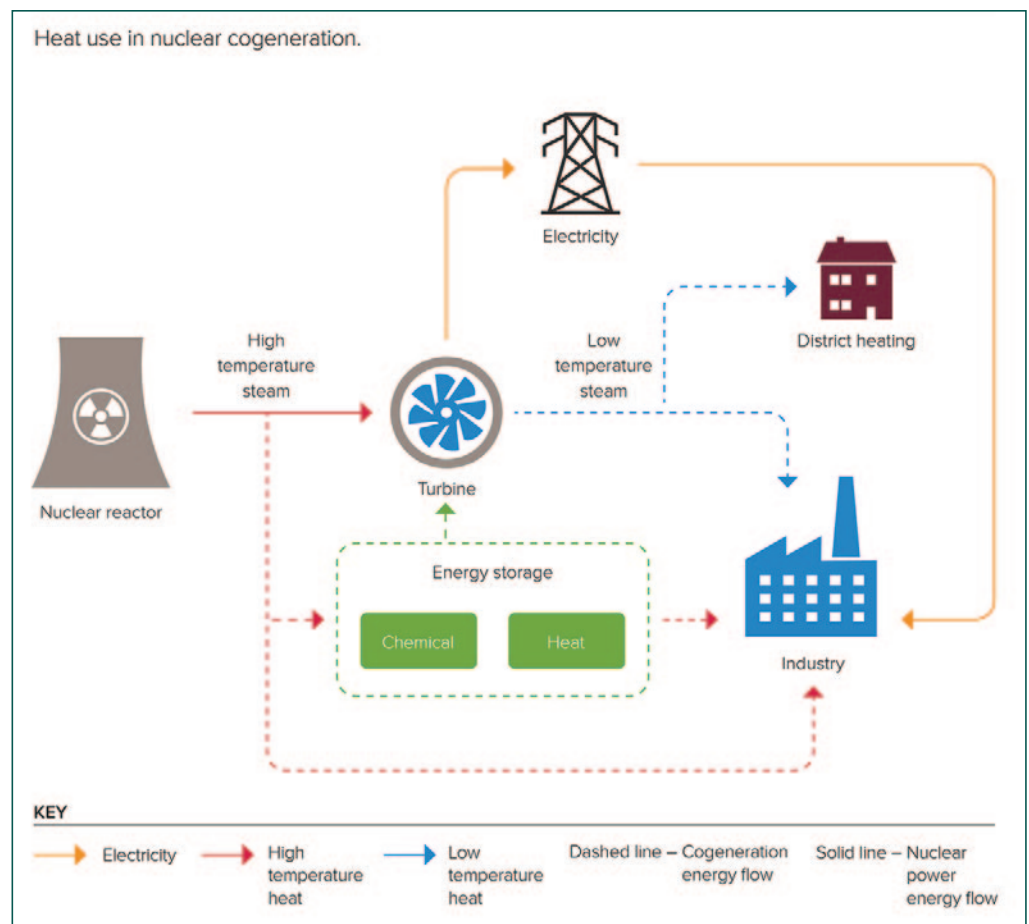
generate electricity directly but nuclear produces large quantities of heat. Currently all nuclear heat is turned into electricity, but that does not have to be the case.

So, how could nuclear fit in? When the need for electricity is high, the heat created in a nuclear reactor can be used to generate electricity. This may be because the demand for electricity is high, but it may also be that the wind is not strong, or the sun is not shining. When the requirement for electricity is low, nuclear heat and/or nuclear electricity can be used directly in industrial processes to generate chemicals, including hydrogen. This is known as co-generation. Thus, by switching from

electricity for the grid to supplying other products, nuclear can compensate for the intermittency of renewable electricity. Used in this way, the combination of nuclear and renewables will allow the UK to achieve the 2050 target of a net zero-carbon economy, including that 'hard to reach' final 20% of decarbonisation.

COGENERATION – IT'S NOT JUST NUCLEAR ELECTRICITY

Options for nuclear co-generation were described in detail in a recent Royal Society report (See <https://royalsociety.org/topics-policy/projects/low-carbon-energy-programme/nuclear-cogeneration/>). The range of



options for cogeneration are categorised as using either low (less than 300°C) or high temperature (greater than 500°C) heat or using the electricity generated.

With low temperature heat, space heating, especially via district heating, holds the most potential. The Haiyang nuclear power plant in Shandong province is China's first commercial nuclear heating project. The plant is run by Shandong Nuclear Power Company. This winter, the system is heating 700,000 square metres of housing and when subsequent units are complete it will heat all of Haiyang city (population >300,000) and provide 20TWh of electricity (around one third of the annual domestic demand of Shandong province). Low temperature heat has also been used by industry, for example at Gösgen in Switzerland for cardboard production.

In addition to the chemical processes, high temperature nuclear heat can be used as the energy source in hard to decarbonise industrial processes such as steel and cement making. High temperature heat can also be stored directly and efficiently, to be used when the need for electricity production is high (e.g. compensating for renewables intermittency).

The production of "green" hydrogen is a particularly versatile cogeneration option as there are many immediate and potential uses for this product. For example, much has been written about hydrogen for transport, especially via fuel cell technologies in vehicles. Hydrogen can replace natural gas in domestic and some industrial settings but can also be used as a bulk low carbon energy store.

Hydrogen is an important

feedstock product. For example, the production of ammonia requires the reaction of hydrogen with nitrogen using the Haber Bosch process at 350 - 500°C. For 'green ammonia' production nuclear hydrogen could be used directly as it is produced, or from storage and the power required could be delivered by renewables or from nuclear depending upon grid availability. Ammonia is widely used to make agricultural fertilisers and has the potential to be used as a clean fuel and energy store. Optimum decarbonisation could therefore result from a commitment to a systems approach.

Synthetic hydrocarbon fuel production, for example for use in aviation, also benefits from a systems approach. In this case production is via Fischer Tropsch synthesis, which requires the reaction of hydrogen with carbon monoxide at up to 300°C. Again, nuclear heat and power could be used to generate hydrogen, with direct capture of carbon dioxide from the air for conversion to carbon monoxide.

A STRATEGY FOR NUCLEAR COGENERATION

While the potential for nuclear cogeneration to contribute to a zero-carbon future is clear there is a long way to go. The UK would have to employ a staged approach that integrates into the 2050 decarbonisation programme. This is because the different nuclear options that are needed are more or less technologically ready. It could be achieved in four stages. Progression through the stages contributes gradually to decarbonisation targets, resulting in the upskilling of the workforce and the development of a UK supply chain.

In the first stage large gigawatt reactors continue to be built to

replace the current aging nuclear fleet. The UK is already engaged in this 'new build', with Hinkley Point C construction well under way. This is developing UK nuclear civil engineering sector skills that will be used in subsequent stages.

The second stage focuses on small modular reactors (SMRs). This could provide the UK with an entirely 'built in the UK' supply chain if a conventional water-cooled design were selected. The modularity of this design means building three or more adjacent reactors, increasing build-efficiency and reducing costs.

SMRs will demonstrate some direct heat applications - but they have a limitation. SMRs produce heat but not the high temperature heat required to produce hydrogen and other chemicals directly – though this does not preclude water electrolysis. For this reason, progression to stage 3 and the development of a high temperature advanced modular reactor (AMR) build is attractive for decarbonisation. This could be based on a high temperature gas cooled design. While more engineering development is required, a demonstrator could be operational by 2035, accompanied by the development of a UK supply chain.

The final stage in a UK nuclear energy cogeneration strategy involves the development of nuclear fusion. This delivers similar high temperatures as the AMR but is based on different physics. The UK has been a world leader in fusion for 50 years with many 'firsts' in technology deployment as well as research achievements. The UK Atomic Energy Authority at Culham (UKAEA) hosts JET, the world's most advanced fusion reactor.

THE ROAD TO NET ZERO

The UK must generate much more zero carbon electricity to achieve the 2050 decarbonisation goal. Increased renewables will make a crucial contribution but come with the challenge that renewable generation is intermittent. Part of the answer will come from new large gigawatt nuclear generation, but more flexibility is needed to address renewables intermittency. That's where smaller modular reactors and advanced modular reactors contribute. They deliver electricity when electricity is needed but employ their heat directly for co-generation when electricity is not needed. AMRs are especially suited to deliver hard to decarbonise products, like hydrogen and synthetic fuels.

Using this idea of co-generation, it is possible to develop a robust and secure energy supply. Other countries are pursuing the similar ideas, but the UK has the historic expertise in technologies that deliver higher temperature output that lend themselves to industry needs. In the longer term the same high temperature applications developed with AMRs can be serviced by fusion reactors, the ultimate nuclear energy source. □

HARVESTING BLUE ELECTRONS IN WALES



Stephen Hall CMarSci FIMarEST

Steve Hall is CEO of the Pembrokeshire Coastal Forum (www.pembrokeshirecoastalforum.org.uk) a community interest company with a portfolio of projects that includes Marine Energy Wales. He was previously CEO of the Society for Underwater Technology, and led the international office of the National Oceanography Centre where he was head of the UK's delegation to UNESCO's Intergovernmental Oceanographic Commission, and Vice-Chair of said Commission 2015-17. Steve is a Chartered Marine Scientist, and Fellow of the Institute of Marine Engineering, Science and Technology and Society for Underwater Technology. He can be contacted at steve.hall@marineenergywales.co.uk

2021 marks the beginning of the United Nations Decade of Ocean Science for Sustainable Development, tied-in closely with the UN Sustainable Development Goals, the aspirations by many nations to achieve their Paris Accord carbon reduction targets, and greatly expanded marine protected areas, such as the '30% by 2030' goal advocated by the Global Ocean Alliance which Britain has led since 2019.

The United Kingdom is a leader in taking these goals seriously, and we are making good progress, helped by our scientific excellence that has given high-quality policy advice to deliver broad cross-party consensus that climate change is real, driven largely by human activities, and that there are actions we can realistically take that will help us deliver a cleaner, more sustainable world, with a thriving post-carbon economy.

How we rebuild after COVID presents Britain with an early opportunity to build back better, cleaner and greener, and initiatives are emerging in all four nations to grow a new kind of economy that attempts, as far as possible, to work in balance with nature. So how are we in Wales playing our part?

One way is by investing in the broad 'Blue Economy' – a term that refers to all of those businesses and activities that can generate wealth from the sea and coastal region. Wales has a small fisheries industry, aggregate extraction, and a successful and tourism and leisure sector that relies upon having clean, beautiful beaches and coast – but the ability to generate copious clean energy from ocean resources is going to be key to our sustainable economic future.

Two hundred years ago Wales was the powerhouse of in the industrial revolution, our coal powering industry, locomotives and the steamships that flew the Red Ensign across the world, protected by the coal-fired White Ensign. Coal production peaked by the Great War, and as oil and gas supplanted coal as the driving force for transportation, the role of Wales as a source of energy rapidly fell away, with the last deep colliery, Tower, closing in 2008.

Could energy still be a cornerstone of the Welsh economy in a zero-net carbon world? It turns out that yes, it can – and as we enter the second quarter of the 21st Century Wales is once again a net exporter of energy. As early as 2017¹ land-based wind turbines were producing 1 GW, 35% of renewable energy in Wales, and the 726 MW of offshore wind turbines along the North Wales coast were producing 30%. Solar photovoltaic cells were generating useful amounts of power and biomass had grown significantly too.

Wales now has a target of 70% of our energy from renewables by 2030, and is on track to meet or exceed that target, largely through the use of offshore renewables. Wales isn't a large nation, with a land area of 21,000 km², a coastline of

2120 km – but we have an offshore area of 32,000 km² blessed with powerful winds, predictable currents, and in the case of the Bristol Channel the second-highest tidal range in the world at some 13m. These natural resources present many ways to generate clean, secure and reliable power. In October 2020 Prime Minister Boris Johnson stated that he wanted to see 40 gigawatts of offshore wind power in place by 2030, enough to power every home in Great Britain. We'll certainly play our part - Wales is taking the necessary actions to grow our infrastructure and renewable generating capacity.

GROWING OFFSHORE WIND CAPACITY

Building on the success of the Gwynt y Mor project already in place off the coast of North Wales, in February 2021 BP and German energy company EnBW won the seabed development rights to build a 500km² wind farm 30km from the North Wales coast that will generate enough power for 3.4 million homes - a significant part of the UK's capability to achieve zero net carbon by 2050.

The shallow sea off North Wales is fine for monopile wind turbines that are driven into the seabed, but if you want to deliver wind energy from deeper

waters in the west you can build your turbines to float, and tow them out to a site offshore optimised for wind conditions, away from shipping lanes or land-nesting seabird colonies. The deep-water harbour of Milford Haven in Pembrokeshire is aiming to become the home of a new generation of floating wind turbines that will be moored over 40km offshore in the Celtic Sea. A collaboration between Total and Simply Blue Energy, Blue Gem Wind,² has been formed to start work on the Erebus 96MW demonstration project. Blue Gem aim to be producing electricity by 2027, and other developers are looking to enter the sector and produce energy from Welsh, Irish and Cornish waters in coming years, using large floating wind generators to eventually produce some 50GW of energy from a resource estimated at 150 to 200GW. That's more than the Prime Minister's target of 40GW without even counting what has already been built around the UK coast – we clearly will be

able to achieve net zero carbon for electricity production from wind alone.

However floating wind is not the only way to generate electricity from the ocean. In Anglesey, the community-owned Morlais Project³ manages a 35km² area of seabed near Holy Island that has the potential to become one of the largest tidal stream energy sites in the world, capable of generating 240MW. Orbital Marine Power⁴ are developing floating tidal stream turbines, manufacturing the anchors in Llangefni, North Wales.



The Orbital O2 2MW tidal turbine design includes components built in Wales, and improved versions will soon be in service off Anglesey with the Morlais Project.

In Pembrokeshire, Australian company Bombora⁵ has launched a £17 million project to construct and test the 1.5MW mWave wave energy device. Minesto⁶ UK Ltd in Anglesey are developing the Deep Green tidal stream energy device, and Marine Power Systems⁷ in Swansea are developing technology to harvest energy from ocean waves with a mission to become a world leader in the manufacturing and supply of marine energy extraction. Another innovative project quite near the Morlais site, is the Enlli Tidal Energy

project by Nova Innovation,⁸ which aims to use the natural ebb and flow of the tide around Ynys Enlli to become the world's first blue energy island, initially with five 100kW turbines on the seabed.

Alongside these developments is a growing network of organisations to support and grow the new industry. We're building META – the Marine Energy Test Area,⁹ to develop and test prototype units in Milford Haven, and MEECE¹⁰ – the Marine Energy Engineering Centre of Excellence – at Pembroke Dock via the Offshore Renewable Energy Catapult will deliver research, development and demonstration activities to support innovation in the supply chain. The Pembrokeshire Marine Demonstration Zone¹¹ is also being established via Wavehub Ltd.

With any form of intermittent energy, it's essential to also invest in the storage of power, both to provide electricity when the wind doesn't blow but also to smooth-out fluctuations to the



Floating offshore wind turbines will be deployed in the Celtic Sea as part of the Erebus programme by the late 2020s
Photo courtesy of Principle Power. Artist: DOCK90



Looking towards the sea from Milford Haven, home of the Pembroke Dock Marine cluster that includes the Marine Energy Test Area, Marine Energy Engineering Centre of Excellence, and Pembrokeshire Demonstration Zone. Photo by Marine Energy Wales

grid. The most well-established technology is that of pumped storage where water is pumped uphill into reservoirs at peak supply of power, then released to flow through turbines when more power is required. Batteries can be used, but an innovative way of storing energy created by renewables is being developed by Gravitricity Ltd.¹² It's a simple concept – raising and lowering a heavy weight to store and release energy, in this case weights of 500 to 5000 tonnes in deep shafts held by a number of cables, each attached to its own winch with plenty of safety redundancy.

It's ideally suited to be used alongside the renewables industry in Wales, building on our legacy of mining engineering, and offers some advantages compared with pumped storage and batteries including long design life, very fast response time of less than one second, and low cost compared with lithium battery storage.

The other way of effectively storing renewable energy and one I believe will be core to how we power our homes, transportation and industry in the near future, is to turn those blue electrons into hydrogen, electrolysing seawater to split the H₂O then compress, store and transport the hydrogen building on decades of experience by our hydrocarbons industry. Chancellor Rishi Sunak announced £4.8 million for a hydrogen hub on the island on Anglesey in his budget speech of 3rd March 2021, which will use renewable energy to produce hydrogen from seawater to fuel heavy goods vehicles, and eventually hydrogen-powered ferries and trains. Milford Haven is ideally suited to servicing the hydrogen economy too, already having an extensive infrastructure developed since the 1960s to support the oil and gas sector, connections to Britain's natural gas grid, and readily adaptable to adapting to hydrogen.

CONCLUSION

The Wales that once powered the industrial revolution of Britain a century and more ago will re-emerge as a clean energy hub, a clean blue revolution driven by wind, wave, current and tide, that by the end of the decade will be harnessed to store energy as hydrogen that can be used to power transportation, legacy gas turbines, heat our home and manufacture clean steel. We're successfully encouraging new investors to relocate to Wales, enabling our young people to see that there is a future for them to stay in Wales and build their lives here, whilst working wherever possible in harmony with protecting our world-class landscape and coastline to help encourage healthier, more active population who understand the benefits of 'vitamin sea'.

The future is bright, clean, and 'blue'.

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TREEVIEW: PRECISION FORESTRY FROM SPACE TO SUPPORT THE UK RESPONSE TO MITIGATE CLIMATE CHANGE

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There is now widespread recognition that unprecedented action is required to address the significant disruption being brought to the climate system. The UK is positioning itself to become a leading nation amongst developed economies in confronting the climate crisis by being the first to legislate for a net zero emissions status by 2050. Across the nations, a number of institutions, organisations, and local authorities are declaring their commitment and formulating and implementing policy to tackle ongoing climate change. A combination of technological, behavioural, and nature-based solutions will be required to achieve this ambitious, but essential, goal. Nature-based solutions are those that use elements of the natural world to mitigate environmental pressures, and extensive tree-planting is a nature-based solution that forms a major pillar of the UK national response to the climate emergency. Trees remove carbon dioxide from the atmosphere through the process of photosynthesis, returning it first to the living biomass of the tree and then over time locking it away in the soil.

But trees provide many more benefits than carbon capture. As trees establish and grow, complex ecosystems develop around them through the processes of ecological succession. Increasing habitat diversity provided by the trees themselves and the shelter, soil

enrichment and rainfall retention due to the trees promotes a significant increase in biodiversity, addressing the other main environmental crisis requiring urgent attention: the accelerating loss of species. Trees are engrained in our culture and woodlands provide highly valued space for recreation. Hundreds of millions of hours are spent each year by Britons in woodland visits, and the health and wellbeing benefits and importance of local green space access has been brought to the fore during the pandemic. Trees also trap and neutralise pollutants, providing healthier environments and saving millions of pounds in health costs each year.

An increase in tree cover in urban environments provides additional benefits. Urban areas tend to be warmer than surrounding areas, placing greater demands on energy for cooling and stress on the population in summer, which is only going to worsen as temperatures increase. Trees in cities help mitigate this 'urban heat island' effect both through shading and through the process of evapotranspiration. As trees evaporate water from their canopy, they cool the air around them.

The combined benefits of UK's woodlands were valued at over £130 billion pounds by the Office for National Statistics in 2017. Threats to the treescape from pests, disease, fire, and climate change necessitate active

management of this valuable asset. Tree planting initiatives are expected to increase the number of small-scale plantings, and the development of urban green infrastructure and a shifting emphasis in large scale plantations to mixed species stands calls for new technology to monitor, and new data products to help manage, this expanding asset. The scale of information required underpins the emerging area of Precision Forestry and has motivated the conceptualisation of a new Earth Observation project dedicated to the management of the UK treescape.

TreeView is a satellite mission that intends to fill a data gap that exists between very large, expensive satellites providing very high-resolution sub-metre spatial coverage with limited spectral information, and scientific missions that typically have coarser spatial resolution, 10 m and above, but high to very high spectral resolution. With TreeView, the aim is to map, characterise, and monitor the UK treescape in a manner not previously achieved. As a secondary priority to the UK, data from other countries, both forests and urban environments, will be captured within the constraints of the spacecraft operations and mission budgets.

For tree identification, classification and characterisation, spatial resolution on the scale of a typical tree crown is required,

and multiple spectral bands are needed to differentiate between species, and to determine key factors such as the health of the trees, resilience to drought, rate of growth and when the leaves might fall.

TreeView is being studied with funding from the UK Space Agency's pathfinder National Space Innovation Programme.¹ Partners from academia and industry have been studying the mission feasibility from the hardware and technical requirements through to the science, commercial and societal benefits.

The technical solution being proposed makes use of UK expertise and heritage in the design and development of small satellites and optical instrumentation. The satellite is a pioneering design currently undergoing qualification through ESA programme funding from a UK disruptive SME, In-Space Missions Limited based in Hampshire, in the heart of the Enterprise M3 Space Cluster. The telescope design was led by the Rutherford Appleton Laboratory based in the Harwell Space Cluster. The camera or eyes of the telescope is utilising leading technology from Teledyne e2v headquartered in Chelmsford Essex, leveraging previous UK government funding for the development of the next generation high resolution multispectral image sensors. The sensor and telescope, making up the satellite payload will be controlled by electronics under the leadership of XCAM, a Northamptonshire SME recognised nationally and internationally for high-end space and scientific solutions. The team is led by The Open University with expertise in space instrumentation, optical payloads and most importantly, in the classification and characterisation of trees with remote sensing.

TreeView will provide a number of innovative scientific

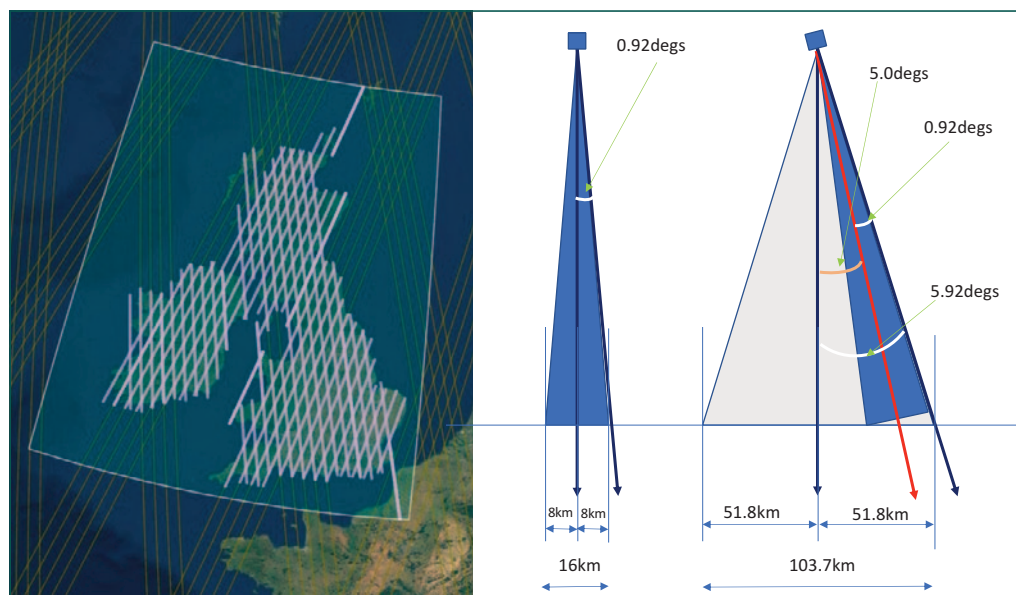


Figure 1: Full coverage of the UK is achieved by a combination of nadir and off-nadir pointing, maximising the use of a compact small satellite with a modest swath of 16 km within a field of view 104 km wide.

opportunities. It will develop the most detailed maps yet of the UK treescape that will answer questions about the size, species distribution and potential of UK's tree-based carbon stores and the current state, resilience and vulnerability of UK tree biodiversity. The potential to monitor individual trees and green infrastructure in urban

areas will enable a new era of urban-focussed EO science and new understanding of the role of trees in our urban landscapes. One of TreeView's goals is to provide a national monitoring system for understanding threats to our national tree resources for the early detection of climate-stress, such as drought, or onset of pests and disease. As part of

the feasibility study we have developed an end-to-end simulation of TreeView to start exploring these possibilities. Working from airborne imagery provided by project partners 2Excel-geo, we have produced maps of key vegetation indices across an urban area that demonstrate the detection that can be achieved in these

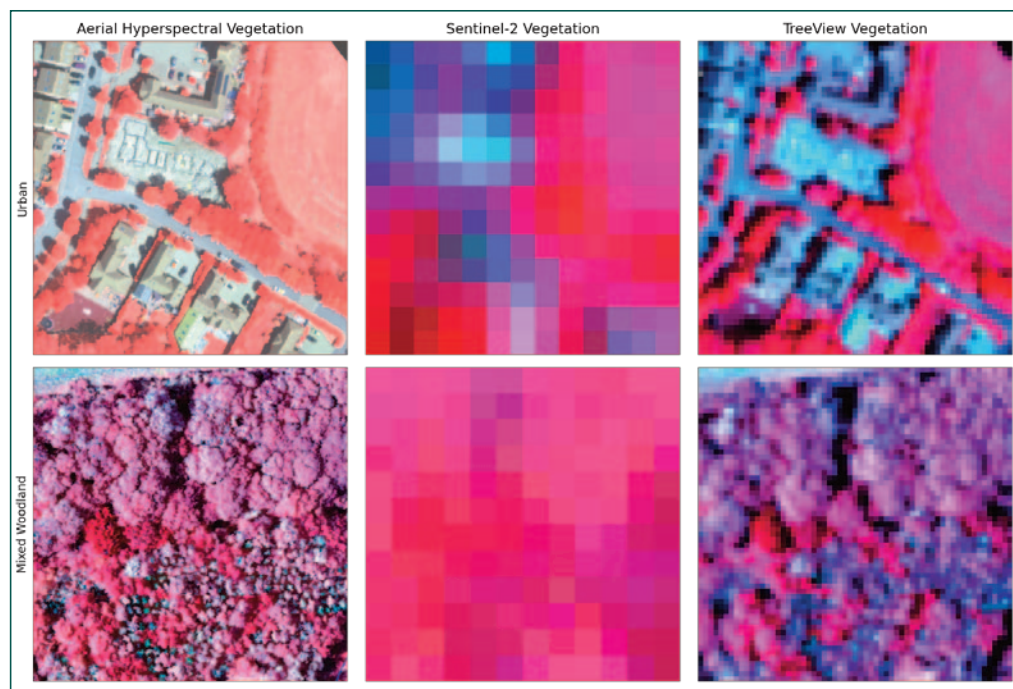


Figure 2: High resolution data from aerial reconnaissance of an urban (top left) and mixed woodland (bottom left) scene. Simulated satellite imagery of the vegetation indices for Sentinel-2 (central figures) and TreeView (righthand column) showing the improved resolution of TreeView. In the urban scene we can see the complex patterns and location of the trees in the urban environment. In the woodland scene the finer-scale variations in tree condition, and the difference between the oak-dominated and ash-dominated stands are visible in TreeView's data (2m GSD) but not at 10 m GSD.

complex environments, and are exploring the potential to detect and monitor the onset of ash dieback in a woodland.

During the feasibility study, the team has been looking at commercial opportunities for the data. Whilst many ideas are still in their infancy, there are potential applications in dedicated land use monitoring, encroachment of canopies on infrastructure such as rail and power lines, monitoring carbon offsetting through tree plantations, forecasting of pollen release and as a consequence of land use monitoring and carbon offsetting, factoring into companies' corporate social responsibility and nature based solutions.

Another innovative aspect of TreeView is the opportunity to

engage the public through citizen science platforms. In particular, we will be linking with Treezilla, a citizen science project run by the Open University which includes the largest database of urban trees in the UK. We will use this rich database for ground truthing the satellite data as well as integrate TreeView information into Treezilla. Users will therefore get space-derived information about their trees as well as be able to validate satellite outputs and indicators of, for example, tree health. This will enable public engagement in a significant science programme and inspire younger users to engage in STEM subjects.

Satellite data presents a more affordable solution than airborne imagery or Lidar datasets when

the investment in the mission is considered in the context of the coverage, frequency of revisits, and duration of even a short space mission. Despite that advantage, potential commercial users are still very reluctant to spend significant sums per annum on satellite data. Furthermore, with scientific and societal benefit at the heart of this mission's objectives, there is a drive to make the data as freely available as possible. One solution is to marry commercial use with government funded data for monitoring the UK's treescape through tasking of the satellite to image areas of commercial interest and priority.

The budget for the mission remains at £15 million. From an authorisation to proceed we would expect to launch within

four years. This represents a fast and affordable mission compared to ESA Earth Explorer or Sentinel spacecraft which typically take ten years or more to develop and launch and cost several hundred million euros.

With the importance and value of trees to society so clear, from their mitigating effect on climate change, to their roles in urban cooling, mental health and wellbeing; investments in tools such as TreeView for monitoring and informing the management and protection of this valuable asset are essential for the future.

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THE POWER OF LIGHT IN MEDICINE – CHALLENGES AND OPPORTUNITIES IN VASCULAR OPTICS



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INTRODUCTION

Light has to be important (@IDLofficial, www.lightday.org/). It helps us to define our universe, from the larger scales gauging themselves by the speed of light, to the smallest of scales looking towards quantum theory. There is also that wonderful light from our own star, our primary source of energy on Earth. However, behind what seems to be the obvious, light can also be a mystery with its duality in which the same beam of light behaves as a particle ('photon') and/or as a wave depending on the

experiment. Despite its sometimes-puzzling nature, it is clear that the impact of light on modern medicine and surgery has been enormous, with widespread clinical applications in the assessment of health and wellbeing as well as for diagnosis and/or treatment of disease. Assessments include the detection of cardiovascular and microcirculatory disease, measuring tissue composition, perfusion and viability, cancer diagnosis, researching Raynaud's phenomenon, and the monitoring of oxygen in the blood (for example, using a pulse oximeter device as has

been publicised in the Covid-19 pandemic). I believe there is great scope to achieve much more with optical techniques, for example, in the way patient measurements can be made and also the way these are subsequently analysed and communicated.

All the 'colours of the spectrum' can be utilised for clinical optical measurements, from the ultraviolet (UV) to the red, through to the far infrared. The choice of colour ('wavelength') being a fundamental consideration for a diagnostic technique, its

selection depends upon what needs to be detected. For example, the wavelengths of green, red or near infrared are often used to study blood flow and dynamics in skin. More generally though, there can be some uncertainty as to what exactly is being measured optically since the interaction of light with tissue is complex. The validation of novel health technology devices thus forms a specialist field of study, and one which goes hand-in-hand with ensuring the safe use of optical radiation for the target medical application.

VASCULAR OPTICS

This article focuses on the field of Vascular Optics (VO) - a growing area in the application of light to medicine. VO can probe the micro-structures and blood flow in tissue; it can characterise the microcirculation where early-stage disease can sometimes be detected. There are of course challenges but there are also opportunities. VO is a specialist field and for the UK there are only a small number of clinical measurement facilities currently undertaking such work. There are also only a limited number of types of VO devices on the market, but there are many innovations under development and new ideas continue to be explored. VO includes imaging and non-imaging technologies, many being non-invasive.

In my former life as an NHS Clinical Scientist I had spent a few recent decades establishing state-of-the-art VO measurement and research and development (R&D) facilities at

Newcastle's Freeman Hospital, providing specialist diagnostics for patients from across the North East of England. Significant R&D was also undertaken on medical device development and innovative approaches to patient measurement. With a recent promotion and move into academia I have since brought the know-how to Coventry University's new research Centre for Intelligent Healthcare (the CIH), and despite the unprecedented Covid-19 situation the planned new VO measurement and R&D facilities at CIH are almost ready – their official opening will be in 2021.

SOME KEY APPLICATION AREAS AND TECHNIQUES

VO techniques have the capability to assess tissue *perfusion*, *structure* as well as *composition*. However, there is a challenge as non-invasive measurements are often restricted to the skin surface. One can probe deeper though in a number of ways, by the careful selection of operating wavelength, by optically changing the surface properties of skin, e.g., with clear oil, by closing down superficial blood vessels with skin cooling, but also by being skilled in knowing about the referred medical symptoms for the disease being studied. For example, with some types of thyroid disease there is also active eyelid inflammation – in this case, the eyelid area can be imaged to get the specific information needed rather than trying to look at the deeper tissues of the neck.

Perfusion i.e., blood flow: The Laser is a remarkable invention – it can give a monochromatic and coherent light source with designer wavelength to illuminate tissue for measurements. A key laser imaging technique being Laser Doppler Perfusion Imaging (LDPI) which can provide tissue perfusion mapping. The laser light penetrates the skin to a certain depth governed by wavelength and power and the light is scattered by the blood flowing in the tissue, the Doppler shift in the received signal indicates the degree of blood flow present. LDPI is particularly useful in imaging burn wounds to give the clinician information about wound depth, noting images need to be taken 2-5 days after a burn when a hyperaemic healing response is expected. There is also Laser Speckle Contrast Imaging (LSCI) which can provide faster and higher resolution perfusion images by measuring the changes in 'speckle' pattern from a laser light illuminating the target tissue.

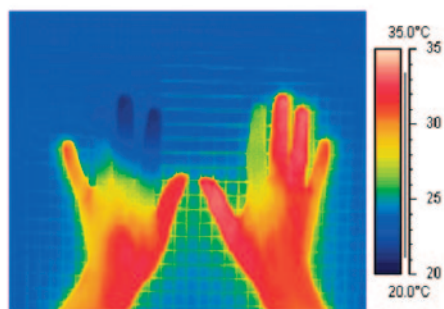
Another important research technique in a VO facility is thermal imaging. All objects (including humans) that are above the temperature of absolute zero produce thermal radiation which can be detected using a thermal camera. In humans, higher temperatures are associated with increased blood flow. Thermal imaging has a number of clinical uses but most fall within the research domain, for example in studying Raynaud's phenomenon, detecting tissue inflammation,

and predicting the onset of foot tissue problems in patients with diabetes. In Raynaud's, the fingers (toes) change colour on just mild cold exposure and typically in a sequence which can include 'white', 'blue', and burning 'red'. Raynaud's is important to study objectively because it can be an early symptom of an underlying autoimmune condition or a number of other medical conditions. Thermography can be used to assess the degree of vasoconstriction of the finger blood vessels on mild cold exposure.

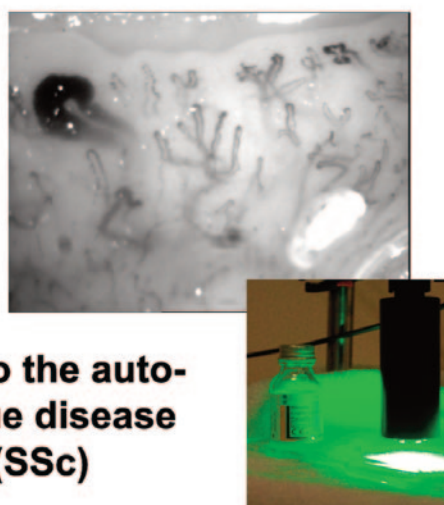
Structure: The thermal imaging test for Raynaud's goes hand-in-hand with a simple microscope test for studying the finger nailfold area to look for significant microvascular damage linked to autoimmune conditions. This imaging test is known as nailfold capillaroscopy (NFC). It is low-cost and used carefully can be very powerful. One can tell a lot just by looking at a person's hands with capillaroscopy and thermal imaging (Figure 1).

Composition: We can all glow ("fluoresce") in the dark. By shining light onto tissue, typically in the UV, it can be re-emitted at slightly longer ("red-shifted") wavelengths. There are known fluorescence signatures for different tissues, such as collagen or haemoglobin, allowing an "optical biopsy" to be made. This fluorescence spectroscopy approach is largely a research technique but with great potential looking for a clinical application.

Abnormal Thermal Imaging



Microvascular disease on Capillaroscopy



= Raynaud's secondary to the auto-immune connective tissue disease Systemic Sclerosis (SSc)

Figure 1: The power of vascular optical imaging using combined thermal imaging and green light nailfold capillaroscopy. They have detected thermal patterns consistent with Raynaud's as well as localised microvascular disease consistent with the auto-immune connective tissue disease Systemic Sclerosis (SSc). The capillary image is 3x2 mm.

A more sophisticated way to measure tissue structure is to use Optical Coherence Tomography (OCT). OCT is an imaging technique that uses low-coherence light to capture micrometre-resolution 2D or 3D images from tissue. It can use infra-red light to detect tissue discontinuities and reveal micro-structures in blood vessels and layers of the eye.

PHOTOPLETHYSMOGRAPHY (PPG) – FOR OPTICAL PULSE

PPG is a simple and very low-cost optical technology that can detect the pulsatile blood volume changes in skin tissue with each heartbeat. The PPG pulse signature can change with advancing age and also in arrange of cardiovascular diseases.

PPG sensors are essentially a light source (light emitting diode, LED) and a light detector (photodiode) packaged to allow

measurements at a target skin site, e.g., the ear lobe, finger or toe pad sites. PPG lends itself to miniaturization and also for use in digital e-health systems / smartphones, but there is also capability for tattoo sensing and fibre optics implementation.

PPG is utilised extensively in pulse oximeters, wearable sensors – including personal health monitors and watches and also for research devices for cardiovascular assessment. Recent advances in image / signal processing, including

machine learning and Artificial Intelligence (AI), have opened up exciting opportunities for PPG-based diagnostics (Figure 2).

SUMMARY

The power of light applied to medical diagnostics has been highlighted in this focus article on vascular optics. These technologies have the capability for miniaturization and for modern manufacture, they utilise an improved know-how on clinical application to give optimal measurement quality, and they seem to be developing alongside a 'crest of the wave' in AI (and ultimately quantum) computing methods for medical image or signal analysis. There are so many clinical applications and opportunities for light in medicine, for the benefit of the patient, the NHS and also for UK plc. □

Image representations for AI analysis

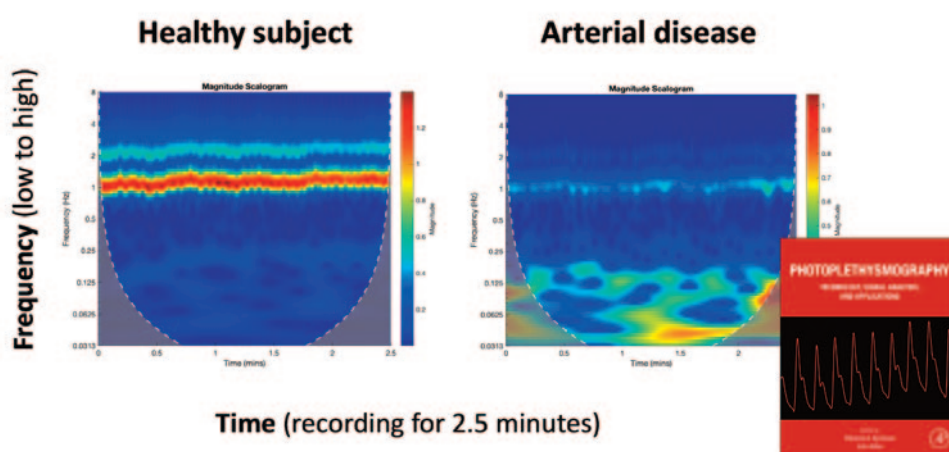


Figure 2: Example toe PPG spectrogram 'images' comparing a healthy subject and a patient with significant arterial disease in their legs, with the optical pulse measurements collected over 2.5 minutes. Their time-frequency dynamics can be represented in an image which captures the low and high frequency information changes with vascular disease. This imaging approach lends itself well to automatic, robust, and quick classification by AI using a deep learning approach. (This new AI-empowered vascular assessment technique piloted by Allen is covered in a unique new holistic book on PPG technology, i.e., Photoplethysmography: Technology, Signal Analysis and Applications. 2021 Academic Press books - Elsevier. Editors: Prof. P Kyriacou & Prof. J Allen.)

THE FUTURE OF THE UK'S TELECOMMUNICATIONS INFRASTRUCTURE



Roger Brown, CEO and President, Cioux Group



David Essery, COO and Principal Consultant, Cioux Group

Since the advent of the Internet the UK telecommunications infrastructure has undergone a massive transformation; from the initial dial-up connections through to high-speed fibre optic connections. The growth in Internet usage and the proliferation of Internet based services has increased demand in fast, reliable, and cost-effective network services. The UK saw its Broadband usage double in 2020.

BROADBAND SERVICES IN THE UK

The Broadband market is now a major part of the UK telecommunications industry reaching around 82% of the UK's population.

The term Broadband covers both fixed and mobile services. Fixed-based being those provided via a cable and Mobile-based refers to 3G/4G/5G services available from all of the main Mobile service providers.

Broadband services in the UK are relatively new with the first cable-based service launched in 2000. At this time, speeds were limited to 512Kbps (Kilobits per second). Today we are looking at services providing 1Gbps (Gigabits per second), these being 2,000 times faster than when the service was first launched 20 years ago. We are seeing the demands on bandwidth doubling year on year.

Home consumer Broadband services are often bundled with other telecommunications services such as fixed and mobile telephony with extras such as premium television channels and streaming services.

2008 saw the biggest step change in Broadband services in

the UK with over 1.5m connections being provided. By 2009 almost 50% of all households in the UK had access to Broadband services.

Broadband services initially ran across the legacy telephony infrastructure utilising copper cables. The legacy copper cabling system has its limitations, particularly in terms of the speed of service that can be provided.

Today the copper infrastructure is being phased out and replaced with fibre optic technology.

The demand for Broadband services has grown exponentially with the growth of online services.

The current pandemic has also added significant pressure on the infrastructure through home schooling, working from home and the increase of online shopping. The proliferation of video streaming services such as Netflix, Amazon Prime, BBC iPlayer and Disney+ during lockdown has also put significant demand on the infrastructure.

DELIVERY OF BROADBAND SERVICES IN RURAL AND REMOTE LOCATIONS

One of the major challenges in providing Broadband services to rural and remote locations is the lack of supporting infrastructure. Technically, standard Broadband services are available anywhere that has a BT phone line. However, due to distances and the quality of the infrastructure available these lines are so slow they cannot support a usable Broadband service.

To overcome some of these challenges and limitations several options are available:

- Fibre Broadband where fibre can be delivered easily and cost effectively.
- Mobile Broadband
- Satellite Internet via services.
- Fixed wireless Broadband

5G TECHNOLOGY

5G, as it is known, is the 5th Generation of wireless mobile communication. It will ultimately replace the current 4G service. 5G is set to offer new technical capabilities through its high speed, ultra-reliable, low-latency and high device density service.

The roll-out of 5G across the UK is well underway with a number of towns and cities providing coverage.

With 5G Speeds of up to 1Gbps are achievable.

SATELLITE INTERNET SERVICE

Starlink is a satellite-based Internet access service. It is the brainchild of Elon Musk's SpaceX company and the plan is to have around 42,000 satellites orbiting the Earth providing Internet connectivity. The service is currently in deployment with over 1,000 satellites already launched. New satellite chains are being launched on a weekly basis. Testing has already begun in the UK with estimated speeds of around 150mps being achievable to the consumer. Although Gigabit speeds will not be available with the service, 150mps will be sufficient to support most applications in rural and remote communities. The obvious benefit of this service is its ability to provide a relatively high bandwidth Internet service to areas that have limited Internet access enabling us to achieve our target of 100% Internet coverage.

INCREASING USE OF WI-FI TECHNOLOGY

We all use Wi-Fi in some shape or form, sometimes without even realising it. Whether it is in the office, the coffee shop or at home. Wi-Fi provides networking of devices and access to the internet wirelessly.

Wi-Fi offers the benefits of increased efficiency, ease of access and availability, flexibility, it is economic to deploy and enables new opportunities to be exploited through the speed to market.

However, there are some disadvantages such as security, radio interference, coverage and can be less efficient than a physical connection.

By 2019, over 3 billion Wi-Fi enabled devices were being shipped globally each year.

Almost every piece of electrical equipment sold today will have some form of Wi-Fi connectivity. This can be from a fridge, a cooker, washing machine through to your vacuum cleaner and television. Also, more and more people are utilising smart home technology and can remotely control their lighting and heating in the home. Cars are now utilising the technology transmitting diagnostic data back to the manufacturers, tracking performance and journeys. Insurance companies are now using this technology to analyse driver habits using the data to calculate driver risk and insurance premiums and logistics companies can drive efficiencies through tracking their fleets.

Over the coming years we are going to see a continued growth in Wi-Fi enabled devices. There will also be a continued growth in applications utilising Wi-Fi devices.

THE GROWTH OF IoT – THE INTERNET OF THINGS

The Internet of Things (IoT) describes physical objects, or "things", that contain sensors, software and other technologies enabling them to connect and exchange data with other devices and systems over the Internet.

When all these connected devices are combined with automated systems it is possible to analyse the data and create actions. A good example of this is the Smart Ink facilities the large printer manufacturer offers. The printers communicate back to a central system reporting on printer usage and ink levels. Through a subscription service the printer manufacturer can then automatically send the

consumer ink replacement. Another example are fridges. Fridges will be able to automatically order food direct from retailers when items of food begin to get low.

In conjunction with 5G, IoT can be used to provide connectivity across devices within factories, manufacturing, restaurants, education, and healthcare. Combining the technologies will enable more automation and efficiencies through the IoT enabled devices.

The potential for IoT applications is endless.

FUTURE DEVELOPMENT OF BROADBAND SERVICES TO ACHIEVE THE GOVERNMENT'S TARGETS

With the continued increase in the demands on Internet access and development of Internet based applications significant investment is required in the UK's telecommunications infrastructure.

The Government has initiated a £5bn Broadband investment plan to facilitate full fibre roll-out across the UK. This will make 1 gigabit services more accessible to both businesses and home consumers particularly in the more remote and less populous rural areas.

There are currently 3.5m direct fibre Broadband connections to businesses and consumers in the UK. Openreach currently plan to provide access to another 3.2m premises by the mid. 2020s.

With regards to mobile Internet access, we will see the continued deployment of 5G services across the UK. The technology will continue to be developed with 6G already being tested in other countries.

With the advances in space launch technology and increased competition in this area, the

launching of communication satellites is becoming more commercially viable. SpaceX's Starlink satellite Internet service is well underway with its satellite launch program and will continue to provide Internet coverage in areas hard to reach. Other satellite Internet service providers such as OneWeb are well on the way to launching their service.

The benefit of low orbiting satellite communications bring is that it provides access to consumers in remote and rural locations where the provision of high bandwidth cable-based services is cost prohibitive.

The growth in Internet based applications in conjunction with our increasing reliance on online services, social media, and streaming services will continue to stretch the infrastructure.

The more bandwidth that is available the more we consume; where will this stop?

To meet the needs of the consumers we are going to see an increased use of blended cable, mobile and satellite Broadband services in the immediate future.

LAST BUT BY NO MEANS LEAST - DATA SECURITY

With all the advances and development in the communications industry the biggest challenge facing us going forward is protecting our data and privacy. Every time we add a device to the network there is a possibility that device could be breached to provide access to our private and personal data.

Along with improving and increasing ways of access to the telecommunications infrastructure whether it be cable, mobile or satellite based, we need to ensure the mechanisms are in place to protect us. □

POOR DIET QUALITY: IMPACT ON HEALTH, SARCOPENIA AND AGING



Professor Ailsa Welch

Ailsa is a professor of nutritional epidemiology and researches into the protective factors in diet for aging particularly for musculoskeletal health (sarcopenia, skeletal muscle mass and function), osteoporosis and fracture risk. She also has research in identifying malnutrition, dietary assessment methods, quantifying measurement error, and evaluating public health improvement interventions. Ailsa aims to understand the effects of micronutrients (vitamins & minerals), diet quality (dietary patterns, fatty acids & acid-base load) on aging.

Ailsa has been based at Norwich Medical School, University of East Anglia since 2007. She has 210 publications and an H index of 72. Ailsa is the Public Health Nutrition Scientific Theme lead for the UK Nutrition Society and chairs the UK initiative 'Optimising Nutrition and Hydration in Care Homes'. She chaired the Nutrition & Lifestyle Forum of the UK Royal Osteoporosis Society and was a member of their Scientific Advisory Committee until this year. Ailsa is also a State Registered Dietitian.

INTRODUCTION

The condition of Sarcopenia exists in older people and consists of low skeletal muscle function or strength, accompanied by low muscle mass. This condition develops slowly during aging due to gradual losses of both muscle mass and function, starting from the age of 30 years¹. Over the age of 50 years, rates of loss of muscle mass and strength accelerate, being 2-3% per year for strength and 0.5-1% for muscle mass. These changes

Reversing the changes associated with sarcopenia, malnutrition and frailty is difficult, so preventing and reducing progression to sarcopenia is crucial. Evidence is accumulating that higher quality diets could slow down the processes of aging, which is important given that diet is modifiable.

Sarcopenia and its associated conditions not only reduce quality of life in individuals but also increase the costs of health and social care in the UK.

bn/year for malnutrition. Not only do these conditions impose huge costs on the UK government, they also impact on quality of life for individuals and on their ability to maintain independence during aging.

SARCOPENIA, AGING AND MICRONUTRIENTS

My recent research uses population epidemiological approaches to study the links between the nutritional quality of diet and the risks of sarcopenia and fractures in middle and older aged

Key points:

- Sarcopenia (low skeletal muscle mass and function) occurs during aging and is associated with frailty, osteoporosis, falls, fractures and malnutrition
- Better diet and physical activity are important modifiable factors that can slow the progressive decline in skeletal muscle mass and power that occurs with aging
- In middle and older age eating a balanced diet rich in micronutrient vitamins and minerals, coupled with regular physical activity is an effective way to prevent the risk of age-related chronic disease

with aging may seem small but by the time a man who is 60 years old today reaches his 70th birthday he will have lost around 30% of his muscle strength, 10% of his muscle mass, and may notice these changes.

Sarcopenia is associated with the conditions of frailty, osteoporosis, and malnutrition, increasing the risk of falls, fractures and morbidity (or chronic diseases)². Loss of muscle mass also contributes to the onset of type-2 diabetes and the onset of obesity¹.

Around a third of people over the age of 60 years have sarcopenia, and a third have malnutrition, with frailty being present in a quarter of people over the age of 80 years³. One in two women and one in five men over the age of 50 years will also sustain a debilitating fragility fracture during their lifetime. The financial burdens on the NHS of sarcopenia and associated conditions range from £2.5 bn/year for muscle weakness, to £4.4 bn/year for osteoporosis and fractures, £6 bn/year for frailty, and to £10.0

populations, with the aim of slowing down progression of aging of muscle and bone. (Epidemiology studies the differences across populations that determine health or disease.) A large body of research has already focussed on how much protein needs to be consumed to ensure muscle mass and function is maintained in older people. This is because protein is important for the structure of muscle and the delicate balance between muscle breakdown (catabolism) and build up (or protein

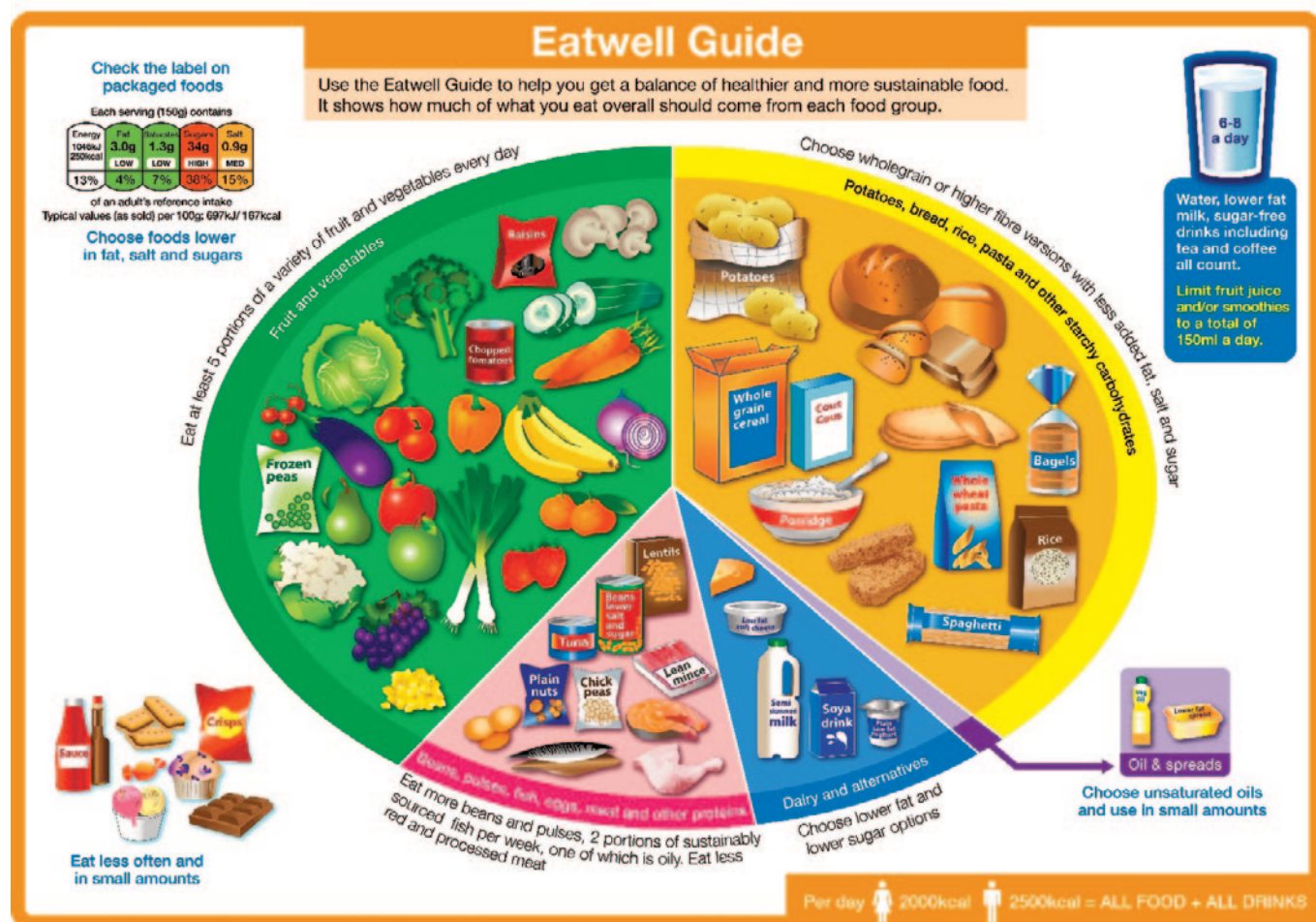


Figure: The Eatwell Guide, UK Healthy Eating Guidelines: <https://www.gov.uk/government/publications/the-eatwell-guide>

synthesis - anabolism) needs to be maintained. However, comparatively little research has focussed on the importance of micronutrient vitamins and minerals for muscle health, although more recent research has found that vitamin D is likely important.

The micronutrients are found in small quantities in foods in our diet and micronutrient dense foods contain high concentrations of vitamins and minerals. Examples of vitamins include vitamins C, D, E, B₁₂, folic acid, and the carotenoids (carotenes). Minerals include iron and magnesium. Examples are vegetables and fruits which are rich in carotenoids (found in brightly coloured vegetables and fruits such as carrots, lettuce, broccoli and oranges), vitamin C, folate and magnesium. Also, fish and meat are rich in

magnesium, iron, vitamin D and vitamin B₁₂.

We have long known that deficiency or low intakes of vitamins and minerals leads to physical symptoms. Deficiency of vitamin C causes scurvy and symptoms of lethargy and fatigue^{4, 5}. Vitamin D deficiency causes osteomalacia (soft and weakened bones) in adults, with symptoms also including fatigue, weakness and muscle pain. Anaemia, arising from iron deficiency, also causes fatigue and weakness, as does magnesium deficiency which leads to disorientation. These symptoms of deficiency indicate the importance of micronutrients to the physiological, biochemical and metabolic processes in the body. They also mirror the symptoms of aging.

So not only is it essential for health that micronutrients are consumed in large enough quantities to prevent deficiencies, but many of these micronutrients also interact with and moderate the physiological mechanisms of aging of skeletal muscle⁴⁻⁶. During aging there is an increase in basal inflammatory status, known as inflammaging, as well as an increase in reactive oxygen species (ROS) which cause direct damage to muscle cells. Aging also leads to negative effects on the mitochondria present in cells which is a problem as the mitochondria burn (or metabolise) the nutrients we eat to generate energy. Many of the micronutrients, such as vitamin C, magnesium and carotenoids, act to dampen down the effects of these increases in

inflammation and ROS in aging⁶. Magnesium is essential for synthesis of protein, and vitamin C for formation of collagen; a structural component of skeletal muscle and of carnitine; a molecule required for muscle contraction⁵.

Recent research from my group shows that higher intakes of magnesium, vitamins C, E, and carotenes are related to greater muscle mass and strength or function in middle-aged, as well as older men and women⁴⁻⁶. In our studies differences, in either muscle mass or function, between the lowest and highest intakes of these nutrients varied between 1% and 8%. One study found that women had leg power measurements (strength of muscle contraction) that were 25% higher in those with the greatest intakes of magnesium compared with

those with the lowest⁴⁻⁶. So, compared with annual losses of 1-3% per year of skeletal muscle mass or strength, increasing intake of vitamins C, E and carotenoids as well as magnesium could have potential clinical significance. Also, our findings were over and above protein intake, indicating micronutrients may be more important. We also found that C-Reactive protein, a measure of inflammation in the blood, was lower in the women with the highest intakes of magnesium⁴⁻⁶. Several of our results have been confirmed by measurements of nutrients in blood, such as vitamins C, E and carotenes, so adding reassurance to our findings with dietary intakes⁵. We also published evidence that good quality diets, such as the Mediterranean Dietary pattern, are protective for skeletal muscle or risk of fracture⁷. These effects of better dietary patterns are mediated through the higher intakes of micronutrients dense foods found in better-quality diets, such as vegetables and fruits. Our earlier research also shows that better quality diets as well as micronutrient status prevent death from all causes and cardiovascular disease.

PREVALENCE OF MICRONUTRIENT DEFICIENCY AND POOR DIET QUALITY IN THE UK POPULATION

While evidence is accruing for the influence of better-quality diets on conditions of aging, at present there are no dedicated dietary guidelines for older adults. So how should the population eat? In the UK the Eatwell Guide provides guidance on how to eat to meet our requirements for protein as well as micronutrients, see Figure. The Guide encourages eating a broad range of foods

that are micronutrient dense or high in fibre, while limiting foods high in sugar and saturated fats such as chocolates, crisps and sweets. The guide emphasises the significance of eating 5 or more vegetables and fruits a day (5-a-day) and moderate amounts of protein foods from animal or plant sources.

Despite the recommendations outlined in the Eatwell Guide large sectors of our population do not reach them. These vulnerable sectors of our population include adults over 65 years, those in low income groups and in Care Homes. We know these vulnerable populations are at nutritional risk from our extremely valuable National Diet and Nutrition survey⁸ which monitors the nutritional health of all sectors of our population, using measures of dietary intake as well as nutritional status measured in blood. Of real concern are low intakes of vegetables and fruits within our population, with only 20% of people over 75 years consuming 5-a-day or more. In care homes 40% have blood concentrations of vitamin C indicative of scurvy, as do 4% of older adults in the population. Also, 57% of men and 39% of women have blood concentrations of vitamin C considered insufficient. Prevalence of vitamin D deficiency in care homes is also high (40%) and is 15% in free-living older adults. Dietary intakes of magnesium are also low: a quarter of those over the age of 75 years consume amounts below the Low reference Nutrient Intake. Given the importance of micronutrients for healthy aging, these examples of low intakes and deficiency of micronutrients in the population are concerning. Much more needs

to be done to improve diet quality in the UK population.

CONCLUSION

The science shows that better-quality micronutrient dense diets are protective for skeletal muscle, bone, and cardiovascular health during aging in our population. We also know that many vulnerable sectors of the population have poor or inadequate diets. Comprehensive public health approaches are needed to ensure access and affordability of good quality foods to our population. After all, prevention is better than cure.

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STEM for BRITAIN 2021



STEM for BRITAIN 2021, the Parliamentary & Scientific Committee's annual competition for early-career researchers, hosted by Stephen Metcalfe MP, was held online this year.

The standard of work displayed was exceptionally high.

The announcement of the awards and medals was made on the 8th March and included all finalists in each of the five major categories, Biological and Biomedical Sciences, Engineering, Mathematical Sciences, Physics, and Chemistry, and for the Westminster Medal.

The finalists had presented their work during the previous week to the judges and their local constituency MPs were encouraged to join the zoom sessions to see their constituents present their work.

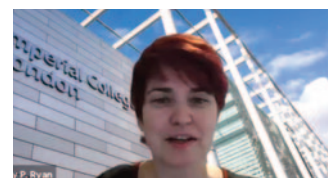
All the winners and their posters can be accessed at <https://stemforbritain.org.uk/>



Stephen Metcalfe MP, Chair STEM for BRITAIN



Prof Julie Lovegrove, The Nutrition Society



Prof Mary P Ryan, Royal Academy of Engineering

- 1 L-R: Dr Stephen Benn, MC, STEM for Britain; Dr Isabel Spence, STEM for Britain, Leigh Jeffes, STEM for Britain, Lucinda Bruce-Gardyne, Society of Chemical industry
- 2 L-R: Prof Allan Wilson, Institute of Biomedical Science; Sue Wharton, STEM for Britain; Stephen Metcalfe MP, Chair STEM for Britain; Lucy Green, The Physiological Society
- 3 L-R: Prof Geoffrey Grimmett, Heilbronn Institute for Mathematical Research; Dr Mark Downs, Royal Society of Biology; Prof Martin Freer, Institute of Physics; Prof Rory Duncan, United Kingdom Research and Innovation
- 4 L-R: Prof Gill Reid, Royal Society of Chemistry; Prof Martin Bridson, Clay Mathematics Institute; Prof Sylvia Richardson CBE, Council for the Mathematical Sciences; Dr Derry Mercer, Biochemical Society

We thank all those who supported STEM for BRITAIN 2021



UK Research
and Innovation

IOP Institute of Physics





STEM for BRITAIN 2021

CONGRATULATIONS TO THE WINNERS!

BIOSCIENCES AND BIOMEDICAL SCIENCES

Gold Medal and The Physiological Society Award



Nikita Patel

TACKLING TRAUMA ONE ORGAN AT A TIME USING A REVERSE TRANSLATIONAL APPROACH
Translational Medicine & Therapeutics, The William Harvey Research Institute, Queen Mary University London

"I'm absolutely thrilled to not only win The Physiological Society Prize but also the Gold Medal at this year's STEM for Britain! The event was a great opportunity to share my research and raise awareness to the field of trauma and blood loss, given its high prevalence in society. The ability to communicate and discuss scientific research to a non-expert audience is an important skill to have and I'd definitely encourage other early career researchers to take part. I'd like to thank the organisers for giving me the chance to present my poster and a platform to engage with a wider audience."

Silver

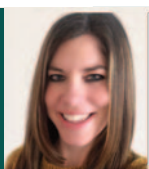


Paula Martin

PERSONALISING THERAPY IN OVARIAN CANCER: AN INTEGRATIVE APPROACH USING ARTIFICIAL INTELLIGENCE
CRUK Cambridge Institute, University of Cambridge

"It is not very common to find opportunities where we can share our research with policy-makers and I think STEM4Britain does a great job generating these spaces. For me, it was really interesting to share my PhD work with MPs during the Biomedical Sciences session. The discussions with them about the impact of the work we are doing and how they can translate to real-world solutions were really encouraging."

Bronze



Siân Morgan

ENHANCED DRUG DELIVERY METHODS TO COMBAT CORNEAL BLINDNESS
School of Optometry and Vision Sciences, Cardiff University

"I am extremely proud and honoured to have been awarded Bronze in the category of 'Biological and Biomedical Sciences' at this year's STEM for BRITAIN. It was a fantastic experience, and I am very grateful to have been given the opportunity to share my research at this prestigious event. I highly recommend that early-career researchers in UK universities apply for future events as it really is an excellent platform to showcase your research. The poster that I presented at the event described my current research which centres around the development of more effective methods of delivering medications to the cornea of the eye in an attempt to combat corneal blindness."

Nutrition Society Award



Amber Bozward

TRANSLATING DISCOVERY SCIENCE INTO A NEW THERAPY TO CURE AUTOIMMUNE LIVER DISEASES
Institute of Immunology and Immunotherapy, University of Birmingham

"I was personally delighted to be able to present our exciting research programme on T cell immunotherapy at University of Birmingham to parliament at the Stem for Britain 2021. I am very honoured and grateful to have received The Nutrition Society award for this presentation. Although we were unfortunately unable to visit the Palace of Westminster this year for the event, the virtual presentation and subsequent award ceremony was made an enjoyable experience by everybody involved. I am looking forward to celebrating this win with my colleagues when we are able to do so."

ENGINEERING

Gold



Bernard Cooper

MINATURISED COOLING OF QUANTUM DETECTORS TO -272C
Electrical Engineering, University of Glasgow

"I am delighted to have won gold in the engineering category of STEM for BRITAIN. It is a great motivator to know my research was appreciated by both Members of Parliament and other top academics from across the country. I am now looking forward to achieving the ambitious targets set out in my poster over the course of my doctorate."

Silver



Marlini Simoes

ADDITIVELY MANUFACTURED SMART CELLULAR MATERIALS FOR SPACE APPLICATIONS
Department of Physics, Cavendish Laboratory, University of Cambridge

"I feel very honoured to win Silver in the Engineering category, given the strong competition. The award is important because it recognises our ability to communicate our projects, not only to other scientists but also to MPs and the public in general. I feel very grateful to receive the award because it also highlights the importance of my field of research: aerospace. Being a medallist will also be a boost for me in disseminating my work in the future."

Bronze



Joseph van Batenburg-Sherwood

JAMVENT: A ROBUST VENTILATION APPROACH FOR COVID-19 AND BEYOND
Department of Bioengineering, Imperial College London

"Communication of science and engineering to policy makers and the public is more important now than ever. STEM for Britain supports and encourages this communication and it is an honour to be a medal winner amongst such excellent researchers."

Bronze



Andrew Creagh

THE DEVELOPMENT OF DIGITAL BIOMARKERS FOR NEURODEGENERATIVE DISEASES THROUGH SMARTPHONE- AND SMARTWATCH- BASED REMOTE PATIENT MONITORING
Institute of Biomedical Engineering, University of Oxford

"I feel very honoured to win Silver in the Engineering category, given the strong competition. The award is important because it recognises our ability to communicate our projects, not only to other scientists but also to MPs and the public in general. I feel very grateful to receive the award because it also highlights the importance of my field of research: aerospace. Being a medallist will also be a boost for me in disseminating my work in the future."

MATHEMATICAL SCIENCES

Gold

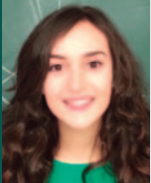


Scott Harper

CLASSIFYING ISOLATED SYMMETRIES
School of Mathematics, University of Bristol

"Mathematics underpins so much of our lives and it gives a fascinating perspective on the world. It was a pleasure to share the importance and beauty of mathematics to parliamentarians at this year's STEM for Britain event, and I was delighted to be awarded a Gold Medal for my poster on how mathematics sheds light on symmetry, something we see all around us every day."

Silver



Georgia Brennan

MATHEMATICALLY MODELLING CLEARANCE IN ALZHEIMER'S DISEASE; A MATHEMATICAL DRUG TRIAL FOR THE UK'S PROTEIN PANDEMIC
Mathematical Institute, University of Oxford

"The UK faces an aging crisis; neurodegenerative diseases present the next health and economic pandemic facing this great nation. As a woman in mathematics, I am also aware of the need to be a voice for underrepresented communities, including the elderly. My DPhil research, at Oxford University, speaks directly to both challenges. I have introduced the first mathematical models, and software, which combine patient data with mathematical dynamics to simulate 40 years of Alzheimer's disease progression in less than 40 seconds of computational time. My current phase of research leads in early exploratory drug development, providing a foundation for the rapid and non-invasive testing of novel treatments for dementias."

Parliament stands with the people of the United Kingdom. Their selection of my work for presentation re-affirms their long-standing commitment to mathematics and neurodegenerative disease research. In accepting the silver award for the mathematical sciences division, I stand in agreement with parliament: it is time to fight for our elderly and to rally behind the resounding excellence of the United Kingdom's women in mathematics and science."

Bronze



Gioia Boschi

OPINION DYNAMICS WITH MEMORY: HOW A SOCIETY IS SHAPED BY ITS OWN PAST.
Mathematics, King's College London

"Given the social implications that my research has, it's been a great opportunity for me to present my work to the UK Parliament. I find that all the posters presented were amazing and I feel very honoured to have been awarded the bronze prize."

PHYSICS

Gold Medal and The Westminster Medal



Ben Fernando

SEISMOLOGY AT THE EXTREMES – FROM THE OCEANS TO MARS
Department of Earth Sciences, University of Oxford

"It's a real honour to have won both the Physics Gold award and the Westminster Medal. I'm really grateful to both the STEM for Britain organisers and the judges for giving up their time to hear about my work! I would very much encourage other early-career scientists and parliamentarians to get involved with the competition next year, as it was a really worthwhile experience."

Silver



Vicky Fawcett

RED QUASARS: THE MISSING LINK IN GALAXY EVOLUTION?
Centre for Extragalactic Astronomy, Durham University

"I am so happy and honoured to have won this award. It was really interesting trying to communicate my research to such a wide audience, and to summarise everything in three minutes was quite difficult."

Quasars are extremely bright objects powered by gas that spirals into supermassive black holes. The majority of quasars have very blue colours but recently we have found a subset that show much redder colours ("red quasars"). In my research, I have found fundamental differences in the radio properties of red quasars that suggest these red quasars may play an important part in galaxy evolution. I also found this enhanced radio emission to be on very small scales, rather than the huge galactic jets we sometimes see, which suggests this emission is driven by out-flowing material such as winds. This outflow could have a big impact on the host galaxy, and shape how it evolves."

Bronze



Heidi Thiemann

SUPERWASP VARIABLE STARS: CLASSIFYING STARS USING CITIZEN SCIENCE

School of Physical Sciences, The Open University

"Taking part in STEM for Britain 2021 was a fantastic experience and I'm really happy to have been awarded the Physics Bronze award! It was a good opportunity to represent The Open University to the Parliamentary & Scientific Committee and showcase the work we're doing in the School of Physical Sciences. I personally enjoyed talking to MPs about how we can engage with the general public in astronomy research to produce real scientific results, and I valued the discussions we had. The power of citizen science has been demonstrated time and time again, most recently through the discovery of the Winchcombe meteorite, the first UK meteorite in 30 years, and through my project's discovery of a new type of binary star."

CHEMISTRY

Gold



Ben Lewis

IMAGING G-QUADRUPLEX DNA USING FLUORESCENCE LIFETIME IMAGING MICROSCOPY (FLIM)

Department of Chemistry, Imperial College London

"It was a huge honour to be selected as a finalist for this year's STEM for Britain competition, and I am delighted to have won the Gold Medal for Chemistry. It was clear from looking at all of the other posters that there is a huge amount of excellent and fascinating research being done, and it has been a great opportunity to see what everyone else has been working on. Whilst it was a shame we couldn't be physically together in Westminster this year, it was great to still be able to come together virtually and have the opportunity to share what we do with such a broad audience. It is particularly special to be able to show our research to parliamentarians - it is a rare and important opportunity to have, and I am incredibly grateful to the organisers for facilitating it."

Silver



Rachel Irlam

TOWARDS A NEXT-GENERATION BIOINK FOR 3D BIOPRINTING: FINE CONTROL OF THE RHEOLOGICAL PROPERTIES OF CAF1-BASED HYDROGELS VIA MODULATION OF PROTEIN FOLDING

Chemistry, School of Natural and Environmental Sciences, Newcastle University

"The STEM for Britain experience was a very exciting one; I've presented my research to people many times, but never to an audience of MPs! The nature of research means it can sometimes feel mundane and it's disheartening when things don't work, so it is easy to lose sight of the bigger picture. Taking my work out of the lab and into Parliament made me realise how important research really is for society and how big an impact it could have!
I finished my PhD in September and then started a Postdoctoral Research Fellowship in October, at a new university and in a different field to the one I was working in. This was very challenging, particularly in the middle of a pandemic, since the people who would usually have been around to show me the ropes weren't and it was a very steep learning curve. This was my first presentation of my postdoctoral research, so to have received an award for it, when I have often felt in the last few months that I've just been struggling along, feels incredible. I'm delighted to have had the opportunity to partake in the competition!"

Bronze



David Brossault

WHEN LEGO BRICKS INSPIRE MICROSCOPIC MATERIALS: SUSTAINABLE PRODUCTION OF MULTIFUNCTIONAL PARTICLES

Chemical Engineering and Biotechnology, University of Cambridge

"STEM for Britain is a great opportunity for early-career academics to connect with politicians and share the importance of academic research to tackle current societal challenges. It was an honour for me to be shortlisted and be given the opportunity to present my PhD project during the Chemistry finals. I really enjoyed explaining to Daniel Zeichner (Cambridge MP) and other Members of Parliament, how multifunctional microparticles could be produced using commercial nanoparticles as building blocks, and how such systems could be used for both biological (e.g. Bio-separation) and environmental (e.g. Water treatment) applications. I was over the moon to discover a few days later that my project was awarded the Chemistry Bronze at this year's event. This award motivates me even more for the future, and I am now looking forward to going further with my project before submitting my PhD thesis in the coming few months."

ALZHEIMER'S DISEASE – A CLEAR AND FUTURE EPIDEMIC



Dr Bryan Hanley, FRSC, FRSB, Biophys Ltd, Usk, UK and ACTA, Amsterdam, Netherlands

INTRODUCTION

Alzheimer's disease is the most common form of dementia. The loss of cognitive function in the elderly was known to the Ancient Egyptians and has also formed part of literature (e.g. King Lear) and folk knowledge. Pythagoras defined six ages of life - infancy (age 0–6), adolescence (age 7–21), adulthood (age 22–49), middle age (age 50–62), senescence (age 63–79), and old age (age 80 or older). Senescence and old age were times of decline in bodily and mental functions and the decline in mental function was generally considered to be an inevitable consequence of ageing.

Alzheimer's disease was eventually described in detail by Dr Alois Alzheimer in 1906 who recorded both the symptoms of a patient (referred to as 'Auguste D') and, after post mortem analysis of her brain, reported the presence of plaques and neurofibrillary tangles. The protein constituents of these physiological characteristics – beta-amyloid and tau – were found to be typical of those who suffered from Alzheimer's disease and this, together with neuropsychological testing, forms the basis of diagnosis (Yang, HD *et al*, 2016).

Many approaches to preventing or curing Alzheimer's disease have concentrated upon preventing formation of plaques or tangles however these have been largely unsuccessful and new approaches are being examined including the "Antimicrobial Infection Hypothesis" which postulates that the development of Alzheimer's disease is, at least in part, a consequence of pathogen interference and the response of the innate immune system (Moir *et al*, 2018).

In this brief review, we will outline the growing problem of cognitive decline in our ageing populations, the current approaches to dealing with Alzheimer's disease, how the most recent hypotheses offer some hope for future efforts to mitigate the disease and its effects.

PREVALENCE

The proportion of the population that are over 65 years of age will continue to increase in most countries in the world. Large population-based studies demonstrate an exponential increase in dementia incidence after 65 years of age, doubling roughly every five years. Based on the numbers of people in different age groups

now and in the future, we can determine the numbers who will suffer from Alzheimer's Disease at different time points in the future. In this way we can also determine the socioeconomic burden that will be associated with such a prevalence.

The Alzheimer's Society has estimated that in 2019 there were over 850,000 people with dementia in the UK. This is equivalent to 1 in 14 of the population aged 65 years and over. By 2040, the figure will be over 1.5 million people. Up to 75% of those will be suffering from Alzheimer's disease. The cost of dementia in 2040 [healthcare costs (costs to the NHS), social care costs (costs of homecare and residential care), and costs of unpaid care (provided by family members)] is estimated to be around £100bn. This is an annual and rising cost. In comparison, when the UK government bailed out the banks in 2008 they spent £500 billion and this triggered 10 years of austerity. The Office for Budget Responsibility (OBR) has said that UK government borrowing would be £355bn for the current financial year (April 2020 to April 2021). The cost of Alzheimer's disease is of the same order of magnitude as these – with the exception that this cost will happen every year and will rise year on year.

CURRENT THERAPIES AND PROSPECTS

Since the cost will be so high and the numbers likely to be affected are predictable, there should be a strong impetus to reduce the impact of Alzheimer's disease. There seems to be a genetic predisposition to

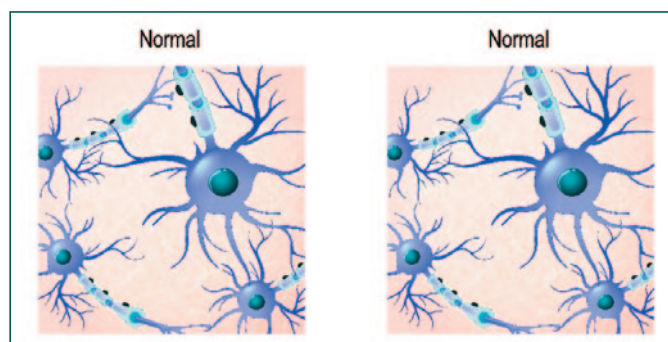


Figure 1: Beta amyloid plaques in Alzheimer's and normal brains



Figure 2 – A representation of Cognitive Decline

Alzheimer's Disease (susceptibility runs in families) and more than 40 genes/loci have been linked to the risk of developing the disease (Bellenguez et al, 2020). Identification of genetic risk factors is an active area of investigation. In addition, substantial efforts have been made to develop a pharmaceutical approach that focuses on beta amyloid plaque formation and to thereby prevent the physiological consequences of the disease.

One particular genetic trait, having an inherited form of a particular gene – the E4 variant of apolipoprotein E, increases the likelihood that an individual will develop Alzheimer's disease. Other, rarer forms of the gene may reduce that risk while the most common form is neutral – i.e. it does not affect susceptibility. (Liu CC *et al*, 2013). The identification of other predisposing genetic traits is underway.

Much of the research into the development of pharmaceutical approaches to Alzheimer's disease has been directed towards the beta amyloid plaques which, together with accumulations of the tau protein (generally referred to as 'tau tangles') form a characteristic agglomeration in the brains of those affected by the disease.

While both plaques and tangles have been associated with the disease, it was considered that the former were causative while the latter were more indicative of disease progression. Unfortunately trials of drugs that inhibit the beta amyloid plaque process have been unsuccessful and others have suggested that tau accumulation is a more important trigger and occurs at an earlier (and hence more treatable) stage in the disease process. In addition, the brains of many people who died after diagnosis of Alzheimer's disease did not contain beta amyloid plaques so causality has continued to be questioned (Shi *et al* 2020).

INFECTIVE HYPOTHESIS

The idea of an inflammatory aspect to Alzheimer's Disease is not new. The cause and consequences are, however, becoming clearer. It is known that one of the normal functions of beta amyloid protein in the brain is to act as an anti-infective agent. In addition, it has been suggested that neuroinflammation may be linked to beta amyloid production. Neuroinflammation itself can also occur as a result of infection by bacteria or viruses.

Several microbes have been proposed as triggers of Alzheimer's, including human herpes viruses and

Porphyromonas gingivalis, which causes gum disease. Work is continuing to determine if specific microbial agents could act as triggers for an inflammatory response that might act as a trigger for the development of Alzheimer's disease. There are, however, a number of caveats.

Neuroinflammation is part of the normal ageing process so infection may not be required.

Trials with anti-inflammatory agents have failed. A non-steroidal anti-inflammatory drugs (NSAIDs) trial with asymptomatic people in their 60s at high risk of Alzheimer's disease gave them daily naproxen for two years. The drugs did not affect their cognition or imaging and cerebrospinal fluid markers, and may have even made a composite of all these measures a bit worse. Nonetheless, several immune related genetic risk factors which may contribute to the inflammatory process and increased cytokine production in Alzheimer's disease have been identified (Shi *et al*, 2020).

CONCLUSION AND FUTURE PROSPECTS

Further work is needed to confirm if a single or multi-targeted approach to Alzheimer's disease might be successful. The National Institutes of Health (NIH) in the US has launched a major programme of work to investigate the infectious theory of Alzheimer's disease (NIH Notice number NOT-AG-19-012. "Research on Current Topics in Alzheimer's Disease and Its Related Dementias (R01 Clinical Trial Optional)" regarding the infectious etiology of Alzheimer's disease. This high-priority topic aims to:

(1) determine whether microbial pathogens represent a causal component of Alzheimer's disease (AD),

(2) establish mechanisms by which microbial pathogens impact neurodegenerative processes in AD, and

(3) inform aspects of future translational studies in AD, including discovery of candidate therapeutics aimed at regulating pathogen-associated networks and molecules in AD.

A UK-based consortium led by Biophys Ltd and involving a multidisciplinary group from the UK and the Netherlands has responded to this call and are using a novel paradigm to develop potential therapies for further investigation. This proposal – Inflammatory Signatures of Oral and Neural Cells – is currently under review by the NIH.

Dr Michael Graz,
Dr Heather Graz

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THE FUTURE OF TELECOMMUNICATIONS: NATIONAL SECURITY IMPLICATIONS OF FOREIGN INVOLVEMENT AND INVESTMENT IN 5G



Dr Ashley Thomas Lenihan
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As technology evolves, telecommunications become even more intertwined with national security – necessitating that those involved in our information and communication technology (ICT) infrastructures must be trusted partners. In addition to the general security risks raised by 5G, foreign competitor involvement in Western 5G (and future) telecommunications infrastructures raises specific concerns, all with distinct policy implications.

TELECOMMUNICATIONS AND NATIONAL SECURITY

Secure and timely communications have been vital to strategic planning, diplomacy, and military operations throughout history. What has changed is the speed at which these communications can take place, the number of people that can be reached and influenced, and how these communications are sent and secured.

The telephone and telegraph changed personal communication, as well as diplomatic and military possibilities and outcomes. Radio and TV made instantaneous mass communication possible, changing culture and the ability to spread information, propaganda, and other messaging during times of hot and cold war. Telecoms have played a crucial role in statecraft since WWI, from its military use in intelligence gathering and sharing, to its role in shaping alliance relationships.¹ Wireless capability and the mobile phone were particularly transformational. Their integration with computer technology cemented telecoms, and ICT more broadly, as a critical strategic asset.

As critical national infrastructure (CNI), telecoms and other ICT have historically been protected from foreign influence and control in many countries,

Western and non-western. These protections often involve restrictions on greenfield and non-greenfield foreign direct investment, supply chain restrictions, and export controls.

The strategic importance of telecoms and ICT is so high that even foreign investments originating from close allies and friendly states have been blocked or mitigated in the past (see Figure 1), especially when there are concerns over adherence to export control laws, or fears that untrusted component suppliers might be used in future.²

5G AND NATIONAL SECURITY

5G will significantly increase data rates, mobility, reliability, connection density, and area traffic capacity – all while decreasing latency, and offering potentially greater security through, for example, authentication and roaming security improvements. By

Acquiror	Target	Year	Status
Intelsat (US)	Eutelsat (FR)	2002	Effective Block
PanAmSat (US)	Eutelsat (FR)	2003	Effective Block
Check Point Software Technologies (IL)	Sourcefire (US)	2006	Effective Block
Alcatel (FR)	Lucent Technologies (US)	2006	Heavily Mitigated
Alliant Techsystems (US)	MacDonald Detweiler (CA)	2008	Blocked
Softbank's (JP)	Sprint (US)	2013	Heavily Mitigated
Broadcom (SG)	Qualcomm (US)	2018	Blocked
Connect Bidco (US, UK, CA)	Inmarsat (UK)	2019	Heavily Mitigated

Figure 1. Cross-border Mergers & Acquisitions in the Telecommunications, Satellite, and ICT Sectors

enabling the Internet of Things (IoT), it will lead to a massive increase in the number of connected devices, and 5G use cases will range from smart cities, grids, and military bases to factory automation, autonomous vehicles, and remote medicine.³

All of this will again transform the relationship between telecoms and national security, as increased connectivity will affect almost every area of society and the economy, reach wider populations, and go deeper into every aspect of peoples' lives. Moreover, almost all 5G improvements will be dual-use: enabling government and military, as well as civilian and industrial, innovation. On top of the need to maintain the network's physical security, the greatest challenges will be in the area of cyber security. A recent report by the US Government Accountability Office (GAO) outlines some significant challenges in these areas, that may be summarized here as follows:

First, 5G architecture significantly increases the 'surface area' and volume of potential points of attack by state and non-state threat actors. Greater reliance on software and network virtualization increases network flexibility and reduces dependency on purpose-built hardware, *but* also means quality coding, consistent monitoring, updating, and patching will be required from highly trusted vendors. Similarly, 5G network slicing creates efficiencies, but also the potential for malign actors to attack one slice through the vulnerabilities of another. Continuously connected devices (like medical devices) and IoT devices (like autonomous cars) can also be vulnerable to attack.

Second, the increased volume and scope of personal data offer more *targets* for attack. Though useful for industry and crime

fighting, personal data can also be used for leverage, ransom, or worse in the wrong hands. In addition to basic privacy issues, perhaps more concerning is the improved capabilities for precision location (to inches or feet), which in the wrong hands could endanger personal liberty and security.

Third, are the risks associated with the quality and security of the 5G supply chain. The potential for malicious software and built-in backdoor access points – and concern over poor quality components, service, or future provision of updates and patching – again all require countries to trust vendors at all points in their supply chain.

There are also concerns raised by the fact that many potential 5G security enhancements are optional (and often expensive) for providers to implement. There will be continued legacy vulnerabilities as backward compatibility with 4G is required until core networks are fully upgraded.⁴

Acquiror		Target		Year	Status
Lenovo (CN)		IBM's PC Business (US)		2005	Mitigated
Huawei (CN)		3com (US)		2008	Effectively Blocked
TCIC (CN)		Emcore (US)		2010	Effectively Blocked
Huawei (CN)		3Leaf Systems (US)		2010	Forced Divestiture
Grand Chip Investment (CN)		Aixtron (US business)		2016	Blocked
Grand Chip Investment (CN)		Aixtron (DE)		2016	Blocked
Canyon Bridge (CN)		Lattice Semiconductor (US)		2017	Blocked
Hytera (CH)		Sepura (UK)		2017	Mitigated
Hubei Xinyan (CN)		Xcerra (US)		2018	Blocked
Beijing Shiji Information Technology (CN)		StayNTouch (US)		2020	Forced Divestiture

Figure 2. 'Going out' – Attempted Chinese Investments in the Telecommunications, ICT, and Semiconductor Sectors

All of these are in addition to the unknown, and as yet undiscovered, points of vulnerability.

5G AND CHINA

The primary 5G equipment providers globally are Huawei, Nokia, Ericsson, Samsung, and ZTE. Yet, to truly understand why the involvement in 5G

infrastructure of certain Chinese companies like Huawei and ZTE have raised specific security concerns in the West, we must look beyond market dominance, and at the wider strategic and policy context.

First, China is emerging as a near-peer competitor with fundamentally different values (on the liberal economic order, freedom, democracy, liberty, and human rights), making it a focal point for concern in the area of ICT influence and control.

Second, Chinese law and policy gives companies like Huawei and ZTE distinct competitive advantages, while making it difficult to trust that they could not be compelled to comply with requests from the Chinese government in future.⁵

China's 'Going Out' strategy, for example, encourages and supports (often through financing and subsidies) outward foreign investment in strategic sectors, like ICT, to gain a global competitive and technical

The 'China Standards 2035' strategy outlines the government's plans to set global standards for next generation technologies.

More importantly, China's National Intelligence law mandates that all companies, organizations, and citizens in China assist in national intelligence efforts, that they not disclose those efforts, and that they will be protected by the State for doing so. China's 2014 Counterintelligence Law makes similar requirements.

It is thus understandable why concerns have been raised over companies like Huawei and ZTE. A history of attempted purchases of sensitive companies, lack of transparency, suspected links with the Chinese government and military, and repeated charges of industrial espionage / intellectual property theft in the US – all within the context of Chinese state policy and law requiring companies to comply with information requests and engage in espionage – makes it

clear why the US, and more recently the UK and other countries, have either formally or effectively banned Huawei from their 5G infrastructures going forward. Yet, while concern focuses on these companies now, other actors may be of greater concern in future.

In sum, the major risks raised by foreign competitor

involvement and investment in domestic 5G infrastructures include:

- espionage,
- intellectual property theft,
- the potential lowering of security standards,
- the use of data, or the provision of supply and maintenance, as leverage by foreign actors, and
- the future availability of the network (i.e. – due to potential discontinuity or attack on service/supply).

POLICY IMPLICATIONS

First, with regard to the Telecommunications (Security) Bill, the above shows the importance of maintaining a

‘clean’ telecommunications infrastructure going forward. This means purchasing equipment, software, and integration services from trusted vendors in allied and partner countries; and investing in R&D to ensure a competitive edge in next generation innovation.

Second, it shows that the UK and its allies require strong foreign investment regulations to review transactions on national security grounds. Passage of the National Security & Investment Bill will help achieve this aim – but, as I have argued elsewhere, the challenging volume and scope of covered transactions under the proposed regime means it will require regularized multi-agency feed-in, adequate

staffing, training, and funding if it is to truly fulfill its purpose and protect national security.⁶

Third, none of this need result in a Cold War with China. China certainly limits inward foreign investment and involvement in its domestic ICT infrastructure, and benign Chinese investment or trade should continue to be welcomed by the West.

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- 4 <https://www.gao.gov/assets/gao-21-26sp.pdf>
- 5 See
<https://ccdcoe.org/uploads/2019/03/CDCOE-Huawei-2019-03-28-FINAL.pdf>;
<https://fas.org/sgp/crs/natsec/IF11251.pdf>.
- 6 <https://parliamentlive.tv/event/index/c7c4733e-0ca9-4f45-858c-2c09598a4605>;
<https://parliamentlive.tv/event/index/de472ea0-c918-4733-8000-7529e0c37e97>



CELTIC ACADEMIES ALLIANCE LAUNCHED TO POOL EXPERTISE

The Alliance will enable the RSE, LSW and RIA to pool the wide-ranging expertise and practitioner experience that exists within their memberships to inform public policy developments at both the UK level and within the devolved nations.

The Celtic Academies Alliance brings together the national academies of Ireland (the Royal Irish Academy), Scotland (the Royal Society of Edinburgh) and Wales (the Learned Society of Wales) to provide a forum for researchers, policy makers, industry, and the arts and cultural sectors on the island of Ireland and in Scotland and Wales to connect, communicate and collaborate, while working to strengthen understanding at UK level of issues facing the devolved nations.

The Celtic Academies Alliance aims to:

- Provide independent expert advice on higher education and research and other shared issues;
- Support the evolution of more effective intra-UK and UK–Ireland governance, especially in the post-Brexit context; and
- Ensure that the UK Government and its bodies take proper account of the needs and differing situations of the devolved nations.

To meet these aims, the Alliance will:

- Organise meetings and events that bring together policy makers, institutions and other stakeholders;



Acadamh Ríoga na hÉireann
Royal Irish Academy

- Work to strengthen links between our academies and relevant UK bodies, including government departments and research bodies;
- Produce briefing papers and other documents that set out the Alliance's shared positions; and
- Share learning and information between our member academies.

The establishment of the Alliance comes at a critical time as the higher education and research sectors deal with the major twin challenges of Covid-19 and Brexit. It also presents significant opportunity with the UK Government developing a new R&D strategy for the UK, including commitments to 'levelling up' investment across the whole of the UK and with plans emerging for the UK Shared Prosperity Fund.

Speaking at the launch on the 25th March 2021:

Professor Dame Anne Glover, RSE President said: "The establishment of the Celtic Academies Alliance is a significant development. Our national academies are uniquely placed to draw upon our extensive and multidisciplinary expertise, experience and networks to help inform and shape policy developments at all levels of government. It is vital that policy making at the UK level takes

account of the distinctive priorities and needs of the devolved nations and the Alliance can play its part in supporting this process."

Dr Mary Canning, RIA President commented: "A great strength of the three academies is that they span the full range of academic disciplines within their respective fellowships. This together with their independence and convening power makes them invaluable in analysing the many complex issues which underpin and permeate scientific, economic, social and cultural development. The Celtic Academies Alliance will act as a catalyst for enhanced and synergistic academic and research collaborations between the nations for the mutual benefit of all."

Professor Hywel Thomas, LSW President remarked: "The Celtic Academies Alliance is an opportunity to further develop and amplify the voices of the research and innovation communities of Scotland, Northern Ireland, and Wales. We will work together to understand what is needed to build research capacity, productivity, and impact in the devolved nations, recognising regional variation within the nations themselves. We hope to contribute constructively to the discussions around levelling up research, development and innovation funding."

CELTIC ACADEMIES ALLIANCE ACTIVITIES 2020–2021

- Submissions and responses to government initiatives and consultations, e.g. letter to the UK Secretary of State for Business, Energy and Industrial Strategy on the implementation of the UK Research and Development Roadmap;
- Roundtables on research and development in the devolved nations;
- Explainer notes, e.g. *The European Structural and Investment Funds: contribution to UK research and innovation* (with the British Academy).

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SECTOR DEALS FOR SMEs

DISCUSSION MEETING FEBRUARY 15, 2021

Representing the vast majority of the UK businesses, as well as being a large section of the GDP, SMEs are vital for the UK economy. Prof. Karl Ryder from the University of Leicester talked about how the university sector can help SMEs with research and development. Paul Mason from Innovate UK gave us insight into this organisation and how it helps connect companies to facilities for research and development, as well as how crucial innovation is for the future of the UK economy.

Brian Norton, the Managing Director of Indestructible Paints Ltd, spoke about how his SME has been innovating in their sector and how crucial this has been to the sustainability of the company. The Q&A focused mostly on how this process has been effected by the Covid-19 pandemic, and ways that the Government can ease this strain on resources.

The UK currently ranks 4th on the recent Global Innovation Index, and exploiting our resources here will be crucial for the future UK economy. With 97% of the world's GDP existing outside our borders, looking outwards provides a massive opportunity for growth. The UK is in a position to be able to provide goods and services of high quality which are difficult to copy, but tomorrow's trade will come from today's innovation, and supporting new development will be crucial to growing our economy.

SMEs represent 99.9% of the UK's business population and in 2019 had a turnover of £2.17billion. This large section of the economy is also one of the most innovative, often having to develop unique, sophisticated services and products in order to compete with larger businesses. For these reasons, the ability to access resources for research and development is vital to the success of these enterprises. However, this is no easy task. Access to research facilities is competitive, and larger companies are able to outperform SMEs when applying for these resources.

Innovate UK is one organisation that helps many companies access research and development resources. They have around 5,990 live projects running, and have partnered with an SME on

over 2,000 of those projects. The benefits of Innovate UK's work have been demonstrated, as they have been able to support the creation of over 100,000 jobs in around 8,500 companies, and have added an estimated £2.9billion to the UK economy since 2007. Innovate UK works to connect companies and organisations with similar research areas through their Knowledge Transfer Network, all in order to speed up development. They also provide direct grants for companies to carry out research into areas where the private sector is unable to. Competition for these grants is high however, and they often have to reject credible ideas due to demand.

The university sector is a crucial resource for innovation. Being funded by the public sector, there is a real desire to support economic growth throughout the UK. Universities have high quality research facilities that can be exploited to push forward development of cutting edge ideas. Innovate UK works to connect businesses, including many SMEs, to universities for this purpose, and many universities also have grants specifically for business development.

SMEs currently face many challenges. The economic hit of the Covid-19 pandemic as well as the changes to international trade due to Brexit means SMEs are having to navigate difficult economic times. Research and development is often one of the first budgets cut when a business faces tough time, but evidence shows that companies that continue to innovate come out of the economic downturn stronger. Therefore, access to research facilities is crucial for the future economic growth of SMEs. Competition for these facilities was already high, but due to the strain of the pandemic many universities are focusing more resources onto teaching and fundamental research. If we wish for SMEs to continue innovating and increasing their contribution to the economy, widening access to these facilities will be crucial.

By Alfie Hoar, Parliamentary & Scientific Committee



L-R: Professor Karl Ryder, University of Leicester; Paul Mason, Innovate UK and Brian Norton, Managing Director of Indestructible Paints Ltd.



HOUSE OF COMMONS SELECT COMMITTEES

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.

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.

Membership:

Darren Jones MP, Labour, Chair
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
Charlotte Nichols MP, Labour
Sarah Owen MP, Labour
Mark Pawsey MP, Conservative
Alexander Stafford MP, Conservative

Inquiries:

- Post Office and Horizon - Opened 4 March 2020
- My BEIS inquiry - Opened 5 March 2020 Published 11th July 2020
- Net zero and UN climate summits - Opened 6 March 2020
- The impact of coronavirus on businesses and workers - Opened 13 March 2020
- Delivering audit reform - Opened 18 March 2020.
- Work of the Department and Government Response to coronavirus - Opened 14 April 2020
- Post-pandemic economic growth - Opened 3 June 2020.
- Post-pandemic economic growth: Industrial Strategy – Opened 23rd July 2020.
- Post-pandemic economic growth: Levelling up local and regional structures and the delivery of economic growth – Opened 24th July 2020.
- ONE WEB – Opened 16th September 2020.

- Freed Labour in UK value chains – Opened 18th September 2020.
- Decarbonising heat in homes – Opened 2nd October. Accepting written evidence until 13th November 2020.
- Business and Brexit preparedness – Opened 17th November 2020.
- Mineworkers' Pension Scheme – Opened 18th March 2021. Deadline 12th April 2021.

For further details: Tel: 020 7219 5777

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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.

Membership:

Rt Hon Philip Dunne MP, Conservative, Chair
Duncan Baker MP, Conservative
Dan Carden MP, Labour
Sir Christopher Chope MP, Conservative
Barry Gardiner MP, Labour
Rt Hon Robert Goodwill MP, Conservative
Helen Hayes MP, Labour
Ian Levy MP, Conservative
Marco Longhi MP, Conservative
Caroline Lucas MP, Green Party
Cherilyn Mackrory, Conservative
Jerome Mayhew MP, Conservative
John McNally MP, Scottish National Party
Dr Matthew Offord MP, Conservative
Alex Sobel MP, Labour
Claudia Webbe MP, Independent
Nadia Whittome MP, Labour

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.
- Biodiversity and Ecosystems – Opened 13th July
- Technological Innovations and Climate Change: Tidal Power – Opened 9th November 2020
- Green Jobs – Opened 17th November 2020.
- Water Quality in Rivers – Opened 8th December 2020.
- Next steps for deposit return schemes – Opened 12th February 2021.
- Technological Innovations and Climate Change: Community Energy – Opened 19th February

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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).

Membership:

Rt Hon Greg Clark MP, Conservative, Chair
Aaron Bell MP, Conservative
Dawn Butler MP, Labour
Chris Clarkson MP, Conservative
Katherine Fletcher MP, Conservative
Andrew Griffith MP, Conservative
Mark Logan MP, Conservative
Rebecca Long-Bailey MP, Labour
Carol Monaghan MP, Scottish National Party
Graham Stringer MP, Labour
Zarah Sultana MP, Labour

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.
- A new research funding agency – Opened 9th April 2020.
- The role of technology, research and innovation in the COVID-19 recovery – Opened 24th July 2020.
- Coronavirus – Lessons Learnt – Opened 6th October 2020.
- The Role of Hydrogen in Achieving Zero – Opened 4th December 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.

Membership:

Rt Hon Jeremy Hunt MP, Conservative, Chair
Paul Bristow MP, Conservative
Rosie Cooper MP, Labour
Dr James Davies MP, Conservative
Dr Luke Evans MP, Conservative
Neale Hanvey MP, Scottish National Party
Barbara Keeley MP, Labour
Taiwo Owatemi MP, Labour
Sarah Owen MP, Labour
Dean Russell MP, Conservative
Laura Trott MP, Conservative

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.
- Delivering Core NHS and Care Services during the Pandemic and Beyond - Opened 22 April 2020. Published 30th October.
- Safety of maternity services in England – Opened 24th July 2020.
- Workforce burnout and resistance in the NHS and social care – Opened 30th July 2020.

- Coronavirus – Lessons Learnt – Opened 6th October 2020.
- Coronavirus – Recent developments – Opened 5th January 2021.
- Children and young people's mental health – Opened 29th January 2021.
- Treatment of autistic people and individuals with learning disabilities – Opened 3rd February 2021.

- Department's White Paper on health and social care – Opened 25th February 2021.

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HOUSE OF LORDS SELECT COMMITTEES

SCIENCE AND TECHNOLOGY COMMITTEE

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

Inquiries

- Ageing: Science, Technology and Healthy Living - Opened 25 July 2019
- The science of COVID-19 Opened 7 May 2020.
- The Contribution of Innovation Catapults to Delivering the R&D Roadmap – Opened 11th November 2020.
- Role of batteries and fuel in allowing Net Zero – Opened 3rd March

Members

The Lord Krebs, Crossbench, Chair
 The Lord Patel KT, Crossbench, Chair
 The Baroness Blackwood of North Oxford, Conservative
 Viscount Hanworth, Labour
 The Rt Hon. the Lord Kakkar, Crossbench
 The Baroness Manningham-Buller LG DCB, Crossbench
 The Lord Mitchell, Labour
 The Baroness Rock, Conservative
 The Lord Sarfraz, Conservative
 The Baroness Sheehan, Liberal Democrat
 The Baroness Walmsley, Liberal Democrat
 The Baroness Warwick of Undercliff, Labour
 The Lord Winston, Labour

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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 2020 and 2021 were:

638: Food and drink reformulation to reduce fat, sugar and salt

637: AI and healthcare

636: Woodland creation

635: Screen use and health in young people

634: Mental health impacts of COVID-19 on NHS staff

633: Interpretable machine learning

632: Heat networks

631: Edge computing

630: Digital sequence information

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

POSTbriefs are responsive policy briefings based on mini-literature reviews and peer reviews. Those produced in 2020 and 2021 were:

40: Proposals to increase UK recycling of plastic food packaging

39: Outward medical tourism

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

POST has also introduced some rapid response articles 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

COVID-19 Vaccines: July update on research

Effects of COVID-19 on the food supply system

COVID-19 in children – July update

Child and adolescent mental health during COVID-19

COVID-19, children and schools

COVID-19: July update on face masks and face coverings for the general public

Immunity to COVID-19: August update

Influenza immunisation programme, NHS winter pressure and COVID-19

COVID-19 vaccines: Immunisation and prioritisation of eligible groups

COVID-19 and the disadvantage gap

Long-term health effects of COVID-19

Contact tracing apps for COVID-19: September update

Interpreting COVID-19 test accuracy

Mental health impacts of COVID-19 on NHS healthcare staff
 The latest in COVID-19 testing: developing new technologies
 Impact of COVID-19 on different ethnic minority groups
 COVID-19 and occupational risk
 Test, trace and isolate programmes for COVID-19
 Test, Trace and Isolate: Behavioural aspects
 COVID-19 vaccines November update: progress of clinical trials
 Technology and domestic abuse
 Mass testing for COVID-19 using lateral flow tests
 Regulatory approval of COVID-19 vaccines in the UK
 Monitoring wastewater for COVID-19
 Monitoring COVID-19 vaccine safety in national immunisation programmes
 COVID-19 and the digital divide
 Manufacturing COVID-19 vaccines
 SARS-CoV-2 virus variants: a year into the COVID-19 pandemic
 Mass testing for COVID-19: January update on lateral flow tests
 The performance of COVID-19 vaccines in clinical trials and in real world conditions
 COVID-19 in pregnant women and newborn babies
 Changing the UK COVID-19 vaccine dosing schedule
 Latest evidence on impacts of COVID-19 in children: March 2021

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/>. The evidence gaps identified through this work and that of parliamentary staff have been published as Parliament's first Areas of Research Interests: <https://post.parliament.uk/covid-19-areas-of-research-interest/>

Ongoing and future projects approved by the POST Board.

BIOLOGY AND HEALTH

In production

Disorders of consciousness
 Researching gambling
 Influence of industry on public health policy
 Testosterone and sports performance
 Mental health impacts of COVID-19
 Living organ donation
 Developments in vaccine technologies
 Childhood obesity
 Preventing zoonotic diseases

ENERGY AND ENVIRONMENT

In production

Food waste
 Sustainable cooling
 Hydrogen
 Regulating product sustainability
 Coastal management

Environmentally efficient residential buildings
 Net zero and decarbonising construction

DIGITAL AND PHYSICAL SCIENCES

In production

Smart cities
 Digital skills for life

SOCIAL SCIENCES

In production

Distance learning
 Remote and flexible working

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
- Secretary: Claire Quigley

House of Commons

- Rt Hon Greg Clark MP
- Alan Whitehead MP

House of Lords

- Lord Oxburgh, KBE, FRS
- Lord Haskel
- Lord Patel KT, FMedSci, FRSE

Non-parliamentary

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

Ex-officio

- Vacant, Head of the Parliamentary Office of Science and Technology
- Penny Young, House of Commons Librarian and Managing Director of Research & Information
- Farrah Bhatti, 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

- Vacant

PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY

Houses of Parliament
 Westminster
 London SW1A 0AA





HOUSE OF COMMONS LIBRARY

The House of Commons Library is an impartial research and information service 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 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/>). This includes:

A series of briefings on Coronavirus restrictions:
<https://commonslibrary.parliament.uk/coronavirus/coronavirus-restrictions/>

A series of briefings on Vaccination:
<https://commonslibrary.parliament.uk/coronavirus/coronavirus-vaccination/> including:

UK Vaccination Policy
Published 21 January 2021, CBP-9076

Coronavirus: Covid-19 vaccine roll-out - Frequently Asked Questions
Published 4 March 2021, CBP-9081

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

Establishing the National Institute for Health Protection (Insight)

Published 17 February 2021
An article on the functions moving to the new organisation.

Energy bills and tariff caps

Published 17 February 2021 CBP-8081
This briefing provides a summary of the UK energy market, a breakdown of the components of energy bills, and details of concerns and reforms in the market, including the tariff cap.

End of Brexit transition: chemicals regulation (REACH)

Published 3 March 2021 CBP-8403
This briefing discusses plans for UK REACH and the impact of Brexit on the chemicals industry.

Building telecommunications infrastructure

Published 4 March 2021 CBP-9156
This briefing explains the rules and permissions needed to build broadband and mobile infrastructure including proposals for reforms to make building infrastructure easier.

Gigabit-capable broadband in the UK

Published 4 March 2021 CBP-8392
This briefing provides information on the Government's gigabit-capable broadband targets, policy and funding for hard to reach areas.

Estimates Day Debate: COP26 Climate Conference

Published 9 March 2021 CDP-2021-0033
A briefing for the Estimates Day debate on Wednesday 10 March on preparations for the COP26 Climate Conference.

Forensic Science Regulator Bill 2019-21

Published 10 March 2021 CBP-8815
A briefing for the Private Members' Bill which completed Commons stages on 12 March.

The future of research and development funding

Published 16 March 2021 CDP-2021-0035
A briefing covering trends of, and policy on, research and development spending prepared for a debate.

UK-EU Trade and Cooperation Agreement: Fisheries

Published 18 March 2021 CBP-9174
A short overview of some of the changes that took place for the fisheries industry on 1 January 2021 after the Brexit transition ended.

Advanced Research and Innovation Agency Bill 2019-21

Published 19 March 2021 CBP-9176
A briefing on the Government Bill to establish a new research funding agency specifically aimed at providing long-term support for high risk 'blue-skies research'.

Plastic waste

Published 24 March 2021 CBP-8515
A briefing on plastic waste in the UK, including statistics on plastic waste and information on UK Government and devolved Government plans and ambitions to reduce avoidable plastic waste and examples of voluntary initiatives from the plastics industry, environmental groups and retailers. □

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

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.

AMPS

The Association of
Management and
Professional Staffs.

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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 [@basnews](http://www.bas.ac.uk)



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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.



Tracey Guise, Chief Executive Officer
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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) was founded in 1947 and is an established international membership organisation and charity committed to the study of soil in its widest aspects. The society brings together those working within academia, practitioners implementing soil science in industry and all those working with, or with an interest in soils.

We promote research and education, both academically and in practice, and build collaborative partnerships to help safeguard our soil for the future. This includes hosting the World Congress of Soil Science 2022 in Glasgow, where those with an interest in soil science can meet to discuss the critical global issues relating to soil.



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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.



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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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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, agricultural 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.



serving science, profession & society

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



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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.



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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.



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

Institute of Marine Engineering, Science and Technology (IMarEST)



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

The Institute of Materials Finishing



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

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

Institute of Measurement and Control



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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.



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.



The Institution of Chemical Engineers

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

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

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The 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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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.



Advancing the science of nature

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We challenge the way people think about the natural world – its past, present and future

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

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

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

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

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



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The University of Northampton is an institution committed to science education through initial teacher training, a STEM Ambassador network which works within the community and teaching and research to doctoral level. We are an Ashoka U 'Changemaker Campus' status university recognising our commitment to social innovation and entrepreneurship.



The University of Nottingham

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With 43,000 students and campuses in Nottingham, China and Malaysia, The University of Nottingham is 'the nearest Britain has to a truly global university'. With more than 97 per cent of research at the University recognised internationally according to the Research Excellence Framework 2014, the University is ranked in the top 1% of the world's universities by the QS World University Rankings.



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



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As the largest network of physiologists in Europe, with academic journals of global reach, we continue our 140-year tradition of being at the forefront of the life sciences.

We bring together scientists from over 60 countries, and our Members have included numerous Nobel Prize winners from Ivan Pavlov to John O'Keefe.



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Prospect is an independent, thriving and forward-looking trade union with over 120,000 members across the private and public sectors and a diverse range of occupations. We represent scientists, technologists and other professions in the civil service, research councils and private sector.

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

QUADRAM
INSTITUTE



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



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As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering. We have four strategic challenges: drive faster and more balanced economic growth; foster better education and skills; lead the profession; and promote engineering at the heart of society.



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RBG Kew is a centre of global scientific expertise in plant and fungal diversity, conservation, and sustainable use, housed in two world-class gardens. Our scientific vision is to document and understand global plant and fungal diversity and its uses, bringing authoritative expertise to bear on the critical challenges facing humanity today.

Kew's strategic priorities for science are:

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

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

The Royal Institution Science Lives Here

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

THE ROYAL SOCIETY

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

Royal Society of Biology

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

ROYAL SOCIETY OF CHEMISTRY

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

society for applied **SfAM** microbiology

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

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:

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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.

SMI Society of Maritime Industries - UK

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The Society of Maritime Industries (SMI) is the voice and champion of the UK maritime engineering, marine science & technology and business service sectors.



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



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



University of Essex

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

Universities Federation for Animal Welfare



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UFAW, the international animal welfare science society, is an independent scientific and educational charity. It works to improve animal lives by:

- supporting animal welfare research
- educating and raising awareness of welfare issues in the UK and overseas
- producing the quarterly scientific journal *Animal Welfare* and other high-quality publications on animal care and welfare
- providing advice to government departments and other concerned bodies.



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DISCUSSION AND OTHER MEETINGS 2021

Monday 17th or 24th May

Discussion Meeting topic and details to be advised

Sponsored by The Physiological Society
 Virtual Meeting

Monday 7th June

Discussion Meeting on Natural Capital Initiative

In partnership with the Plymouth Marine Laboratory

5.30pm to 7.00pm Virtual Meeting

Tuesday 22nd June

Extraordinary General Meeting

12.30pm – 1.30pm Virtual Meeting

Monday 5th July

Discussion Meeting on Climate Change

Sponsored by the Met Office
 5.30pm to 7.00pm Virtual Meeting

Monday 13th September

Discussion Meeting on Mathematics and Algorithms

Sponsored by the Institute of Mathematics and its Applications
 5.30pm to 7.00pm

Monday 12th October

Discussion Meeting on Neurological topic

Sponsored by the British Neurological Association
 5.30pm to 7.00pm

Monday 8th November

Discussion Meeting on COP 26

Sponsored by the National Physical Laboratory
 5.30pm to 7.00pm

Tuesday 16th November

Annual Lunch

Cholmondeley Room, House of Lords
 12.30pm – 2.00pm

Monday 29th November

Discussion Meeting on topic to be advised

Sponsored by the Nuffield Council
 5.30pm to 7.00pm

Monday 6th December

Discussion Meeting and STEM for Britain 2021 Awards Ceremony

Attlee Suite, Houses of Parliament
 10.00am – 1.00pm

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 For scientific meetings queries: scientificmeetings@royalsociety.org

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

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

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For further details please contact Events@rsc.org



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Biosciences - GOLD
Nikita Patel

G-Quadruplexes: Unravelling the next knot in the DNA story

Benjamin Knoll^{1,2}, Dr Peter Sommer, Dr Peter Borker, Veronika¹, Rüdiger Böhmer¹, Michael Reinhardt¹ 

¹ Department of Chemistry, University of Bonn

What is a G-Quadruplex?

G-Quadruplexes are four-stranded DNA structures that can form in regions of the genome with high GC content. They are found in telomeres, centromeres, and other regions of the genome. They are formed by the stacking of G-quadruplex planes, which are held together by Hoogsteen hydrogen bonds. They are stabilized by monovalent cations, such as potassium and sodium.

The Challenges

The challenges of studying G-quadruplexes are many. They are difficult to study by conventional methods, such as X-ray crystallography and NMR. They are also difficult to study by computational methods, as they are highly flexible and can adopt many different conformations. However, recent advances in cryo-electron microscopy and molecular dynamics simulations have allowed for a more detailed understanding of their structure and function.

Our Solution

Our solution is a new method for studying G-quadruplexes. We have developed a new technique for the synthesis of G-quadruplex DNA, which allows us to study them in a more controlled environment. We have also developed a new method for the visualization of G-quadruplexes, which allows us to see their structure in real time. This new method is based on the use of a special dye that binds to the G-quadruplex and fluoresces when it is bound. This allows us to see the G-quadruplex as it forms and changes shape.

Why do we care?

G-quadruplexes are important for many biological processes. They are involved in telomere maintenance, DNA replication, and gene expression. They are also involved in the regulation of cell growth and differentiation. Understanding their structure and function is therefore important for understanding many aspects of biology and medicine.

Admiration and Acknowledgments

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References

Knoll, B., Sommer, P., Borker, P., Veronika, V., Böhmer, R., Reinhardt, M. (2023) G-Quadruplexes: Unravelling the next knot in the DNA story. *Chemical Reviews*, 103, 1-45.

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