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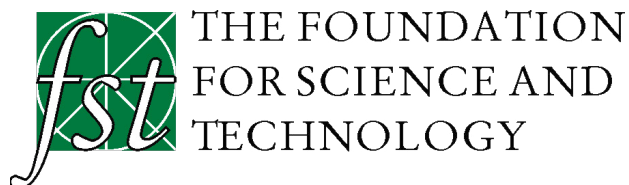
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Mike Keoghan: Keeping statistics meaningful and useful



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UK creates department for science, innovation and technology

The UK has created a new Department to focus on science, innovation and technology. Michelle Donelan, until recently the Culture Secretary, becomes Secretary of State at the new Department. Responsibilities for digital technology are also transferred from the Culture Department to the new DSIT. Ms Donelan is a former minister for Further and Higher Education.

The move will bring together what the Government refers to as 'the five technologies of tomorrow' – quantum, AI, engineering biology, semiconductors, future telecoms – along with life sciences and green technologies, into a single Depart-



Michelle Donelan: also takes on digital

ment, according to the Government.

Ms Donelan will, however, soon be taking maternity leave and Norwich North MP Chloe Smith will act as Secretary

of State during her colleague's absence.

Another Norfolk MP, George Freeman, has been appointed Minister of State in the Department. His responsibilities include: Horizon Europe, UKRI, the life sciences and the space sector.

Responsibility for energy and climate change has also been placed in a separate Department. Grant Shapps, previously head of BEIS, is now Secretary of State for Energy Security and Net Zero (DESNZ).

Former international trade secretary Kemi Badenoch, will now head up a combined Department for Business and Trade.

www.gov.uk/dsit

Guarantee fund awards £1 billion

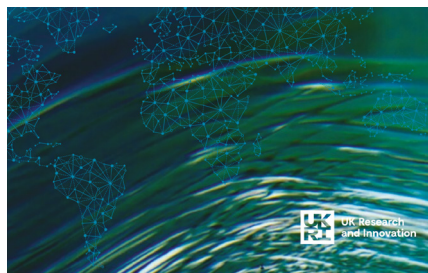
The Horizon Europe Guarantee fund has reached an important milestone with more than £1 billion now awarded to UK-based researchers and innovators.

The funding is enabling them to participate in Horizon Europe projects while the UK's association to the flagship EU funding programme is delayed.

At the beginning of April, the Government set out its prospectus for a programme to protect and support the UK research and innovation sector, should it be required.

The guarantee fund is delivered by UK Research and Innovation (UKRI). It supports researchers and innovators who have been successful in Horizon Europe competitions but cannot receive EU funding due to the delays to the UK's association to the programme. With guarantee funding they can continue their work in research and innovation.

www.ukri.org/news/horizon-europe-guarantee-fund-awards-1bn-in-grants



UKRI: funding milestone

Government drafts AI regulatory blueprint

The UK Government launched an AI Regulation White Paper in March. Five principles, including safety, transparency and fairness, will guide the use of artificial intelligence in the UK, says the Department for Science, Innovation and Technology, as part of a new national blueprint for regulators to drive responsible innovation and maintain public trust in this revolutionary technology.

The UK's AI industry is thriving, employing over 50,000 people and contributing £3.7 billion to the economy last year. Adopting artificial intelligence in more sectors could improve productivity and unlock growth, says the Government, which is why it is committed to unleashing AI's potential across the economy.

As AI continues developing rapidly,

questions have been raised about the future risks it could pose to people's privacy, their human rights or their safety. There are concerns about the fairness of using AI tools to make decisions which impact people's lives, such as assessing the worthiness of loan or mortgage applications.

The Government believes that the proposals in the AI regulation white paper will help create the right environment for artificial intelligence to flourish safely in the UK.

Currently, organisations can be held back from using AI to its full potential because a patchwork of legal regimes causes confusion and financial and administrative burdens for businesses trying to comply with rules.

www.gov.uk/government/publications/ai-regulation-a-pro-innovation-approach

UN delegates finalise High Seas Treaty

The UN Secretary-General Antonio Guterres has commended delegates to an Intergovernmental Conference at the UN for finalising a text to ensure the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.

This breakthrough — which covers nearly two thirds of the ocean — marks the culmination of nearly two decades of work and builds on the legacy of the United Nations Convention on the Law

of the Sea (UNCLOS). The new agreement, known as the United Nations High Seas Treaty, was agreed at the UN on 4 March.

The Secretary-General said that: "This action is a victory for multilateralism and for global efforts to counter the destructive trends facing ocean health — now and for generations to come. It is crucial for addressing the triple planetary crisis of climate change, biodiversity loss and pollution."

Prime Minister launches Science and Technology Framework

At the beginning of March, the Prime Minister and Technology Secretary together launched the Government's plan to make the UK a science and technology superpower by 2030, together with announcements about a raft of new measures backed by £370 million to boost investment in innovation, bring the world's best talent to the UK, and seize the potential of new technologies like AI.

The Science and Technology Framework is the first major piece of work from

the newly created Department for Science, Innovation and Technology and will require every part of Government to put the UK at the forefront of global science and technology this decade through 10 key actions – creating a coordinated cross-Government approach.

In doing so, the Government aims to foster the right conditions for industry innovation and world leading scientific research to deliver high-paid jobs of the future, grow the economy in cutting-edge industries, and improve peo-

ple's lives in ways ranging from better healthcare to security.

As the Framework was launched, the Government announced that delivery of this new Framework will begin immediately with an initial group of projects worth around £500 million in new and existing funding, which will help ensure the UK has the skills and infrastructure to take a global lead in these technologies. www.gov.uk/government/news/plan-to-forge-a-better-britain-through-science-and-technology-unveiled

Net Zero Review report prompts response

In autumn 2022, the Government commissioned an Independent Review of Net Zero. Led by former Energy Minister Chris Skidmore MP, the review was tasked with assessing the Government's approach to net zero, to ensure it was pursuing the most economically efficient path to meeting its climate change commitments, given the changed economic context.

The Net Zero Review travelled to all four nations of the UK, received over 1800 responses to the Call for Evidence, and held more than 50 roundtables. The final report states: 'We heard a clear message from businesses, organisations, individuals, and local government across the country: net zero is creating a new era of opportunity, but Government, indus-

try, and individuals need to act to make the most of the opportunities, reduce costs, and ensure we deliver successfully.'

The Government has now published its response to the final report from the Review. In addition, it has also published Powering Up Britain setting out how the Government plans to enhance the country's energy security, seize the economic opportunities of the transition, and deliver on our net zero commitments.

www.gov.uk/government/publications/review-of-net-zero

www.gov.uk/government/publications/powering-up-britain

- The Foundation held a meeting about the Review on 21 March which will be featured in the next issue of *FST Journal*.



Angela McLean: took up role this month

New Chief Scientific Adviser appointed

Professor Dame Angela McLean DBE FRS took up the role of Government Chief Scientific Adviser (GCSA) on 3 April, having been appointed by the Prime Minister in February.

Dame Angela was previously Chief Scientific Adviser for the Ministry of Defence and Deputy GCSA. She is the first woman to hold the post.

The role of the GCSA is to provide independent scientific advice to the Prime Minister and members of Cabinet and advise the Government on aspects of policy on science and technology. The GCSA ensures the quality of – and improves the use of – scientific evidence and advice in Government.

The GCSA leads the Government Office for Science, is Head of the Government Science and Engineering Profession, Co-Chair of the Council for Science and Technology and is part of the executive team of the Department for Science, Innovation and Technology.

www.gov.uk/government/organisations/government-office-for-science

Blair and Hague in call to reshape the state

Former Labour Prime Minister Tony Blair and former Conservative leader William Hague have published a joint report calling for "a fundamental reshaping of the state" based on a new consensus across the political spectrum on the central role of science and technology in UK society.

"The future of Britain will depend on a new age of invention and innovation," they say. "Technological superpowers such as the United States and China are investing heavily in their futures, raising the possibility that everyone else will be trapped behind these two forces – a risk the European Union is belatedly recognising and acting upon."

They add: "Britain must find its niche in this new world. To do so requires a radical new policy agenda, with science and technology at its core, that transcends the fray of 20th-century political ideology."

"With science and technology as our new national purpose," they conclude, "We can innovate rather than stagnate in the face of increasing technological change. This purpose must rise above political differences to achieve a new cross-party consensus that can survive any change of Government."

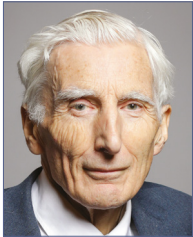
www.institute.global/insights/politics-and-governance/new-national-purpose-innovation-can-power-future-britain

GUEST EDITORIAL

Science and research in the UK have been subject to unprecedented political and economic stresses, and the research landscape may change further after the completion of the Nurse Review. Here, the Astronomer Royal focusses on two aspects of the research landscape: education and the international dimension.

Laying foundations for success

Martin Rees



Lord Martin Rees OM FRS is an astrophysicist and cosmologist, and the UK's Astronomer Royal. He is based at the University of Cambridge where he has been Professor of Astronomy and Director of the Institute of Astronomy. He is a Fellow, and former Master, of Trinity College, Cambridge. In 2005, he was appointed to the House of Lords, and he was President of the Royal Society from 2005 to 2010.

Those running universities should not be berated for taking risks in admissions, nor pressured to entice students to stay, least of all by lowering degree standards.

Last year, two prime ministers were flung from office. The current incumbent, Rishi Sunak, is striving to restore stability to a divided and discredited party. Ideally, crucial sectors like education and R&D should be governed by a bipartisan consensus that offers long-term stability. In depressing contrast, turbulence within Government has triggered unstable policies and a rapid 'churn' of ministers. Two new Departments were recently set up – one for climate and energy, the other for science and innovation – covering portfolios that previously fell in the remit of one cumbersome ministry, the Department for Business, Energy and Industrial Strategy (BEIS).

Some hope that, with two cabinet ministers fighting its corner, science will have a stronger voice in dealing with the Treasury. At the moment things do not look good; the overall funding of the sector is being squeezed.

Such reorganisations of Departmental boundaries are not in themselves big deals. Apart from the key Departments of State – Treasury, Foreign Office and Home Office, the others are frequently revamped, seldom with evidence of an improvement that outweighs the disruption.

But more relevant than the ministerial reshuffles are changes below the political level. Some five years ago, the Government followed the advice of Paul Nurse, who advocated a merger of six Research Councils (and three other bodies) into a single conglomerate, UKRI. The jury is still out on whether this was a good move, or just an extra layer of bureaucracy.

There has been long-term consistency in a single ministry for education – though it cannot be currently deemed a success. Attainment levels in our schools are poor compared to those of nations in the Far East and Northern Europe.

In particular, there are too few good science teachers to ensure that every pupil engages with one. Young children display enthusiasm and curiosity – often focussed on dinosaurs and the cosmos (blazingly irrelevant to their lives, but fascinating). Yet all too often they are denied the inspirational teaching that could build on this enthusiasm. In consequence, a substantial frac-

tion are 'turned off' science, drop it at 16 and forgo any chance to qualify for the most prestigious university courses. Despite many initiatives, substantial improvements will be slow.

There are three things that can be done: ensure that conditions are good enough to retain excellent teachers, with pay levels appropriate for practitioners of a serious profession; encourage mature individuals into teaching from a career in research, industry or the armed forces; and, thirdly, make better use of the web and of distance learning.

At the university level, our international rankings are higher. However, there is a systemic weakness in UK Higher Education: the missions of our universities are not sufficiently varied. They all aspire to rise in the same league table. Most of their students are between 18 and 21 – undergoing three years of full-time (generally residential) education and studying a curriculum that is too narrow, even for the minority who aspire to professional or academic careers.

Worse, the school curriculum is too narrow as well. The campaign for an international baccalaureate-style curriculum for 16 to 18 year-olds needs a more positive response by universities, whose current entrance requirements disfavour applicants who straddle science and humanities.

Moreover, students who realise that the degree course they embarked on is not the right one for them or who have personal hardship, should be enabled to leave early with dignity, with a certificate to mark what they have accomplished. They should not be dismissed as 'wastage' – they should be able to make the positive claim: "I had two years of college." Those running universities should not be berated for taking risks in admissions, nor pressured to entice students to stay, least of all by lowering degree standards.

More important, everyone should have the opportunity to re-enter Higher Education – maybe part-time or online – at any stage of their lives. This path could become smoother (indeed routine) if there were a formalised system of transferable credits across the whole system of Further and Higher Education.

The Government has proposed a 'Life-long

Entitlement' to three years' support, to be taken 'à la carte' at any stage in life. If on a sufficient scale, this could give those who did not complete an undergraduate course when young an entitlement to return and 'upgrade' later.

It will be a long slog to ensure that high-quality teaching at school is available across the full geographical and social spectrum – and it may be impossible until there is a narrowing of the gulf between the resources of private, fee-taking schools and those in the state system. In the meantime, it would send an encouraging signal if UK universities (whose entry bar is often dauntingly high) were to reserve a fraction of their places for students who do not come straight from school.

In this way, they could offer a second chance to those who were disadvantaged at 18, but have caught up by earning two years' worth of credits at other institutions (or online), maybe via the Open University. Such students could then advance to degree-level in two further years. I would like to see such a reform at my university.

The Covid crisis has given us experience of online and remote teaching: we can make a more realistic assessment of the most effective format for 'contact' hours with students. Purely online courses, the so-called MOOCs, have had an ambivalent reception. As stand-alone courses without complementary contacts with a real tutor, they are probably only satisfactory for Masters-level vocational courses intended for motivated mature learners studying part-time. Yet they can have wider benefits as part of a 'package' that incorporates 'live' tutoring as well.

Higher Education is one of the most international segments of UK society – at both student and faculty level. Yet our ability to attract and retain mobile academic talent is now at risk. To retain its international competitiveness as a destination of choice for mobile faculty despite the setback of Brexit, the UK must raise its game. There is now an international market for the best students as well: they are academic assets, and a long-term investment in international relations.

Concerns have been voiced about accepting students from countries that are deemed to be potentially hostile. I think these concerns are overplayed. The quality and volume of Chinese research is now so high that we could lose as much as we gain by inhibiting exchanges. Moreover – and this is admittedly more controversial – I believe we should maintain contacts with, for instance, Iran. There have been, in the past, refusals to admit Iranian students for courses such as nuclear physics. As these students will learn nuclear physics somewhere, whatever barriers

THE NURSE REVIEW

The Review of the Research, Development and Innovation Organisational Landscape was announced in July 2021 in the UK Innovation Strategy. This independent review was led by Sir Paul Nurse, Chief Executive and Director of the Francis Crick Institute.

The review examined the mix of UK organisations performing Research, Development and Innovation, with recommendations to make the most of the UK's research organisational landscape, ensuring it is effective, sustainable and responsive to global challenges.

The review's findings and recommendations aim to ensure that UK science can go from strength to strength, driving long term sustainable growth, productivity, and prosperity, delivering tangible improvements to the lives of communities across the country, and ensuring that we remain internationally competitive in the years to come.

www.gov.uk/government/publications/research-development-and-innovation-organisational-landscape-an-independent-review

the US and UK impose, it is surely better that they should in their studies make contacts here, and retain them. This will decrease the chance that clandestine programmes can proceed without someone in our country becoming aware of them.

There was an enlightening instance of such benefits during the multinational talks in 2015 aiming to restrain Iran's development of nuclear weapons. The Iranian minister for atomic energy, Ali Akbar Salehi, asked the US negotiating team to include Ernie Moniz – a distinguished physicist who was then the US Secretary for Energy. These two men knew and trusted each other through having studied at MIT at the same time.

The university sector must not be sclerotic and unresponsive to changes in needs, lifestyle and opportunities. Yet sadly, the UK, traditionally a magnet for foreign talent, has lost its allure.

An especially worrying fall-out from Brexit has been the jeopardising of UK participation in the Horizon science programme. This is damaging to the entire European community because there is so much collaboration. Now that there has been progress in unlocking the stand-off over Northern Ireland, we must hope that there is no further vacillation and that our Government views rejoining European scientific collaborations as an urgent priority.

It has indeed been fortunate that CERN, the European Space Agency (ESA) and the European Southern Observatory (ESO) – covering particle physics, space science and astronomy respectively – are bodies that are separate from the EU and through which the UK is still able to engage and collaborate. □

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An especially worrying fall-out from Brexit has been the jeopardising of UK participation in the Horizon science programme. This is damaging to the entire European community because there is so much collaboration.

CONTEXT

The United Nations COP27 climate conference was held in Sharm El Sheikh, Egypt in November 2022. The UK had held the Presidency of COP26, and had made science a key element of the COP meeting held in Glasgow in 2021. As the UK was handing over the baton to Egypt, it was an opportune moment for the Foundation for Science and Technology to hold an event to discuss the contribution that science needed to make in COP27 and future COP meetings.

To explore this, the Foundation was delighted to bring together

Sir Patrick Vallance, the UK Government Chief Scientific Adviser; Professor Mahmoud Sakr, President, Egyptian Academy of Scientific Research and Technology; Emma Howard Boyd, Chair of the Green Finance Institute; and Professor Jim Skea, Co-chair of Working Group III of the Intergovernmental Panel on Climate Change (IPCC). The event was held at the Royal Society on 26 October 2022.

A video recording, presentation slides and speaker audio from the event are available on the FST website at: www.foundation.org.uk/Events/2022/Science,-Climate-Policy-and-COP27

To prepare for tomorrow, look at what is already in place today

Patrick Vallance

SUMMARY

- Climate will be the biggest issue for governments across the globe for the next 40 years
- COP26 saw a focus on innovation
- Scaling up is a massive challenge
- We need to look at what is available today to see what can be used at scale in 2050
- The challenges do not go away in 2050 and we must be prepared for what comes after.

The big issue that will occupy governments for the next 40 years is, of course, climate. Having a strong science base to the response will be critical. Science, after all, identified the problem. It is crucial for tracking where we are and it will be crucial for determining solutions as well. COP26 was the first to include a day dedicated to science which was very well attended.

There were many important outcomes from COP26. One basic result was the consensus among participants from different backgrounds that there is no longer any doubt that the climate is indeed changing. Also, there is no longer any doubt that human activities have contributed to that change. The reason such a consensus was possible is because of the work of many scientists across the world, and of the Intergovernmental Panel on Climate Change (IPCC) in particular.

COP26 was the first Conference of the Parties under the UN Framework Convention on Climate Change (UNFCCC) in which the final text

of the outcome document – the Glasgow Climate Pact – included a commitment to reduce reliance on fossil fuels. And 23 countries agreed to phase out coal and not build new coal-power plants.

There was the launch of Phase 2 of Mission Innovation, which aims to develop innovations that will make a difference to clean technologies: supporting innovation was a priority at Glasgow. Importantly, there was a clear link at the meeting between climate and biodiversity, with 130 countries agreeing to halt, and indeed reverse, forest loss and land degradation by 2030.

This was not just a meeting about mitigation, though, it also focused on adaptation and the Adaptation Research Alliance was launched, involving 100 organisations across 35 nations.

And in advance of COP26, 40 senior scientific advisers to governments from around the world came together to produce a statement calling for science and innovation to be at the centre of global action to tackle climate change.

The challenges

While there were some good outcomes from COP26, there was also a big ‘but’. The scale of the challenge is extraordinary and is going to occupy governments around the world. In addition, there remains a need for further research. There are, for example, many tipping points in this process: the West Antarctic Ice Sheet, glacier destruction, sea-level rises, for example. It will be important to get better resolution modelling in order to more fully understand what happens over time and at much greater granularity.



Sir Patrick Vallance FRS FMedSci FRCP HonFREng is the outgoing Government Chief Scientific Adviser (GCSA), National Technology Adviser (NTA) and Head of the Government Science and Engineering (GSE) profession. Prior to this, he was a clinical academic at UCL and joined GlaxoSmithKline in 2006, where he was President, R&D, from 2012 until 2017. During his period as head of R&D, over 14 new medicines were approved for use worldwide, for diseases ranging from cancer to asthma and HIV. His own research was in the area of diseases of blood vessels and endothelial biology.



Behaviour change: how quickly we choose to take up innovations such as electric vehicles will play a significant part in determining the ultimate size of the challenges we face.

Research remains crucial.

The second big challenge is innovation, particularly with respect to scaling up. There are many novel developments being announced now, but applying these across populations and countries is a huge technical and operational scientific challenge.

As Bill Gates puts it, the cost of a green innovation is much more than the cost of a conventional option, and the difference is what he calls the 'green premium'. Reducing that to a level which is practical for people is again a scientific, technical and engineering challenge. There are areas where there are still no adequate solutions – for instance, massive energy storage. Carbon capture and storage is a technology that will be needed on any journey to net zero, but it is still not clear how to achieve that at scale. Concrete and shipping are others – the list goes on. Then, in addition, there is adaptation: innovations here will have to adjust to a continually changing situation.

Changing behaviours

A further area is behaviour. How quickly we choose to take up electric vehicles, change what we eat, and change how we move between or within countries, will play a massive part in determining the ultimate size of the challenges we face. Rather than prescribing change (which is very difficult to do), it is more important just to understand the factors that are likely to

produce a big swing towards the desired results.

Finally, aspirations and ambition are laudable but delivery plans are needed – and needed now. Of course, these are very difficult politically as well as for individuals. Take the example of innovation: we have to work back from 2050. The scaling challenge means we have to get on with rapidly deploying some of the innovations we have today if they are to play their full part by 2050.

Crucial years

That, in turn means the next five years are crucial in terms of innovation. There has to be a roadmap to deliver all this, with both push and pull mechanisms, financial tools, and everything else needed to make sure that innovation can come through.

Another area where science becomes really important is in monitoring progress against the roadmap. This is at heart a systems problem. People tend to want to pick off distinct elements: 'I can solve electric vehicles', or 'I can solve housing', etc. Yet it all has to be done together. So systems monitoring is critical including, of course, understanding supply chains.

It also needs to be recognised that it is important to continue to research new areas, because the challenge is not going to stop in 2050. The problems will continue and we have to make sure we have the right answers for what comes next. □

DOI: 10.53289/ZWMZ5791

Implementing practical policies to combat climate change

Mahmoud Sakr



Professor Mahmoud M Sakr is President of the Academy of Scientific Research and Technology (ASRT), Egypt. He has more than 15 years' experience in the high-level management of science, technology and innovation. He served as Dean of the Genetic Engineering and Biotechnology Institute, is co-founding director of the Center of Scientific Excellence for Advanced Sciences at the National Research Center (NRC) and is Plenipotentiary of Egypt in the Joint Institute for Nuclear Research (JINR).

COP27 is an African event which reflects the aspirations and expectations of the African people and communities and that makes it very different from its predecessor. COP26 succeeded in making the voice of science heard very loudly. However, Africans are looking for implementation, to see something tangible happening.

I was appointed to coordinate the scientific activity of COP27 in my capacity as President of the Egyptian Academy of Scientific Research and Technology, a governmental organisation responsible for science and technology in Egypt. There are many differences between COP26 and COP27, but the objectives are the same. All of us who are working to confront the impact of climate change are using tools of mitigation and adaptation. Both are equally important; we cannot focus on one aspect and neglect the other.

A further difference between the two COPs is the very limited preparation time for COP27. The Egyptian government was notified very late, almost at the same time the United Arab Emirates were confirmed as hosts of COP28. But we have been very fortunate in the support received from the Royal Society and some UK university networks which helped a great deal. And we have of course built on the success of COP26.

The leaders of the African people believe strongly about the importance of implementation and at COP27 we want to shed light on the role of science in overcoming the barriers to it. There are many applicable solutions to many of the challenges of climate change: the knowhow and the innovations are there. Take the agricultural sector, for instance. It is very easy, using available technologies, to reduce carbon dioxide emissions. Simple changes, such as switching agricultural machinery from diesel power to photovoltaic, minimising the use of agrochemicals and replacing them with organic alternatives, and so on.

One issue here, of course, is to find the funding needed for scaling up and for mass application of the available technology. There are many others too, including changing the mindset of people in local communities, those small farmers whose existing practice is rooted in tradition and who need to be convinced of the value of new

SUMMARY

- COP27 will focus on implementation of measures to combat climate change
- There are already many suitable technologies available today
- Science can help overcome the barriers to implementation
- A key step is to bridge the gap between science and policy making
- Success is not just about technology but also continued international collaboration.

technologies.

Linkage

In Africa, we believe that where there is a will, there is a way. One of the recent positive initiatives within the Egyptian sustainable development community is the linkage between the National Development Plan and the Climate Research Plan. We took the Sustainable Development Goals and Egypt's strategic objectives for sustainable development by 2030. By linking this work to climate change research, the country now has a national strategy for climate change.

One of the specific objectives of the Egyptian strategy on climate change is to enhance scientific research, knowledge transfer and public awareness. A longstanding issue has been the gap between academia and industry. As a developing country, we believe strongly that bridging this gap will have a positive impact on technology transfer, commercialisation and return on investment from scientific research.

When it comes to climate change, bridging the gap between academia and policy makers is the most important issue, because they need to see robust justification for proposed actions. Fortunately, in Egypt, the President is already committed to climate change activities. This can be seen in the hosting of biodiversity conferences over a number of years and the decision to host COP27.

There are a series of mega-projects being implemented to voluntarily lower carbon dioxide emissions. In the south of Egypt, one of the larg-



Egypt is building new resilient Smart Cities such as New Alamein in the north-west of the country, on the Mediterranean Sea.

est photovoltaic facilities in the world is being built with a capacity of 1700MW. Egyptian public transport is being moved from a fossil-powered system to electricity. The country is building new resilient Smart Cities, investing in a major project on water treatment and improving the efficient use of this vital resource.

Egypt and Sudan produce the highest number of international publications related to climate change research. The local and regional science innovation community in Egypt and the Arab States and Africa are directing a relatively large portion of their research towards climate change.

Practical measures

The Egyptian presidency of COP27 is focussed firmly on implementation. One challenge is therefore to find applications which support the efforts of different countries in achieving sustainable development under climate change. By doing so, we hope to convince the people, the policy-makers, NGOs and the private sector that it is worth investing in these measures.

We convinced our government to invest in a national breeding programme for crop varieties that are more tolerant to adverse environmental conditions. We succeeded in creating varieties with low water demand. This success has persuaded policy makers to invest more in climate change research.

In 2015, we started to invest in renewable energy, promoting strategic knowledge transfer, localisation and international cooperation. As a result of this cooperation, we have established the largest central facilities for renewable energy R&D in Egypt. However, this serves not only Egypt but Africa as a whole. Local conditions affect efficien-

cy so innovative approaches, tailored to specific conditions, are needed. There are no 'one size fits all' solutions: technology readiness levels, availability of finance, culture, religion – all of these factors can affect implementation.

The Egyptian government is organising three big events at COP27. The first is entitled ReDirect and focusses on the role of research, development and innovation in addressing climate change. Redirect refers to the redirection of public funds to climate change research, using existing vehicles for cooperation among international sciences to tackle the challenge.

The second event is related to the WIPO Green Technology Book and has been organised jointly by the World Intellectual Property Organisation (WIPO) and the Egyptian Academy of Scientific Research and Technology. WIPO is a catalyst for emerging technology around the world. Much of the information about green IPR is not yet in the public domain but green innovation is vital to tackle climate change.

The third event reflects the Egyptian vision for COP27 of redesigning climate strategies for a changing world. There are technological solutions available now, but sustainable development under climate change also needs collaboration and innovation. So this provides an opportunity to share and discuss the possibilities among the international scientific community. □

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One challenge is to find applications which support the efforts of different countries in achieving sustainable development under climate change.

Financing our net zero future

Emma Howard Boyd



Emma Howard Boyd CBE is Chair of the Green Finance Institute and UN Global Ambassador for Race to Zero and Race to Resilience. She was Chair of the Environment Agency and an ex-officio Board member of the Department for Environment, Food and Rural Affairs from 2016 to 2022. She was the UK Commissioner to the Global Commission on Adaptation from 2018 until January 2021.

The future that scientists and climate activists have long warned about has been a reality for some of the most climate-vulnerable countries for decades. This future is now becoming a reality for all, with huge uncertainty and change at local, national and global levels.

On 22 July, the UK hit a milestone when, for the first time, temperatures of 40°C were confirmed and more than 2,800 excess deaths were recorded. Since then, a third of Pakistan has been flooded, California has been pushed closer to blackouts by heatwaves and Europe has suffered spectacular wildfires. The Yangtze River in China has dried up, nine million people were told to evacuate as super-typhoon Nan Madol hit Japan, Hurricane Fiona wreaked havoc from the Caribbean to Canada, while more than 600 people died and 1.3 million were displaced from their homes in flooding that hit 33 of Nigeria's 36 states and the capital. That is only highlighting a fraction of the climate shocks that are threatening lives and livelihoods around the world.

The V20 group of finance ministers from 58 climate-vulnerable economies estimate that 20 years of climate impacts have cost their countries \$525 billion. Developing countries face a 2030 bill ranging from \$290-580 billion, according to a 2019 study. African nations are losing 5-15% of GDP annually due to impacts says the Africa Development Bank. Leading insurer AON warns that the swathe of impacts in 2022 clearly supports the conclusions of the most recent IPCC assessment.

The science could not be clearer: 40% of the world's population is highly vulnerable to climate change. This is no longer a distant threat but something that is happening now. We must scale up and accelerate a just transition towards cheaper, more accessible, more secure zero-carbon energy.

2022 also represents a turning point for the Food and Agriculture agenda as well as our rela-

SUMMARY

- Climate change is no longer a distant threat but something that is happening now
- Less than one-fifth of governmental targets meet science-aligned criteria
- Green finance is the direct application of science to financial decision-making
- Net zero transition is a highly capital-intensive business
- Resilience must become a core component of innovative, strategic decision making.

tionship with nature. Surging food prices are of particular concern to Africa, Asia, and the Middle East which depend heavily on wheat imports.

Positive developments

Net zero targets now cover over 90% of the global economy. Yet less than one-fifth of the net-zero targets set by national and sub-national governments – and only a third of those from the largest public corporates – actually meet science-aligned criteria, according to the Net Zero Tracker.

The Breakthrough Agenda was designed to strengthen international collaboration where it is most needed. At COP26, leaders of 44 countries plus the European Union, representing over 70% of global GDP, committed to work together to make clean technologies and sustainable solutions the most affordable, accessible and attractive option in high-emitting sectors before the end of this decade. The first phase of work focusses on five of those sectors, accounting for over 50% of current emissions: power, hydrogen, road transport, steel and agriculture. In each of these, there is growing investment and solutions. However, world emissions continue to rise and progress is not yet fast enough to meet the goals that were agreed.

Corporate commitments are also in the spotlight but alongside these are massive green finance opportunities. One way to envisage green finance is to see it as a direct application of science to financial decision-making. This is a critically-important perspective for both the green finance and scientific communities to emphasise. Yet, investing and lending in line with the scientific consensus on both climate

A section of the Humber estuary at Hull, UK, showing flood defence improvements carried out by the UK Environment Agency





A number of cities and communities in Pakistan's Sindh province were flooded in 2022.

change and the depletion of our natural resources is increasingly under attack from those who portray it as an indulgence.

Such 'indulgence' was tolerable, they say, when the basic metrics of corporate returns were supported by low levels of inflation, low corporate tax rates, and historically low interest rates. Those conditions are now changing and markets are correcting. Hence the siren voices to get back to the day job of delivering high risk-adjusted returns, instead of focussing on environmental, social and governance matters. Voices with considerable influence are increasingly comfortable voicing such views in public.

Capital-intensive

Net zero transition is a highly capital-intensive business. To date, much energy has been focussed on secondary market considerations which only indirectly impact the availability and cost of capital for investments in new technologies and new projects. Equal vigour is now needed on bank lending-bond issuance, initial public equity offerings, private equity and venture capital: that is, direct investment in the real economy. This will mean radical collaboration between all aspects of the financial ecosystem, far more emphasis on public capital and on development finance institutions, as well as the use of philanthropic capital to lower the risk for commercial mainstream capital to redeploy monies towards sustainable opportunities.

Everyone knows that investing in adaptation and resilience works. In 2021, the Environment Agency completed the Government's £2.6 billion, six-year capital flood programme – on time and

on budget. That comprises more than 700 flood schemes, protecting more than 300,000 homes and nearly 600,000 acres of agricultural land, as well as thousands of businesses and major pieces of infrastructure.

The Government has increased the budget for its new programme to a record £5.2 billion. It will be important that this is ready for the climate events we know are locked in. The future will also require adaptation standards, not just in the UK but globally. We do not currently know what the optimum level of investment is for UK climate adaptation, nor how this should be balanced between public and private sectors. So I hope the UK Treasury will be asked to commission a review of the economics of resilience. This would consider the costs and benefits of resilience measures and the balance between public and private investment. Its conclusions would help establish a national ambition for climate resilience embedded in all Government Departments.

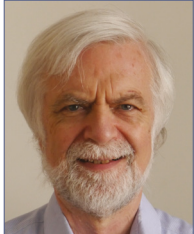
Initiatives like the Coalition for Climate Resilient Investment are working to address the massive gap in financing resilience. The Physical Climate Risk Assessment Methodology (PCRAM) is a global practitioners' guide that supplies practical tools to identify and assess the resilience of infrastructure assets. Resilience becomes a core component of innovative strategic decision making.

If we can align everything we are currently doing, this decade will be the point at which we unlock a just, resilient and sustainable path to prosperity for billions of people around the world. □

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The role of science in delivering international progress

Jim Skea



Jim Skea CBE is Professor of Sustainable Energy at Imperial College London, with research interests in energy, climate change and technological innovation. His current main role is as Co-Chair of IPCC Working Group III for the 6th assessment cycle. He was Research Director of the UK Energy Research Centre 2004-12 and Director of the Policy Studies Institute 1998-2004. He was a member of the UK Committee on Climate Change from its inception in 2008 until 2018 and is currently the Chair of Scotland's Just Transition Commission.

Science is absolutely crucial at COP27. The Intergovernmental Panel on Climate Change (IPCC) has regular meetings with the UNFCCC Secretariat through its Subsidiary Body for Scientific and Technological Advice. One priority has been to map out the way that science (and IPCC in particular) could interface with the negotiations during the conference. There would be a Science Day maintaining the tradition established in Glasgow, but also an Earth Information Day focussing on atmospheric observations and the contribution these can make to climate action.

The sessions at the IPCC pavilion are the result of negotiations between IPCC, the World Meteorological Organisation (WMO) and the MERI Foundation. IPCC ended up with 20 slots – eight for Working Group II on inputs, eight for WG III on mitigation, then two each for WG I and the Task Force on Inventories.

Mitigation

The mitigation sessions in the IPCC pavilion are all of importance to policymakers. To take two in particular – scenarios and the reconciliation of different estimates of emissions – both play into the negotiations.

It has been said that scientists have done a great job of confusing policymakers about scenarios. The IPCC does not develop its own scenarios, it assesses those produced by others and there are thousands of them. It is the IPCC's task to distil them and present clear messages to policymakers. However, with the WG I report, the policymakers cut through the maze of terminology and said they wanted a simpler classification into 'very low, low, intermediate, high and very high' categories of emissions.

There are two sessions on scenarios at the pavilion. The first simply presents what has been done in order to help people to understand the work. The second focusses more on engagement with policymakers, asking them what they want us to do and how they want scientists to construct scenario architectures in ways that are meaningful. That will then lead to an IPCC workshop in April 2023, where recommendations will be made for the next assessment cycle.

SUMMARY

- Science plays a crucial role in underpinning intergovernmental action on climate
- There is still work to be done simplifying and clarifying scientific messages
- Lifestyle and behaviour are explicitly included in an IPCC report for the first time
- The consequences of overshoot need to be better addressed
- A global stocktake of progress towards meeting the Paris Agreement goals, supported by scientific evidence, will be completed in 2023.

On reconciling different greenhouse gas emission estimates, there is a 5 Gigatonne difference between the emissions estimates submitted by countries under the Framework Convention on the one hand and the emissions estimates used in global models on the other. Note that 5Gt is 10% of global emissions. This is troubling.

The discrepancy is related primarily to carbon dioxide fluxes from land. Developing countries that are trying to produce net zero commitments may struggle to understand what net zero means because of that 5Gt difference. There is, therefore, a session with policymakers to try and explain what the differences are and how they can be reconciled.

The main differences are the distinction between managed and unmanaged land, as well as between direct human intervention as opposed to indirect natural effects. The inventories estimate these differently from the global models. The difference is understood but it is not easy to communicate: however, it does have a significance for the setting of net zero targets.

Other mitigation events on the pavilion include issues around economics and social aspects. For the first time in an IPCC report, lifestyle and behavioural issues have been explicitly highlighted: there is currently a great deal of interest in these.

While IPCC is also hosting a session on managing just transitions, the International Labour Organisation has a separate pavilion solely devoted



Science has been core to the sessions at COP27

ed to this issue.

Colleagues in WG II are hosting events on impacts, adaptation and vulnerability. These include nature-based solutions, as well as specific concerns about, for example, the situation of small island states.

One event, which features collaboration between working groups, is on the question of overshoot. Many of the projections for the 21st century envisaged 1.6-1.7 degrees of warming, while taking carbon dioxide out of the atmosphere and so cooling down again. So the consequences of overshoot for impacts, adaptation and vulnerable systems still need to be explored. Dealing with the impacts when temperature reaches a peak and then comes down again is also something that needs to be better understood.

Mitigation measures

On Earth Information Day, there is a session on observations for adaptation and early warning systems – and, interestingly, a session on Earth observation for mitigation. That is designed to help measure the impact of mitigation measures and emission inventories by earth observation, rather than simply multiplying activity by an emission factor to arrive at an estimate. There is a special event on gender-related aspects of the latest Assessment Report, including ways that gender balance could be improved within negotiations and scientific processes.

A high-level ministerial roundtable is being held on ‘pre-2030 ambition’. It is clear that there is an emissions gap: the pledges made to date do not limit warming to 1.5°C and there is also an implementation gap because the policies on the ground

do not even allow these pledges to be met. Both issues have to be addressed.

Under the Paris Agreement, a global stocktake has to take place every five years, with the first one due in 2023. The first technical phase is already under way, making a big demand on IPCC and other scientific programmes to provide evidence to that process.

A set of roundtables at COP27 cover mitigation, adaptation and means of implementation. The UNFCCC has managed to get the term ‘transformation’ into the agenda of the mitigation roundtable. This is a major triumph: in IPCC we have struggled to include this term in agreed texts.

Intersectionality

COP27 will have some focussed exchanges on ‘intersections’. These are, essentially, points at which mitigation, adaptation and means of implementation cut across each other. There are many responses to climate change that have mitigation and adaptation outcomes.

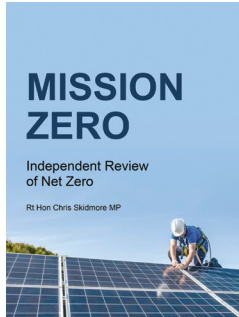
The organisers have created a ‘World Café’ session where people move between about 20 tables to talk about specific topics. This has worked really well in the past. It is a way of getting insights from policymakers, where they are not constrained by the formal nature of the negotiation sessions.

One big conclusion from all the work that has been going on is that negotiators are hungry for scientific advice. One quote, that came out of a preparatory meeting was that the process was not just about keeping 1.5 alive, it was also about keeping the science alive. □

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The debate

After the formal presentations, the speakers joined a panel to listen – and respond – to views and questions from the audience on a range of topics, including: African needs; global finance; UK plans for net zero; Government as opposed to private action; and incentivisation.



Africa needs not just finance but also access to data and information, and it needs to build capacity in terms of both individuals and institutions. Countries need to align themselves to global efforts – they concentrate on adaptation and resilience but should also focus on mitigation and lowering CO₂ emissions. Africa suffers from emerging diseases and a fragmented health system.

Disproportionate influence

There are only five or six major groups that participate in Integrated Assessment Models for climate. That means a relatively small number of countries influence the process – and the questions being asked by the models may reflect a global North perspective.

On finance, the global community needs to agree the \$100 billion package to support developing countries, and there need to be discussions on reforming global financial systems (not just the COP).

There were questions about whether the institutional arrangements for the delivery of net zero in the UK are sufficient and what the new UK Government's plans are for energy. Three years ago, the Council for Science and Technology wrote to the then Prime Minister saying that there needs to be an integrated systems approach and therefore Government needs a systems map at the centre, measuring and monitoring and influencing competing actions. This has not been achieved yet.

To deliver the recommendations of Chris Skidmore's review looking into the requirements for achieving net zero (left) will require a delivery mechanism inside Government.

Private capital cannot provide sufficient investment alone, hence the need for Government action. Major infrastructure requires an unambiguous Government decision (for example, a move to a hydrogen economy needs large investments in the right infrastructure). Climate change regulators, economic regulators and financial regulators have to work together in lockstep to deliver the required results.

How can organisations and governments identify the sweet spot where taking climate action makes money? There are good examples of how to generate revenue from green initiatives, but work is needed to get this information into the public domain and for countries to learn from each other.

Radical change

Incremental change will not deliver net zero and, indeed, some activities are locking in carbon for the future. To persuade people to embark on radical change, there must be the prospect of a just transition to the new system. Education is also vital and perhaps sustainability and climate change should be on every school curriculum. There is an urgent need to incentivise local communities, in order to gain public acceptance of the challenge. □

FURTHER INFORMATION

COP27 <https://unfccc.int/cop27>

COP27: A Preview – FST Blog by Alyssa Gilbert, Director of Policy & Translation at the Grantham Institute, Imperial College. www.foundation.org.uk/Blog/2022/COP-27-A-Preview

Breakthrough Agenda <https://ukcop26.org/the-breakthrough-agenda>

Coalition for Climate Resilient Investment <https://resilientinvestment.org>

Physical Climate Risk Assessment Methodology <https://resilientinvestment.org/pcram>

World Intellectual Property Organisation (WIPO) www.wipo.int

‘Loss and damage’ agreement in Egypt

The United Nations Climate Change Conference COP27 closed with what has been described as a ‘breakthrough agreement to provide loss and damage’ funding for vulnerable countries hit hard by climate disasters.

Set against a ‘difficult geopolitical backdrop’ as the UN described it, COP27 resulted in countries delivering a package of decisions that reaffirmed their commitment to limit global temperature rise to 1.5°C above pre-industrial levels. The package also strengthened action by countries to cut greenhouse gas emissions and adapt to the inevitable impacts of climate change, as well as boosting the support of finance, technology and capacity building needed by developing countries.

On the Loss and Damage agreement, Simon Stiell, UN Climate Change Executive Secretary said: “We have determined a way forward on a decades-long conversation on funding for loss and damage – deliberating over how we address the impacts on communities whose lives and livelihoods have been ruined by the very worst impacts of climate change.”

Recommendations

A ‘transitional committee’ will be set up to make recommendations on how to operationalise both the new funding arrangements and the fund itself at COP28 in 2023.

COP27 saw significant progress on adaptation, with governments agreeing on the way to move forward on the Global Goal on Adaptation, which is due to conclude at COP28 and inform the first Global Stocktake, improving resilience amongst the most vulnerable. New pledges, totalling more than \$230 million, were made to the Adaptation Fund.

COP27 President Sameh Shoukry announced the Sharm el-Sheikh Adaptation Agenda, enhancing resilience for people living in the most climate-vulnerable communities by 2030. The UN Climate Change Standing Committee on Finance was requested to prepare a report on doubling adaptation

finance for consideration at COP28.

The headline output, known as the Sharm el-Sheikh Implementation Plan, highlights that a global transformation to a low-carbon economy is expected to require investments of at least \$4-6 trillion a year. Delivering such funding will require a swift and comprehensive transformation of the financial system and its structures and processes, engaging governments, central banks, commercial banks, institutional investors and other financial actors.

Serious concern was expressed that the goal of developed country parties to mobilise jointly \$100 billion per year by 2020 has not yet been met, with devel-

Discussions highlighted solutions to chart a path to overcome climate challenges

oped countries urged to meet the goal, and multilateral development banks and international financial institutions called on to mobilise climate finance.

At COP27, deliberations continued on setting a ‘new collective quantified goal on climate finance’ in 2024, taking into account the needs and priorities of developing countries.

The World Leaders Summit, held over two days during the first week of the conference, convened six high-level roundtable discussions. The discussions highlighted solutions – on themes including food security, vulnerable communities and just transition – to chart a path to overcome climate challenges and to provide the finance, resources and tools to effectively deliver climate action at scale.

COP27 brought together more than 45,000 participants, including indigenous peoples, local communities, cities

and civil society, as well as young people and children, showcasing how they are addressing climate change and sharing how it impacts their lives.

Young people in particular were given greater prominence at COP27, with UN Climate Change’s Executive Secretary promising to urge governments not just to listen to the solutions put forward by young people, but to incorporate those solutions in decision and policy making. Young people made their voices heard through the first-of-its-kind pavilion for children and youth, as well as the first-ever youth-led Climate Forum.

In parallel with the formal negotiations, the Global Climate Action space at COP27 provided a platform for governments, businesses and civil society to collaborate and showcase their real-world climate solutions. The UN Climate Change High-Level Champions held a two-week programme of more than 50 events. This included a number of major African-led initiatives to cut emissions and build climate resilience, and significant work on the mobilisation of finance.

Simon Stiell reminded delegates in the closing plenary that the world is in a critical decade for climate action. A stark report from UN Climate Change underpinned his remarks, as well as discussions throughout the two-week conference. According to the report, implementation of current pledges by national governments put the world on track for a 2.5°C warmer world by the end of the century. The UN’s Intergovernmental Panel on Climate Change indicates that greenhouse gas emissions must decline 45% by 2030 to limit global warming to 1.5°C. □

<https://unfccc.int/cop27>

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CONTEXT

The Scottish Government announced an upcoming Innovation Strategy for Scotland in 2022, with a Call for Evidence to which many organisations responded. What are the key challenges for promoting innovation in Scotland, and how will the new strategy tackle these? What are the key contributions needed from the Scottish Government, industry, higher education and others? What can Scotland learn from a similar strategy in Wales, and how does this fit in with plans of the UK Government?

To explore these questions, the Foundation for Science and Technology held an event on 7 November 2022 at the University of Strathclyde in Glasgow. The speakers were Ivan McKee MSP,

then Minister for Business, Trade, Tourism and Enterprise, Scottish Government; Professor Sir Jim McDonald, Principal & Vice-Chancellor, University of Strathclyde, and President of the Royal Academy of Engineering; Professor Julie Fitzpatrick, Chief Scientific Adviser for Scotland; Dr Deborah O'Neil, Chief Executive Officer & Scientific Officer, NovaBiotics; and Professor Rick Delbridge, Professor of Organisational Analysis, Cardiff Business School.

A video recording, presentation slides and speaker audio from the event are available on the FST website at:

<https://bit.ly/innovationscotland>

Innovation priorities for Scotland

Ivan McKee



Ivan McKee MSP was Minister for Business, Trade, Tourism and Enterprise in the Scottish Government. His career has involved a number of senior roles in manufacturing and business, managing companies in the UK as well as Poland, Finland, Croatia and Bosnia. Ivan has been MSP for Glasgow Provan since May 2016. He was brought up in Glasgow and studied at the University of Strathclyde. He was previously the Minister for Trade, Investment and Innovation.

Scotland's industrial base, both now and in the future, is built on excellence in research and innovation. This small country has the highest number of top universities per head of population anywhere in the world, but there is a recognition of the importance of translating that research and science into commercial success for business. The country starts in a good place, while it is acknowledged there is much to cement and build on in order to create a global centre of excellence in science and innovation.

The Innovation Strategy itself will sit alongside a number of other strategies that have been developed over the past 15 years, all supporting the overarching National Strategy for Economic Transformation published in 2022. This serves as an umbrella under which there are a series of pillars, from the Export Strategy published several years ago to the Inward Investment Plan which has a number of crossovers to the Innovation Strategy. The Medical Strategy and the Infrastructure Plans are also important elements. These form a series of interconnecting pieces of work that mutually support each other.

This Strategy will tackle head-on some of the hard choices that have to be made and will help set priorities for the coming years. It will provide a framework within which to make informed decisions about the future focus for research and innovation in Scotland.

Scotland is a country of five million people so we have to recognise that Scotland does not need

SUMMARY

- The Innovation Strategy will determine priorities for innovation over the next 10 years
- The strategy builds on a number of existing policies and plans
- Innovation is a key driver for Scottish economic success
- Innovation takes place both within industry clusters and between them
- The public sector has a vital role to play in delivering innovation.

to be good at everything. However, we need to know our strengths, therefore it is important to use evidence in order to understand where Scotland needs to be in terms of 'vertical to horizontal' – sectors and technologies – and the interplay between them.

A robust process

Of course, innovation and technology do not stand still, so we recognise the need for a robust process that facilitates the identification of sectors and technologies that can become part of Scotland's global opportunities. We intend to do that through a cluster identification process: this involves initially identifying where we are best-placed to become a leading player – and we will use data to underpin this process. We will work with the



The public sector supports the innovation process across the Scottish economy, through innovation centres such as the National Manufacturing Institute.

strengths of our research base and industry, and encourage clusters to emerge over time, creating an appropriate structure for them to flourish.

We also need to leave space for innovation between clusters: ground-breaking innovation and new technologies can sometimes result from putting seemingly unrelated technologies together in the melting pot and seeing what happens. There are plenty of examples where, by providing that space and focus, we have been able to achieve good results – this is one of the things that Scotland is good at.

Measurement is important, so we will develop a series of essential metrics to bring a depth of clarity and focus about the specific areas where Scotland performs well, because without that we are not going to deliver this agenda.

The public sector

The public sector is important in two aspects. The first is the way the public sector supports the innovation process across the economy, for example by maintaining the infrastructure to support research and development: whether through innovation centres such as the National Manufacturing Institute or the other pieces of infrastructure we have across the economy. This support includes the funding mechanisms that exist to encourage innovation.

Equally important is how we ensure the public sector itself is innovative and how it maintains itself at the leading edge of technology. To do this, it needs to engage with the private sector. It needs to be agile, responsive and to move with the times. The public sector is a central part of the economy.

The strategy will also require an assessment of what infrastructure and architecture is needed to deliver the vision. The first step will be to identify those successful elements we already have in place and identify how these support our strategic focus

and priorities, as well as understanding – and addressing – any gaps that exist.

Investment considerations fall into two parts. Public sector investment is primarily concerned with the early stages of research and tapers off as we move to the commercialisation part of the process in which the private sector takes the lion's share. However, it is important that the public sector remains engaged through the work of Scottish Enterprise, the Scottish National Investment Bank and other public sector investment processes, helping to secure sufficient private sector investment in innovative products and technologies.

So again, ensuring the public sector investment support is aligned with the strategy is one focus, as well as understanding how we can best take forward and work with private sector investment to expand the pipeline. This builds very much on the work of the Investment Plan which identified types of investor and how to reach them, what their interests are and how to engage with them. We need to explain how Scotland Plc works and put together investment vehicles that are attractive to investors.

Then there is the challenge of diffusion and adoption. While it is clear that the economy is performing well, we recognise that there is much to be done in convincing certain key sectors and technologies, as well as SMEs, to employ these transformative innovations and technologies.

Finally, there is the question of metrics and how impact can be measured. We have a number of different measures for different activities across the economy and the challenge is to identify which ones apply to the different aspects of an innovative economy and how we can build an overall picture that will enable us to implement the strategy most effectively. □

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Innovation drives the success of the life sciences

Deborah O'Neil



Dr Deborah O'Neil OBE FRSE is an immunologist by training. She founded NovaBiotics in 2004, which is now a global biotechnology business developing a portfolio of first-in-class therapy candidates for a number of life-threatening and life-limiting conditions. A board member of the UK's BioIndustry Association, director and founding member of the BEAM Alliance (Biotech of Europe innovating in Anti-Microbial Resistance), she also chairs the UK's Cystic Fibrosis AMR Syndicate and is a board member of the Scottish Life Sciences Association.

The health and life sciences sector is a focus for the National Innovation Strategy. The sector is a broad church in Scotland, split into three main areas. Pharmaceutical innovation is probably the one most people know. This involves the development and testing of medicines and vaccines, including clinical research involving health informatics, digital processing and manufacturing.

There is also a great deal happening in health technology areas such as digital health, AI and data driven innovation, imaging devices and diagnostics. This area is becoming increasingly important. Then there are the three As: animals, agriculture and aquaculture. This area focusses on disease and healthcare through a 'One Health' approach, as well as looking at food security into the future.

Innovation really is at the very heart of the sector, driven by a constant and evolving need for better products and services to ensure the health and wellbeing of the population. Without innovating, businesses will not survive. Health and life sciences employ over 40,000 people across 750 organisations in Scotland. That figure encompasses world class universities, biotech and med-tech SMEs as well as larger pharmaceutical companies, clinical research organisations which provide the services for preclinical and clinical testing of medicines, vaccines, devices, etc. There is also associated non-pharma manufacturing.

Total turnover for the sector grew from £4.5 billion in 2014 to £6.6 billion in 2018 and the Life Science Strategy for Scotland has set a goal to increase that to £8 billion by 2025. Pharma research and manufacturing account for £2.5 billion and £2 billion respectively, supporting £1.8 and £1.2 billion of GVA. Scotland is home to 15% of the UK's healthtech, pharma and wellbeing companies. It is also home to 31% of clean-bio, agritech and industrial biotechnology companies.

In fact, health and life sciences form one of the four pillars of Scotland's economic strength.

SUMMARY

- Innovation is at the heart of the Scottish health and life sciences sector
- The Life Science Strategy for Scotland sets a target of £8 billion turnover by 2025
- Scotland has a very connected and collaborative life sciences ecosystem
- There was a 50% growth in life sciences startups between 2014 and 2018
- Scotland has created a number of new facilities to support the sector.

Innovation is critical for its success over the next decade. There is significant potential for further growth, particularly in certain high growth sub-areas or sub-sectors.

Across the country there is an ecosystem of talent and bespoke facilities located at the heart of both academic and health clusters, connecting some of the world's leading research and healthcare professionals. Each of the clusters is unique in its specific strengths. They tend to have developed from the research base and focus on expertise in their particular geographic areas.

Complementarity

While they may compete for resources – be it funding, scientific talent or management – they are otherwise complementary to each other. It is a very connected and collaborative national ecosystem. Importantly, Scotland outperforms much of the rest of the world in terms of intellectual capital generated by the life sciences, measured against a number of metrics. The UK Life Science Competitiveness Report places Scotland as number one among the 13 countries that were assessed. We also lead much of the world in terms of life science patents filed per head of population and on the investment that went into the research base to generate those patents. So on an international scale, Scotland already performs well.

Strengths in the country's health and life sciences sector can be built on, maintaining and growing its competitive advantage. So, an innovation strategy could provide a framework not

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only to sustain and drive further innovation, but to facilitate the greatest return on that investment. It could enable more innovation to be spun out of our world-leading academic institutions: there is much more that should see the light of day!

The BioCity 2019 Life Sciences Start-Up Report showed a 50% growth in life science start-ups in Scotland between 2014 and 2018. Basic research will still need to be protected, of course. However, spinouts must have support to scale-up and transition from the R&D stage into successful commercial entities.

That is why an innovation strategy is so necessary: to bring all the stakeholders together and provide a framework to ensure that funding, the development of talent, the infrastructure – all the essential ingredients for a successful economy – are brought together.

Biosciences

There is also a need for more bio-entrepreneurs, which links to another national strategy. Bio-entrepreneurs of the future have to be identified and supported in their journey. In terms of infrastructure, Scotland is certainly making headway with a number of new facilities to support the sector. There is the £40 million BioHub in Aberdeen, £65 million of investment in the National Manufacturing Innovation Centre in Renfrew, and more recently in Dundee, what will be a £25 million investment in a Bioscience Innovation District.

Facilities like these will help to retain companies and talent within the country, as well as attracting new organisations into this area. There is certainly potential for the strategy to build on the sector's already strong foundation, generating growth over the next decade and playing a role in realising the sector's full contribution to the economy.

Innovation is the lifeblood of the health and life sciences sector. In turn, this sector is key to the Scottish economy and already punches above its weight in terms of innovation as the relevant metrics demonstrate.

A National Innovation Strategy will drive the return on investment from innovation in priority areas, realising the high growth potential within the sector. With greater investment more jobs will be created and retained. The current innovation ecosystem in health and life sciences has to be protected and sustained, but equally it can be enhanced further to achieve even more impact both nationally and internationally. That will be essential to reach the £8 billion turnover target in a few short years' time, and then continue to grow beyond that. □

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The UK Life Science Competitiveness Report places Scotland as number one among the 13 countries that were assessed.

Creating a leading innovation economy

Jim McDonald



Professor Sir Jim McDonald FREng has been Principal and Vice-Chancellor of Strathclyde University since 2009. He co-chairs, with the First Minister, the Scottish Government's Energy Advisory Board. He is Chairman of the Independent Glasgow Economic Leadership Board and is a past-Chair of the Board of the Glasgow Science Centre. In October 2019 he was elected President of the Royal Academy of Engineering, becoming the first Scottish holder of the office.

How can we find the great technologies and ideas that will make a real difference? Clearly this involves supporting entrepreneurs and business.

In Scotland, we are building on a real position of strength. Aside from classical engineering as well as the health and life sciences capability, Scotland has a real innovation culture. It is worth mentioning, for example, that Glasgow has the largest small-satellite manufacturing capability outside California. There are around 160 companies in this cluster.

The M8 corridor is one of the world's leading photonics and quantum technologies centres with £2 billion annual turnover and 80% of production going to export. This sector's total GVA is higher than the pharmaceuticals sector. Not that these are in competition, because the challenge is to navigate what is sometimes referred to as the 'white space' between sectors in order to tackle some of the cross-cutting issues like digital technology and net zero. We are in the process of developing a world class quantum corridor in the Central Belt, with computing breakthroughs occurring in the M2L innovation park.

The big question is how to capitalise on this? This conversation has been going on for as long as I have been involved in universities and working with partners in industry. How can we find the great technologies and ideas that will make a real difference? Clearly this involves supporting researchers, innovators, entrepreneurs and business. Reassuringly, the public sector has been developing this agenda really fast in response to industry expectations.

The most recent research excellence figures (REF2021) judged 85% of Scotland's research to be world-leading or internationally excellent. Now that is an average and there are some universities that are doing even better but overall that is a very powerful cluster of top universities.

These universities are full of extraordinary talent. The funding mechanisms depend on the talent we have here. In Scotland, there are 80,000 postgraduates and 280,000 undergraduates, more than the population of Belfast or Nottingham: it is a city's worth of research talent.

In order to maximise that talent, we must improve and accelerate our performance in commercialisation. Nevertheless, analysis shows that in the past decade, between Glasgow, Edinburgh and Strathclyde universities, 137 spinouts have

SUMMARY

- Scotland already has a strong innovation culture
- 85% of Scotland's research is world-leading or internationally excellent
- Scotland must get even better at commercialisation
- The commitment must last over multiple Government cycles
- Scotland has all the ingredients to become one of the most innovative nations.

been created: as many as the northern research axis of Manchester, Sheffield and Leeds, and as much indeed as the Cambridge University Super Cluster over that period.

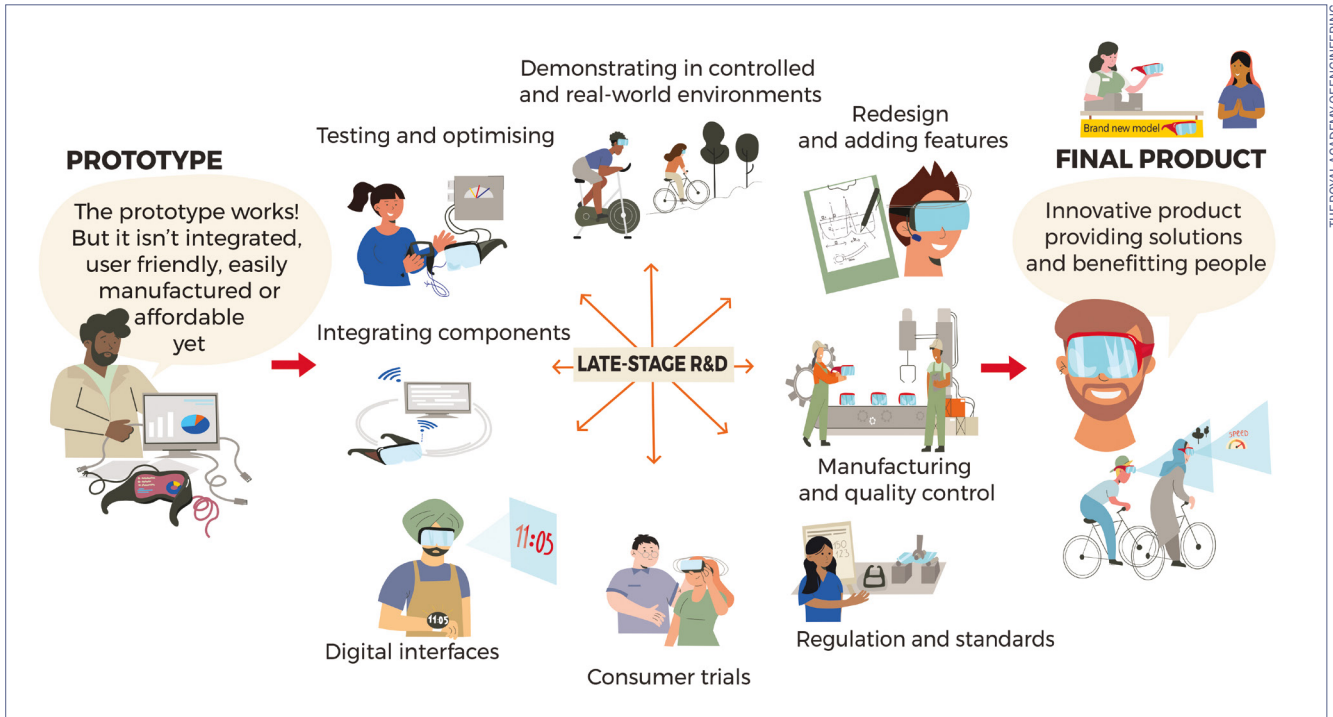
Innovation will always be hindered without absolute commitment to diversity and inclusion. Independent analysis has shown that over the past decade less than 3% of founders around the UK have come from an all-female team. Only about 11% of startup teams included females in them. There is real opportunity for improvement here.

Strathclyde's Technology and Innovation Centre (TIC) is in the heart of Glasgow City Innovation District. This ecosystem is one of the exemplars referred to in the UK R&D Roadmap, where large companies, innovators, the SME supply chain and academia all come together.

All these players have been working together in response to the Levelling Up White Paper, in which £100 million were committed to create Innovation Accelerators in the UK: in Manchester, West Midlands and in Glasgow. Some £32 million of investment is being committed in Glasgow to get this process started, which will in turn leverage at least twice that over the next few years as capability builds across these innovation districts, working hand in glove with industry partners.

Of course, £100 million across the UK is not going to meet all the opportunities. It is just a starting point from which to leverage billions of pounds worth of investment. These Innovation Accelerators and Innovation District concepts are really important.

In terms of measuring the impact of these ini-



tiatives over time, there has to be a commitment to weaving an innovation infrastructure that lasts right across multiple cycles of government and makes it a national capability going forward.

Through its emerging Innovation Strategy, Scotland can become one of the most innovative small nations. We are big enough to be effective, but small enough to be nimble and agile and so seize these opportunities. We have all the ingredients for success, with great research capabilities, good investment support infrastructure and late-stage R&D. The Royal Academy of Engineering has been promoting the journey from R&D to Technology Readiness Levels (TRL) 4-5 and beyond, validating research outputs through development at scale ready for market.

There is no magic single ingredient, rather a mix of ingredients which involves Government, academia and industry working together to identify what is important nationally. Individual clusters have different players, different supply chains, different technological risks and different market opportunities.

This Strategy has a 10-year horizon and it sits alongside the current Scottish Technology Ecosystem Review, and the National Strategy for Economic Transformation. But there must not be a series of parallel streams, we need convergence initiatives and a sense of essential measures we all agree upon. That includes identifying the sectors we will focus upon, such as health and life sciences, energy, manufacturing, quantum and photonics. The existing evidence base will provide some assurance over what needs to be done.

It is important to be sure how innovation will be

supported. There are a number of funding bodies: Scottish Enterprise, Scottish Funding Council as well as regional ones like Highlands & Islands and South of Scotland Enterprise. Now, we should not be starting again with a blank sheet of paper, but there should be high levels of expectation about their ability to lead on innovation. After all, this Strategy has to be delivered in just 10 years.

We need to identify now what actions have to be taken in the next couple of years to give us confidence in the ability to deliver. We cannot take investment for granted, either. Research England committed an extra £30 million last year for commercialisation efforts and have just announced a further £20 million. While we are not in competition with England, we do need to match up in terms of the level of expectation, commercialisation and entrepreneurial effort. Rather than just expecting to have this supplied by Scottish government, let us make an exciting investment proposition and the money will flow in.

So, the overall message is that Scotland is a really exciting place to be: great universities, great people and a growing level of exciting ambition. There is a real opportunity for this Innovation Strategy to make a difference now, over the next few years, indeed the next decade – and we can all play an important part in that. □

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We need to identify now what actions have to be taken in the next couple of years to give us confidence in the ability to deliver.

The Royal Academy of Engineering has been promoting late stage R&D, taking a proof of concept or prototype through to commercial application.

Linking key players together to deliver innovation

Julie Fitzpatrick



Professor Julie Fitzpatrick OBE FRSE is the Chief Scientific Adviser (CSA) for Scotland. She also remains Scientific Director of Moredun Research Institute and CEO of The Moredun Foundation. She holds a Chair in Food Security at the University of Glasgow's College of Medicine, Veterinary Medicine and Life Sciences. Julie became a Fellow of the Royal Society of Edinburgh in 2007, a Fellow of the Royal Agricultural Society of Scotland in 2008 and was awarded an OBE for services to livestock research in 2014.

We have a number of key elements for innovation, including an entrepreneurial economy, a talented, skilled workforce, as well as innovative businesses.

In my role as Chief Scientific Adviser, I focus on three main areas: first, science, evidence and data for all policy areas, especially in cross-cutting and strategic issues; second, Policy for Science, particularly relating to the science and engineering profession within Government where I act as science and innovation champion; and finally there is public engagement, promoting Scotland's science excellence among the public.

Our vision for Scotland is to become one of the most innovative small nations in the world. Our ambition is to boost innovation, productivity, competitiveness and green economic growth. Clearly research excellence is vital in driving innovation across the nation. And we know that industry investment in Scotland is closely linked to our universities' strengths. R&D is the third largest focus of foreign direct investment. Sustained investment into research, development and innovation is critical, as exemplified by the 'triple helix' of government, academic institutions and industry working together. These are the essential elements of the Scottish innovation system.

World-leading scientists

We have world-leading scientists. The 2021 Nobel Prize for chemistry went to David MacMillan of Princeton University who completed his undergraduate studies at the University of Glasgow. Scotland has a very long history as a nation of invention and we will engage in new opportunities for innovation, such as that provided by the Advanced Research and Invention Agency (ARIA).

When it comes to innovative businesses, we have institutions such as the University of Dundee, which was the top-ranked university for Biological Sciences in the REF 21, based on three- and four-star publications. It is the location of the Wellcome Centre for Anti-Infectives and has a world-famous drug discovery unit. It has close links with, and attracts substantial funding from, multiple pharma and biotech companies. The university is developing a Life Sciences Innovation District as part of the Tay Cities Biomedical Cluster and City Deal.

An important focus for Scotland is attracting and retaining innovative scientists, as well as

SUMMARY

- Scotland's aim is to be one of the most innovative small nations in the world
- R&D is a main focus for direct foreign investment
- Life sciences and building business capacity at scale is a priority
- The public sector's role in innovation is vital
- Collaboration and speed of adoption are key to successful innovation.

building life science companies of scale. It is really important that we retain these scientists, rather than them moving to other parts of the UK, or to the United States.

The Centre for Energy Transition at the University of Aberdeen is working on wind power, hydrogen, geothermal, wave and tidal, and oil and gas decommissioning: all different scientific disciplines important for energy transition. It includes the GeoNetZero Centre for Doctoral Training (CDT), a partnership between 12 UK academic institutions. This has attracted investment in training from more than 10 industry partners. The doctoral training programme currently has 178 PhDs enrolled. Of the 75 who have already completed their studies, all found employment within the sector.

This is a fantastic achievement, demonstrating the scope and scale that is required in order to produce innovative scientists in the future. The Centre for Energy Transition also hosts the National Energy Skills Escalator, a collaboration between universities, colleges and Skills Development Scotland.

The public sector's role in innovation is vital. As part of our National Performance Framework, we have a number of key elements, including an entrepreneurial economy, a talented, skilled workforce, as well as innovative businesses. All of these are essential to delivering our National Strategy for Economic Transformation, for delivering Net Zero, reducing inequalities and poverty, and recovering from the cost of living crisis. In the Scottish Government, we have over 600 directly-employed scientists producing some fan-



David MacMillan of Princeton University, who was awarded the 2021 Nobel Prize for chemistry, completed his undergraduate studies at the University of Glasgow.

tastic science and innovation, which will help us to deliver the strategies.

One such example is Marine Scotland which covers a number of areas including fisheries, aquaculture and environment, but also new research and ideas. It focusses on science related to offshore wind, marine ecosystems, including the use of environmental DNA, and diseases of aquatic species. The quality of the marine science is extremely important for all activities and outputs such as surveillance, monitoring, regulation and policy development.

Scotland is also fortunate to have a good number of Institutes collectively called SEFARI. These are Scottish environment, food and agricultural research institutes and their focus on strategic policy focussed research is important for the delivery of useful science and knowledge exchange.

Another important aspect of Scotland's innovation infrastructure is our network of seven innovation centres created in 2012, which includes the Scottish Agriculture Innovation Centre (SAIC), CENSIS and the Data Lab to name a few. They support sectors with strong research potential, they build strong links and provide co-funding for research along with industry.

Health and social care

When it comes to delivering innovation, I want to give an example from health and social care. There is broad agreement that the pressures and challenges currently facing health and social care may only be addressed if outcome-improving, experience-enhancing and value-adding innovations can be rapidly identified and adopted. Radical, perhaps even disruptive, innovation at scale has become a necessity, not a luxury.

And the challenge is that we have lots of activity in this area in Scotland but currently this is rather uncoordinated with many players, so there are huge opportunities to increase momentum. Three regional testbeds have been set up in the Northeast and West of the country. Public sector assets are used by industry to test their innovations in situ. With over £3.5 million invested in these testbeds, they are not just for pharma, but also medtech (particularly medical devices) and digital including AI and machine learning. This links back to the triple helix, bringing together government, academic researchers and industry. This initiative acts as a one-stop-shop for industry wanting to test innovations.

There is continued investment in the Accelerated National Innovation Adoption Pathway (ANIA). All of the main health organisations within Scotland are working together. The aim is to collaborate in: procurement, research capacity, alignment with digital programmes, testing new innovations, baselining data and workforce development. So the key point here is the collaboration and speed of adoption of new technologies across our health and welfare sector.

I work not just with Scottish Government, but also UK Government scientists. With a new strategy being developed in Scotland, we interact with UKRI and Innovate UK about the importance of funding to enhance R&D and innovation in Scotland. The UK Chief Scientific Advisers (CSA) network meets weekly and I speak regularly to other CSAs across the other devolved administrations. Our discussions often focus on the importance of innovation to all of us across all parts of the UK. □

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We have lots of innovation activity in Scotland, but there are huge opportunities to increase momentum.

Balancing national and regional aspects

Rick Delbridge



Rick Delbridge is Professor of Organisational Analysis at Cardiff Business School and co-convenor of the Centre for Innovation Policy Research at Cardiff University. Previously, he was University Dean of Research, Innovation & Enterprise and led the development of the Social Science Research Park which opened in March 2022. He is the university lead for the Local Wealth Building Challenge Fund in partnership with the Cardiff Capital Region. He is special adviser for innovation to the President of the Learned Society of Wales.

The Welsh Government started its innovation strategy review in 2021¹. Cardiff University's Centre for Innovation Policy Research provided a report that includes statistical data and conversations with around 50 stakeholders. Scotland was one of the innovative small nations that we were interested in hearing and learning from.

We made a number of recommendations in our initial report. First, there must be a narrative which captures a level of ambition in what can be achieved. We need to be ambitious, disruptively so in some ways, producing aspirations that industry, the public sector and individual citizens can both recognise and realise.

While Wales does not have the academic strength and depth of Scotland, Welsh universities have impactful agendas too. Yet there are questions about how well universities respond to the innovation agenda. One contributor to the Welsh review complained that Higher Education institutions are often more interested in research-led innovation, rather than innovation-led research.

In Wales, we need to ensure that the next phase continues to support SMEs, but also what has been called the 'nascent' or future clustering of research activity. Without investment in the 'innovation commons' of skills, resources and connectivity, the likelihood of future innovation emerging in successful ways will be limited.

The innovation agenda needs to embrace the world-leading science and technology we have. But another of our recommendations is that it also needs to take a more wide-ranging socio-ecologi-

SUMMARY

- The Scottish experience of driving innovation is one that Wales is keen to learn from
- Targets for innovation need to be aspirational but also meaningful and deliverable
- Innovation policy has to be delivered at a level individuals and communities can identify with
- Public sector procurement has a key role in driving innovation in Wales.

cal view, if innovation is to engage with society's main challenges, for example, climate or health. The Welsh Government's Innovation Strategy is framed around such 'missions' in education, economy, health and wellbeing, as well as climate and nature. So, in Wales we have been working to engage the public sector in order to create innovation opportunities for the nation through leveraging public procurement and actively shaping market opportunities.

Growing complexity

The innovation policy landscape is becoming more complex, not just in Wales but across the UK. The four Welsh City/Growth Deals are developing into economic regions, yet the articulation of those and aligning activities with the funding coming from UK and Welsh Government is proving challenging. Focussing on the regional level in Wales is crucial for translating large-scale ambitions into something that people can recognise themselves in.

We also advocated the restructuring of innovation, so that it sits more squarely in the economy brief. Welsh Government has devoted time to thinking about how the innovation agenda can be incorporated across the divisions of government and related to our Future Generations Act, which requires all Welsh policies to be mindful of the implications for the future.

While we should be ambitious, it is important to take into account the challenges the public sector is facing and whether sufficient investment is being put into building capability and capacity. There is a role here for the public sector in sup-

FURTHER INFORMATION

An innovation strategy for Wales www.gov.wales/innovation-strategy-wales

National Manufacturing Institute www.nmis.scot

Scotland's National Strategy for Economic Transformation www.gov.scot/publications/scotlands-national-strategy-economic-transformation

UK Innovation Strategy www.gov.uk/government/publications/uk-innovation-strategy-leading-the-future-by-creating-it

porting specific industry clusters. Interventions will need to be selective with regard to place and sector. But will our institutions and institutional bodies need to be reviewed in order to achieve this? There is sometimes a gap between great policies and practical measures that are delivering for our citizens.

What does it mean to adopt a mission approach? We know that business as usual will not get us to where we want to be. We need to work in interdisciplinary and cross-sectoral ways in order to turn acutely ambitious headline objectives into real granular activity.

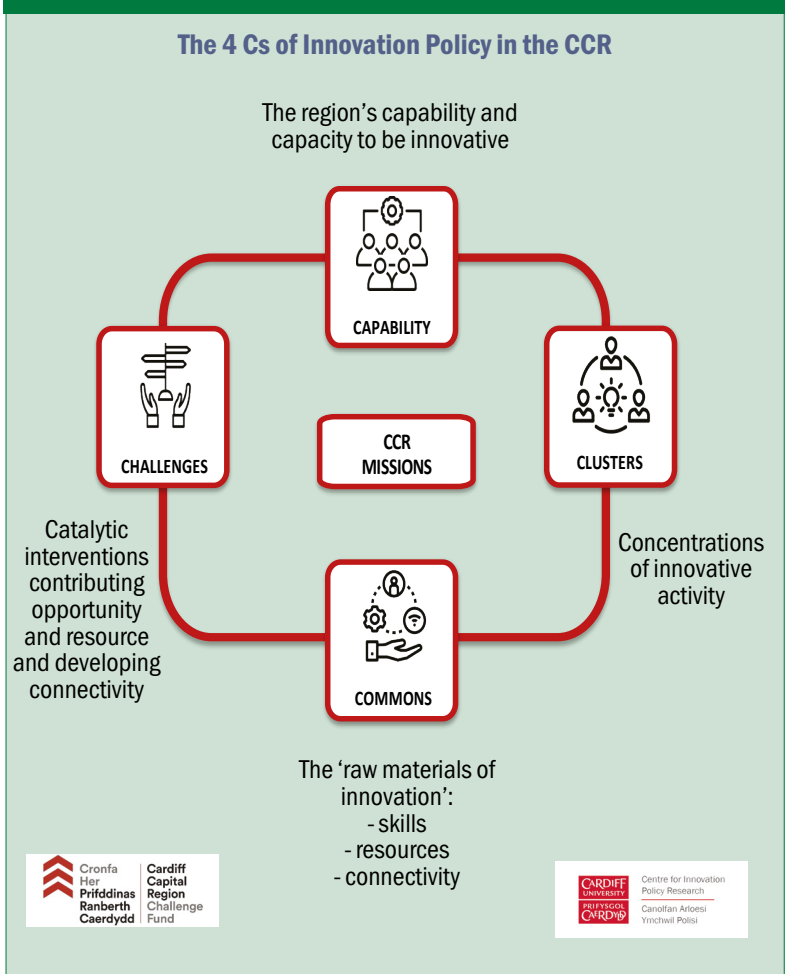
The Cardiff Capital Region comprises 10 local authorities in the southeast of Wales in the biggest single City Growth Deal in the UK. It is distinctive in one important way: it has not committed the majority of its funding (outside of the metro system) to specific projects. So the Region is building a portfolio of investment funds, looking for a series of innovation-acceleration interventions. For example, Cardiff University has been assisting on the design and delivery of a Challenge Fund, based on well-established innovation tools such as SBRI. Where public sector organisations in the region have a public service problem for which there is no solution readily available, we will look to formulate the problem as a challenge for innovators. We can then seed-fund the testing and initial stages of trialling.

One example was to train people in clinical practices during the pandemic. Two virtual reality and simulation technology firms were funded to produce new training for tracheostomy and other medical processes which are now being applied in hospitals. We are keen to use this approach to spearhead further innovation procurement in the public sector in Wales and so leverage the power of the public purse.

Innovation ecosystem

In the Cardiff Capital Region we are employing an innovation ecosystem perspective, bringing together the elements that might aid a mission approach. These include clusters which are absolutely vital to the regional innovation strategy. The 'commons' such as skills, resources and connectivity are the raw materials of innovation. When identifying the leading science and technology clusters, it is important to be mindful of the training and skills that are needed not just by those clusters, but also wider society. The challenge fund is an example of what could be called a 'catalytic intervention', an attempt to energise and nurture innovative activity, particularly in Cardiff's case in the public sector. These activities help develop the region's capacity to deliver on this agenda.

Figure 1. The innovation ecosystem for Cardiff Capital Region



City/growth deals are complex political contexts at the interface between national and regional strategies with, in some cases, an international dimension as well. In Cardiff, we have a programme that focusses on priority clusters, but has also identified opportunities around specific challenges and 'micro missions'. These all need to operate at a level of scale where people can see themselves as part of the innovation process. Underlying this needs to be an overall narrative that is founded on a solid base but that is also aspirational for communities. □

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¹ The Innovation Strategy for Wales has now been published at: www.gov.wales/innovation-strategy-wales

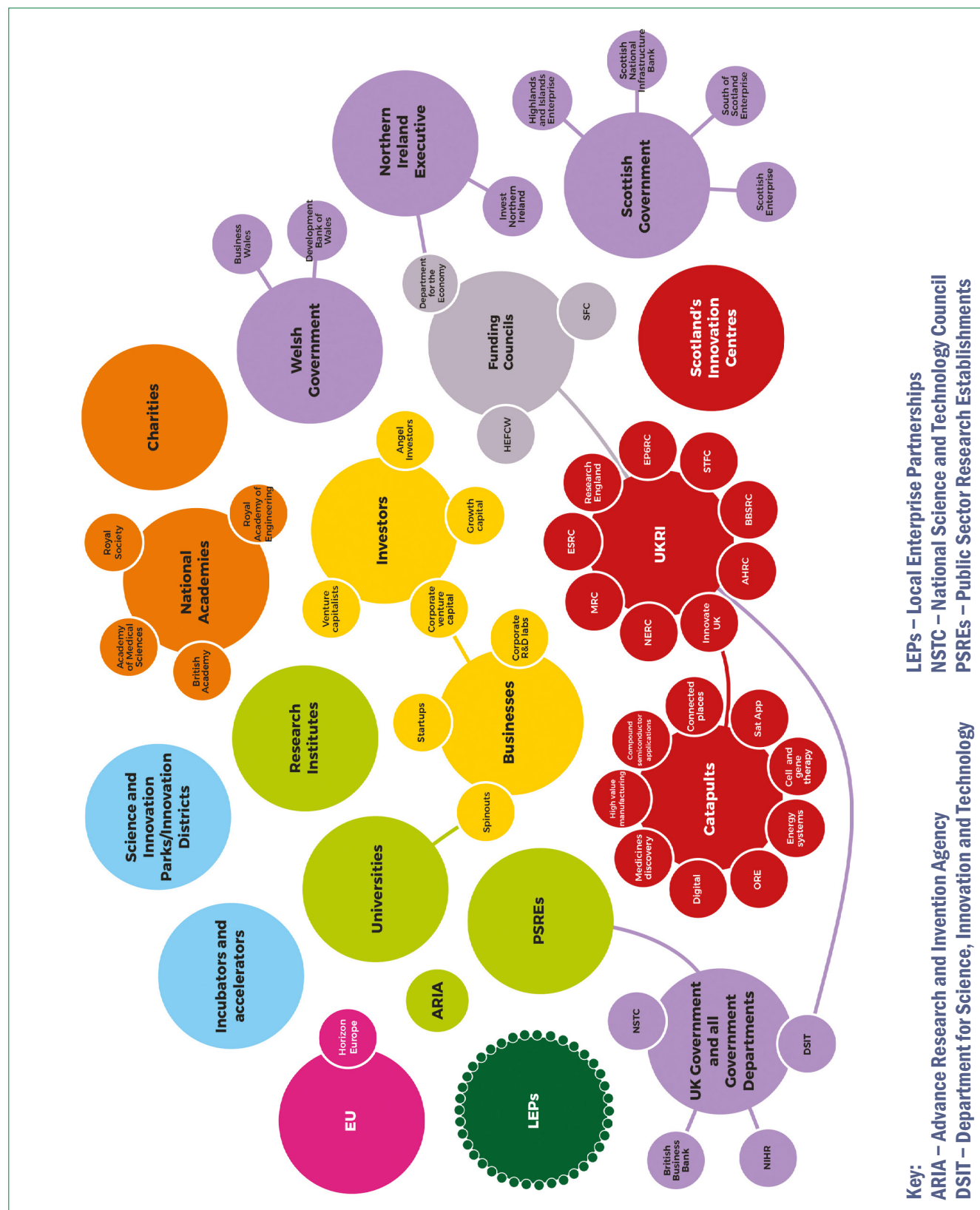
FST PODCASTS

Fraunhofer UK Research –with Simon Andrews, Executive Director of Fraunhofer UK Research

www.foundation.org.uk/Podcasts/2022/Simon-Andrews-Fraunhofer-UK-Research

The UK research and innovation landscape in 2023

In the Dowling Review of Business-University Research Collaborations published in July 2015 a diagram was included to illustrate the complex network of organisations funded by government to support innovation and research. It is not exhaustive. Big circles broadly represent components of the system comprised of multiple parts and small circles broadly represent single components. The Royal Academy of Engineering has updated the diagram following the changes to the machinery of government.



UKRI have developed a portal for searching for what has been supported in the past at <https://gtr.ukri.org>

CONTEXT

Racism is present in science and technology in the UK, as it is across many areas of society. A number of reports in recent years have illustrated the issues, including those from the Royal Society of Chemistry and the Wellcome Trust. The Foundation wanted to explore the current situation and ask some difficult questions. What is the nature and scale of the problem? What is the lived experience of Black scientists in the UK? What actions are already being taken to address the issues? What more needs to be done?

The Foundation held an event on 7 December 2022 at the Royal

Society in London, bringing together: Professor Ijeoma Uchegbu, Professor of Pharmaceutical Nanoscience, University College London; Sigourney Bonner, Co-founder of Black in Cancer and a PhD student at Cancer Research UK; Dr Karen Salt, Deputy Director for Research Culture & Environment, UKRI; and Dr Ale Palermo, Head of Global Inclusion, Royal Society of Chemistry.

A video recording, presentation slides and speaker audio from the event are available on the FST website: www.foundation.org.uk/Events/2022/Black-Scientists-Tackling-Racism-in-UK-S-T

Identifying and addressing the barriers to participation

Ale Palermo

SUMMARY

- Black and ethnic-minority students face barriers in accessing and flourishing in Higher Education
- There is significant under-representation in post-doctoral programmes
- There is a clear problem in retaining Black and ethnic-minority chemists within academia
- The problem of attrition applies beyond academia as RSC data shows
- Longstanding societal issues of racial discrimination add a further complexity to the problem.

There is ample evidence that Black and minority ethnic students face a number of barriers in Higher Education in the UK, from simply access, to representation, to curriculum content (some refer to a 'colonisation curriculum'), to the delivery of that content – all aspects of the overall experience that they have at university.

White students are 13% more likely to get a first or upper-second class degree than Black and ethnic-minority students. This disparity continues – indeed increases – on the journey to postgraduate attainment and academic careers. That results in a pay gap and fewer opportunities for research funding or promotion. It also impacts the outcome of their research and its visibility.

Overall, there is an under-representation of UK students from ethnic minority backgrounds in postdoctoral programmes. This has been rec-

ognised recently by the Office for Students and Research England, which have provided £8 million to fund 13 projects aimed at tackling inequalities in access to postgraduate research. One crucial issue that has emerged is the under-representation of Black scientists in Higher Education research centres. This is more acute in some disciplines than others.

A case study

Chemistry can serve as a case study in understanding some of the issues behind these inequalities. The *Missing Elements* report¹ paints a stark picture of the realities experienced by Black and ethnic-minority students. The report is based on data and evidence gathered over two years of research. It brings together the available data, including Chemistry-specific data from the Higher Education Statistics Agency (HESA), data drawn from our membership as well as our boards, committees and so forth. We also consulted the community. Through this, we tried to understand the lived experience of Black and ethnic minority scientists.

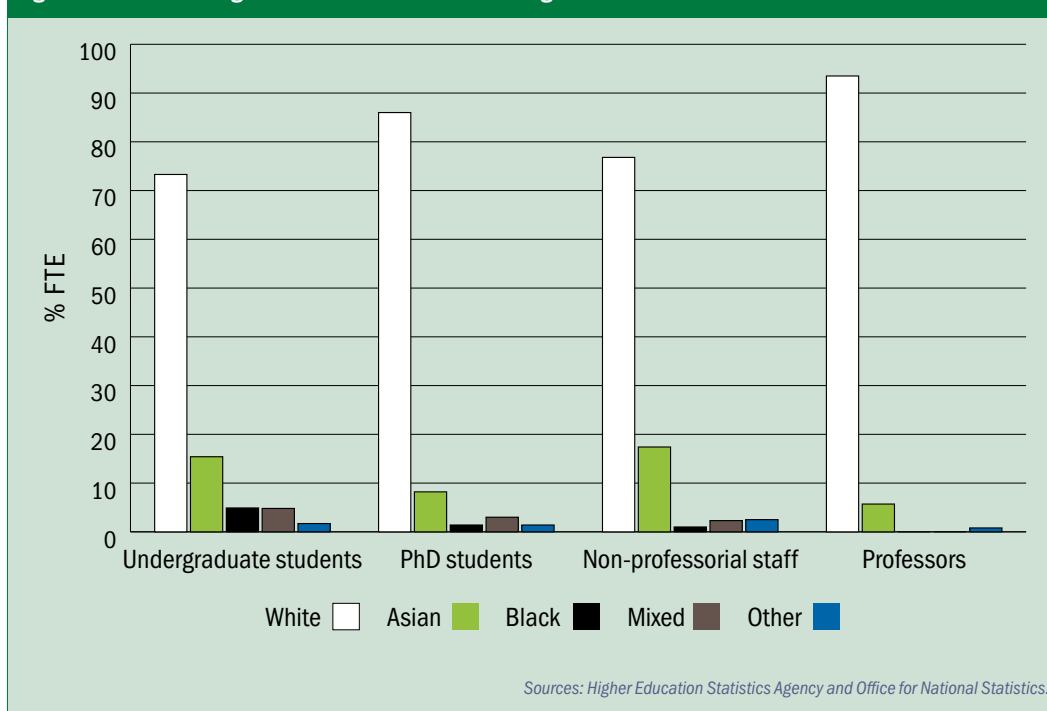
We spoke to hundreds of people about what happens in different career stages as well as those who influence chemistry, like funders and policy-makers. The study reached beyond academia to industry but also included teachers and it also had an international dimension. Given the hard data and evidence, there really is no excuse to avoid tackling the issues and addressing the observed inequalities. That of course includes the Royal Society of Chemistry.



Dr Alejandra Palermo FRSC is Head of Global Inclusion at the Royal Society of Chemistry. Her academic journey began as a chemical engineer, with a PhD in materials science. She became an Assistant Professor in Argentina, before joining Cambridge University under a Royal Society Visiting Fellowship. At RSC, she leads a team working on priority areas such as equity, diversity and inclusion in the chemical sciences, and international large programmes developing inclusive global collaborations.

A clear retention problem is particularly pronounced for Black chemists. The economy is losing these professionals at an alarming rate.

Figure 1. We are losing Black chemists at an alarming rate



By analysing HESA data for 2019-20, the ethnicity breakdown of students and staff in chemistry can provide an indication of the progression of Black and minority ethnic individuals within the chemistry pipeline (Figure 1). The data show a clear retention problem, which is particularly pronounced for Black chemists. The economy is losing these professionals at an alarming rate. Black undergraduate chemistry students account for 4.9% of the total, which is higher than the 3% of the general UK population who are Black, but it is still low. Yet, the figure then drops significantly to 1.4% for PhDs, 1% for non-professional and finally zero for chemistry professors. We know there is at least one Black professor in chemistry, possibly two, but in percentage terms this is reported as zero.

A similar trend is visible with RSC membership. Looking at seniority across the different membership categories, there is a drastic drop in terms of Black representation. It is important to note that membership includes chemists working in many different disciplines as well as industry, policymaking, teaching, etc – and of course the RSC is international so it complements and reinforces the conclusions from the HESA data.

Looking at the attrition which is observed at later career stages, we looked into where the undergraduate students are going. It appears there is a smaller proportion of Black undergraduates at Russell Group institutions. Of all chemistry students, 55% attend Russell group universities, but only 37% of these are Black. This indicates a structural challenge as Russell Group institutions are more research-intensive and have more funding.

So, the opportunities that students have by going to Russell institutions, in terms of progressing to PhD and so forth is likely to be greater. Consequently, the under-representation of Black and ethnic minority students at Russell Group institutions is very important.

We also looked at the intersection between race and ethnicity and gender. It is not surprising that there is a loss of female chemists independent of their race or ethnicity. Yet the loss of Black women is much more pronounced than from any other ethnic group. Of Black undergraduate students, 60% are women. But once again, the numbers decrease dramatically with seniority.

Lived experience

We investigated the lived experience of hundreds of people from minority ethnic backgrounds working in chemistry globally. This qualitative research indicated that there are a number of interconnecting factors that impact their success in chemistry, from structural, funding and cultural issues to the availability of mentoring, leadership roles and role models. These are very similar to those faced by women more generally. However, for Black and ethnic minority chemists, the persistence of the issues is much larger. There is, after all, the long-standing historical context of racial discrimination that adds a further complexity to the topic. □

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¹ RSC Missing Elements report: www.rsc.org/new-perspectives/talent/racial-and-ethnic-inequalities-in-the-chemical-sciences

Increasing diversity is good for everyone

Ijeoma Uchegbu

SUMMARY

- Research has demonstrated that diversity has wide societal benefits
- The education system does not work for some sections of society
- Some groups become progressively disadvantaged as they progress through school into university
- A transparent race equality strategy is needed to transform our education system
- Courses have to be designed to meet the needs of all the students.

I am a scientist and inventor of Nanomerics' Molecular Envelope Technology, a drug development technology which was created in UK academia. The technology is being used to develop medicines with reduced side effects and improved efficacy. We have licensed a number of assets to companies on the NASDAQ. We work with Big Pharma and mid-tier pharmaceutical companies.

Why care about diversity – because it is a social justice issue, or because it is good for society? In my view, it is good for everybody. ESRC research has found that diverse management teams tend to be more innovative. Diverse juries tend to be superior in their decision-making, because they rely on the data rather than on assumptions about 'people like us'. In public companies, ethnically diverse boards tend to be more profitable, according to a number of McKinsey studies. In academia, working across geographical boundaries and across ethnicities tends to result in more citations.

In UK academia, there is reasonably good participation from all ethnicities. About 2% of academic staff are Black, while about 4% of the general population in England and Wales is Black. Yet when the focus is on professorships, you are more likely to be a professor if you are white, but you are really very unlikely to become a professor if you are a Black individual. The number should be 4% if it reflects the census data but it is actually 0.7%. If you happen to be a female professor and

you are Black, then you are part of a very small number of individuals. So, there is a real problem in the system.

I believe this all stems from an education system that is not fit for purpose. When a child is about 11, Black and white pupils are performing at the same standard when it comes to English, mathematics and science. Pupils that are of Chinese or Indian heritage are outperforming white students. At A Level, to progress to a research career, students should try to go to a research-intensive university. To do that, three A grades are necessary. Around 11% of pupils will get three As. Yet only half that number of Black pupils will achieve this. They have been destroyed by our education system; it is not serving their needs and is not fit for purpose.

Pupils of Chinese and Indian heritage are still doing well, but once they get to university the gap they had over white students disappears in three years: they had that advantage for a decade, but it has gone in three years. So, universities are also not fit for purpose because they are not serving this group. Black students are very unlikely to get a good degree.

With that disadvantage, they cannot command a good salary in the workplace. Go into the workplace with A levels and there is already a gap to white counterparts. With a degree, the gap is even larger. I spent many an evening persuading my four daughters that they should go to university, yet I wonder whether I should have done so if they will end up having worse pay rates.

UKRI published data on research awards shows that Black Principal Investigators are almost non-existent. Now, I have been a PI and I have received funding from UKRI for two decades. Yet that is very unusual. So for Black individuals who have managed to get through the system, have achieved A Levels and got into university, got a good degree and a PhD, they are still less likely to be funded by UKRI. At the Wellcome Trust, the story has been the same, but we



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Research has found that diverse management teams tend to be more innovative. Diverse juries tend to be superior in their decision-making.



LORDHARRIS/AT-ENGLISH/WIKIPEDIA, CC-BY-SA3.0

(Above) UCL has removed the names of eugenicists from its buildings; (right) a study has found that a Black newborn was half as likely to die if it was cared for by a Black physician.

are doing something positive about it. Where two grant applications are similarly ranked, we will now select the grant led by a person from an under-represented group.

A race equality strategy is needed across our whole education system. Schools should be rewarded for eliminating any type of award gap and universities should be similarly rewarded. The relevant data should be published because when the data is visible to everyone, people will start to take action.

UCL now has a race equality charter. We say to people: 'If students at UCL are likely to leave with a worse degree, they will go to Kings or Imperial. If they are not choosing your course, it will close, so it is in your interest to make sure that students get the degree and the award that they deserve.'

We have made some changes. We now have a Centre for the Study of Race and Racism. We have removed from our buildings the names of eugenicists who said that Black people were no better than baboons. Over half of UCL students are from ethnic minority backgrounds and faculties have been reducing their awarding gap year-on-year. More people from Black, Asian and minority ethnic groups are being promoted into the senior grades.

A final example of why this is important can be seen in a study by Greenwood *et al* published in 2020. This was a very high-profile study of 1.8 million new-born infants and their outcomes. It found that a Black newborn was half as likely to



SHUTTERSTOCK/ MICHAELJUNG

die if it was cared for by a Black physician. We must make sure that Black newborns, and especially those with complex medical issues, are cared for by people who look like them because they will have a better chance of survival.

We need better representation, we need to train people in our universities of different complexions and from different socio-economic groups, so that we do not encounter the same problems we had during COVID, where under-represented groups suffered disproportionately. □

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Bringing together the Black scientific community

Sigourney Bonner

SUMMARY

- A key mantra for Black in Cancer is: “You can’t be what you can’t see”
- The organisation aims to connect Black science researchers across the globe
- It aims to tackle the problem of racism in science research
- Supporting Black researchers includes providing funds for them to do their work
- Black people do not have to leave science in order to pursue their dreams.

I would like to share something of my journey as a Black cancer researcher and some of the challenges along the way. I am a co-founder of BlackinCancer. In our organisation, a key mantra is: “You can’t be what you can’t see.” It is so hard to see yourself in a position when you have not seen somebody in that role or position who looks like you.

Speaking to my Mum when I was a child, she asked me what I wanted to be when I grew up. I said: “Oh, I want to be an air hostess, because I really love flying and I really love being on planes.” A couple of years ago, I asked her if she remembered that conversation. She did. So I asked why, if she knew I liked flying, she did not suggest I should become a pilot? She told me it did not even enter her head because she had never seen anybody who looked like us doing that. That is why visibility is so important. It is not necessarily a conscious decision but very subconscious about what is possible in life.

I commenced my undergraduate studies in human physiology at Leeds University and took part in lots of things which people tell you will boost your CV. I worked in a lab, I did a paid summer studentship. Then I spent a year in industry at a pharmaceutical company. In the midst of finishing my studies, I applied for a PhD in that lab, focussing on the technology I had worked on there – I thought I would stand out with that relevant experience. The moment my interviewer came out and called my name, I saw him roll his eyes. It is challenging in that moment to walk in

and expect to be treated equally. I did not get that PhD.

I went to work for Pfizer although I was still applying for PhDs. On one unsuccessful application, I received no explanation at all and I spent weeks asking for a response. On another I was told they had picked the other person – I was in the last two – but could not explain why that person was preferred.

Now, I am finally doing my PhD at the University of Cambridge. The statistics of my journey are: 17 applications, six interviews, five years of additional research experience. Three friends who had exactly the same experience as me and exactly the same degrees all went on to do PhDs straight from their undergraduate studies. In 2020-21, fewer than 1% of postgrad research students came from a similar background to mine. That is just not acceptable.

Finding my community

So in the midst of that, I wanted to find my own community. I wanted to find people who looked like me and were working in this area. That was when I met my co-founder, Dr Henry Henderson III – at the time he was a postdoc at Vanderbilt University in Tennessee. We talked about what it



Sigourney Bonner is a co-founder of BlackinCancer, an organisation that aims to strengthen networks between Black people in the cancerfield while highlighting Black excellence in cancer research and medicine. Sigourney is a graduate student at the University of Cambridge in the Cancer Research UK Cambridge Institute. Her research centres on developing novel models and therapeutics for paediatric brain tumours, more specifically supratentorial ependymoma.



BlackinCancer
co-founder Dr Henry
Henderson.



The inaugural BlackinCancer conference at the Science Museum was held in London in 2022, bringing together leading Black cancer doctors, researchers, and patient advocates from around the world.

meant to be a Black cancer researcher and discovered that we had very similar experiences despite being from different sides of the globe.

We wanted to be able to see people who looked like us doing the same kind of things we were doing. Originally, we thought we would post tweets on social media, but today we have gone well beyond that. There has been so much talk about racism within academia and healthcare: we wanted to do something to tackle that. As an organisation, we aimed to connect Black cancer researchers.

As an organisation we do this in a number of ways. For the past two years, we have organised BlackinCancer week, which aims to bring the community together: not just the research community, but also the patient community and advocacy groups in order to help increase cancer survival within the black community. Our Cancer Awareness Project works in education and community engagement. In addition, we have the Black in Cancer Pipeline Programme.

We are international, based both in the UK and the USA. We fully fund an international mentorship programme for 15 US and 15 UK students, who all have a fully-paid eight-week lab placement (we do not want anybody to be hindered by not being paid for this work). In 2021, we awarded

\$250,000 in postdoc funding to Black cancer researchers and made an additional \$100,000 Distinguished Investigator Award: this went to Dr Paula Hammond who is now on the White House Science Committee.

Pursuing our dreams

These events are to encourage people into this space, to let them know that there are many different careers available and that they do not have to leave science to pursue their dreams. There were a number of summer internships at institutes in both the UK and the US. In the Mentorship Programme, 100% of both mentees and mentors said they would recommend it.

In October 2022, the inaugural BlackinCancer conference took place in collaboration with Cancer Research UK, held at the Science Museum. The room was filled with Black cancer researchers, patients, advocates and allies. Some 250 delegates took part with talks from across the cancer spectrum. We awarded almost half a million dollars in postdoc funding, because if we are supporting Black students, they need the money to do the work. And we gave a \$300,000 Early Career Investigator Award for a PI to continue the work she is doing in her lab. It is vitally important to provide support all the way across the pipeline, through mentorship, postdoc awards and indeed all the way through. □

There are many different careers available and Black people do not have to leave science to pursue their dreams.

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Coordinated approach needed to deliver permanent change

Karen Salt

SUMMARY

- Racism is not just a process, but an experience. The key is in putting the lived experience, the people, alongside processes
- Change is happening, in many different programmes and initiatives across the sector
- Programmes to tackle racism by universities can place additional workload demands on existing staff
- Initiatives need to be scaled-up and coordinated
- The next challenge will be supporting new activities while bringing existing programmes together.

As a Black academic woman, I have carried out a significant amount of work on inclusive transformation. Yet the problem that we are trying to address – racism – is deeply embedded in all aspects of our society and needs to be tackled at this level.

This is fundamentally about everyday experience. Although it is important to talk about the data of grants and hiring practices, it is vital to get a sense of what it is like to live in societies in which racism persists and understand its societal impacts. Then, hopefully, we can work together to find ways forward.

I can share some personal experiences around recognition and belonging. For example, in one instance, a white male member of an institution was convinced that I was part of the cleaning staff in the building and did not think to check before handing me materials to be thrown away. His presumption was that I could not possibly be a faculty member, as few faculty members looked like me, so I must be a member of the cleaning staff.

I have been followed by security guards around buildings where you need a faculty swipe card just to get in. I was told that they knew every face that should be there and they did not recognise me – so I had to prove that I belonged. Preconceptions and behaviour run deep.

As Director of the Centre for Research and Race and Rights at the University of Nottingham, I led various research projects and with multiple

grant holders. Before I joined UKRI, I had six active grants and a huge research team. There were postdocs, community researchers and a variety of different activities within the programme. I was also director of a PhD programme with a majority Black student body. This was an anomaly, having so many Black students (all supported by fellowships, by the way) and it entailed a great deal of work to attract sufficient funding from different places.

In my present role, I draw upon that experience in traversing disciplines, cultural organisations, independent research organisations and National Labs, as well as various different industry partners from Rolls Royce to GSK. In addition, the role involves talking with Government.

To be clear, this issue is not just one facing Black scientists. There are plenty of similar stories about Black politics, about Black cultural organisations, or Black philosophy. Yet I can see the amazing work that folks have been doing across various different domains. The transformations that have happened with the widening participation programmes around postgraduate work, around tackling barriers and creating opportunities for postgraduate researchers, for Black and minority ethnic students – these can be clearly seen.

There has, in fact, been a hiring bonanza over the past three to four years. Suddenly universities are advertising roles aimed at Black and ethnic minority groups. They have, however, been packaged up into career slots: this is for undergraduates, this is for postgraduates, these are for these other groups. Yet this all imposes demands on senior Black academics and researchers to service this increase in representation – in terms of admin, mentoring students, working with community organisations and charities, perhaps being asked to be on boards and committees for every single academic year.

Many of these new roles come with an expectation that people will join straight after their PhD or first postdoc. Some who lead university departments want to decolonise the entire curriculum and get their new entrants to work on every single committee. In an ideal world, people would come in and be given some space to figure



Dr Karen Salt is Deputy Director of R&I System Diversity and Security at UK Research and Innovation (UKRI). She has the task of driving UKRI's cross-organisational strategic thinking and policymaking on system diversity and Trusted Research and Innovation. She has over 27 years' experience engaging and co-creating solutions with communities, organisations, charities and governmental bodies. An expert on governance, systems and transformative change, she has led and managed interdisciplinary research centres, collaborative research teams and large research projects.

Although it is important to talk about the data of grants and hiring practices, it is vital to get a sense of what it is like to live in societies in which racism persists.



Established in 1988, the Mellon Mays Undergraduate Fellowship programme aims to help remedy the problem of underrepresentation in the faculty ranks of Higher Education.

out what they might do. They might receive some nurturing and support to allow them to flourish and move forward.

Given the current push (and to be clear, it absolutely needs to happen) some care has to be taken on how it is implemented. There needs to be a recognition of the load being placed on people, from those working with BlackinCancer to Deputy Deans and all the way through to people who are working across policy and Government. It is a lot to ask for every single organisation to wake up to racism and suddenly transform itself: new groups, new teams, new structures. I am not trying to deny the work that needs to happen, nor the urgency of it. But people have to deliver these changes and that involves a great deal of work.

This is a really interesting transitional moment with a large number of important initiatives, for example, the Windsor Fellowship, the UCL initiatives, the Royal Society of Chemistry and Wellcome programmes. Communities have been actively engaging in this process through being on various different networks and groups, from the British Antarctic Survey all the way through to the RISE network, which is UKRI's Black and ethnic minority staff network.

There is however the question of scale and how to achieve this effectively: otherwise, a great deal of work will remain in various different silos. One initiative that could be transformational for the UK would be to create something like the Mellon Mays programme in the USA. The defining

feature of this programme is its size. It brings together 51 different institutions and membership requires them to commit to a range of objectives. The programme is focussed on under-represented faculty. It challenges institutions to work out how to create a cohort, determine what that actually entails and then requires them to create the conditions to enable that group to both learn and grow – from undergraduates all the way through to, ultimately, job market support. There are other programmes, too, that do similar jobs with conferences, mentoring, bringing different sorts of groups together, but also providing places for people to publish, as well as opportunities for them to continue to build their profiles.

I am not trying to suggest that we should stop any of the work currently under way. However, to scale up, we have to band together. We need to create a system with a single focus where all the energy sits, and to which everybody looks first. By bringing everyone together, including Government, this central structure can play a very strong role and ultimately support a number of these different complementary programmes on a consistent basis. In that way, we become less reliant upon charities, or people's goodwill, in order to move forward.

The challenge is to knit these various different initiatives together so that we are not pulling against each other. Instead, we can recognise different groups as inspirational but we can harness all of this energy and actually move forward. In so doing, we can recover the passion that ultimately brought us to research and innovation in the first place. □

One initiative that could be transformational for the UK would be to create something like the Mellon Mays programme in the USA.

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The debate

After the formal presentations, the speakers joined a panel to answer questions from the audience on a range of topics, including: current changes; publishing data; corporate commitment; visibility.

Why has the current push on tackling racism in science and technology occurred – and what needs to happen next? The current ways in which communities are banding together is a source of hope. There is a sense of momentum, and people are listening. One change is that many organisations are openly using the word racism, which makes a big difference. People are starting to take it more seriously and thinking how to be better allies.

Data

Data will make a difference – companies should report their ethnic pay gap in the same way as their gender pay gap, and Government could legislate for this – as well as publishing their own data on differences in educational outcomes. There is still fragmentation on tackling the issues, and an important next step is much more coordination.

Publishing data, while essential, is not sufficient – to avoid these procedures becoming mere tick-box exercises, conversations are needed between people. Some of these may start as hostile, but they will become easier with time. One

problem is that for some organisations, the data they have is poor or fragmented.

One aspect of the Mellon Mays programme in the USA is that organisations commit to self-assessment and analysis and then publish a plan. The UK HE sector should have a conversation about what might work here. Working with other communities is vital to drive forward the changes needed. Bringing younger secondary school students into universities such as Cambridge can help them seem more accessible to those from ethnic minorities.

Visibility

Increasing visibility of Black researchers is key. What did the panel find useful in their early careers? Items mentioned included seeing positive role models, leading to raised aspirations, and the huge benefit of mentorship. Some people have a fear of self-certifying ethnicity data. There are a number of reasons for this and institutions need to understand why people are not disclosing their data. There are real people under the data, and there is a relational aspect to disclosing data. □

FURTHER INFORMATION

Higher Education Statistics Agency www.hesa.ac.uk

Mellon Mays Undergraduate Fellowship www.mmuf.org

Royal Society: Ethnicity in STEM academic communities

<https://royalsociety.org/-/media/policy/Publications/2021/trends-ethnic-minorities-stem/Ethnicity-STEM-data-for-students-and-academic-staff-in-higher-education.pdf?la=en-GB&hash=22B252EFA4A87B0D869BE288F7EF724F>

Royal Society of Chemistry: Missing Elements Report

www.rsc.org/new-perspectives/talent/racial-and-ethnic-inequalities-in-the-chemical-sciences

Windsor Fellowship www.windsor-fellowship.org

FST PODCASTS

Black in Cancer – with Sigourney Bonner, Co-Founder of Black in Cancer UK, PhD student at Cancer Research UK

www.foundation.org.uk/Podcasts/2022/Sigourney-Bonner-Black-in-Cancer

Research and Funding Equity at Wellcome Trust – with Dr Diego Baptista, Head of Research and Funding Equity, Wellcome Trust

www.foundation.org.uk/Podcasts/2022/Dr-Diego-Baptista-Research-and-Funding-Equity-at-W

FUTURE LEADERS

Complexity – in all its forms – provided the theme running through the varied sessions of the first in-person conference organised by the Foundation Future Leaders programme, held at Glaziers Hall, London, on 1 November 2022.

Leadership in tomorrow's world

The challenges facing society today are – almost without exception – complex. People often use the conclusion ‘there is no silver bullet’ in recognition that issues routinely need a multi-disciplinary, comprehensive approach if they are to be solved.

The 2022 Future Leaders Conference was the first to be held in person (the previous two being online events due to Covid), although in addition to nearly 200 delegates who made their way to Glaziers Hall, there were a further 150 joining online.

The Future Leaders programme aims to give early- to mid-career professionals from a civil service, research or industry background an understanding of how other parts of the economy work. It enables them to network with others from different sectors and so build a more comprehensive understanding of the economy as well as developing networks that cross traditional boundaries.

Peer-to-peer

The conference, organised by members of the 2022 cohort, was aimed at their peers, people at a similar stage of career who would benefit from a multi-disciplinary, multi-sectoral view of today's society.

The conference brought together some of the leading thinkers, policy makers and decision makers to discuss the challenges facing the UK and the world – and suggesting ways in which these could be tackled. Each session was chaired by a member of the programme and the panel discussions that followed the main presentations also included a member of the cohort.

The first session, entitled *Tackling the Big Picture*, examined how today's challenges typically stretch well beyond a single specialism. It considered the



Professor Sir Adrian Smith, President of the Royal Society, gives a keynote address at the opening of the conference.

value of taking a systems approach to these issues and how that could help in resolving them.

The second session looked at the way in which these insights were being deployed to address one of the most

What are the skills and capabilities that will be needed by future leaders if they are to create permanent solutions that enable humanity to have a continuing and prosperous future on this earth?

urgent challenges facing the world today – climate change. With the conference taking place just a week before COP27 opened in Egypt, the aspirations and targets for that event provided a useful background against which to discuss

the journey from setting goals to delivering results.

Yet all these actions have to be achieved by people. What are the skills and capabilities that will be needed by future leaders if they are to create permanent solutions that enable humanity to have a continuing and prosperous future on this earth?

The skills question as well as structural issues such as diversity, equality and inclusion (EDI) provided the setting for the afternoon session. How can we create a world of work where everyone has to the opportunity to use their talents productively to improve the social, economic and environmental conditions within which we all live? □

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The sessions were all recorded and made available on the Foundation website at: www.foundation.org.uk/Events/2022/Leadership-in-Tomorrow-s-World-Foundation-Future-L

CONTEXT

Hardtech and high-value manufacturing companies have a key role in the UK economy. As the UK emerges from recession, the Foundation for Science and Technology wanted to explore that role, the challenges they face, and how Government and others (including universities) can help them to build on their success. What should policymakers, funding agencies and the companies themselves be doing going forward?

On 25 January 2023, the Foundation organised an event at the Royal Society in London to discuss these issues. The speakers

were: Peter Marsh, Founder of Made Here Now; Will Butler-Adams, Chief Executive Officer, Brompton Bicycle; Katherine Bennett, Chief Executive Officer, High Value Manufacturing Catapult; and Edmund Ward, Head of Advanced Manufacturing and Resources, Department of Business, Energy & Industrial Strategy.

A video recording, presentation slides and speaker audio from the event are available on the FST website:

www.foundation.org.uk/Events/2023/Hardtech-and-High-Value-Manufacturing

Understanding the manufacturing scene today

Peter Marsh

SUMMARY

- 'Hardtech' refers to technologies used to make tangible products
- Manufacturing only employs about 10% of the global workforce
- The UK is not the outlier it is sometimes described as
- Manufacturing today is very different from the situation a few decades ago
- Hardtech is more than advanced manufacturing or high-tech products.

On a matter of definition, 'Hardtech' simply means using technology, or combinations of technologies, to make tangible products. Softtech, on the other hand, involves using technology in an intensive way to make intangible items.

At its most basic, manufacturing is about adding value to materials: it is really no more complicated than that. Looking at the Periodic Table of the elements, it is clear that there are only 100 basic materials to work with (if you leave out those that are quite hard to isolate). From those 100, the world's manufacturers make around 10 billion products every year, things that are vital to just about every part of life.

All of that is done by really quite a small number of people. In the UK, we are used to thinking we do not have many people working in manufacturing. Yet that is true around the world. Man-

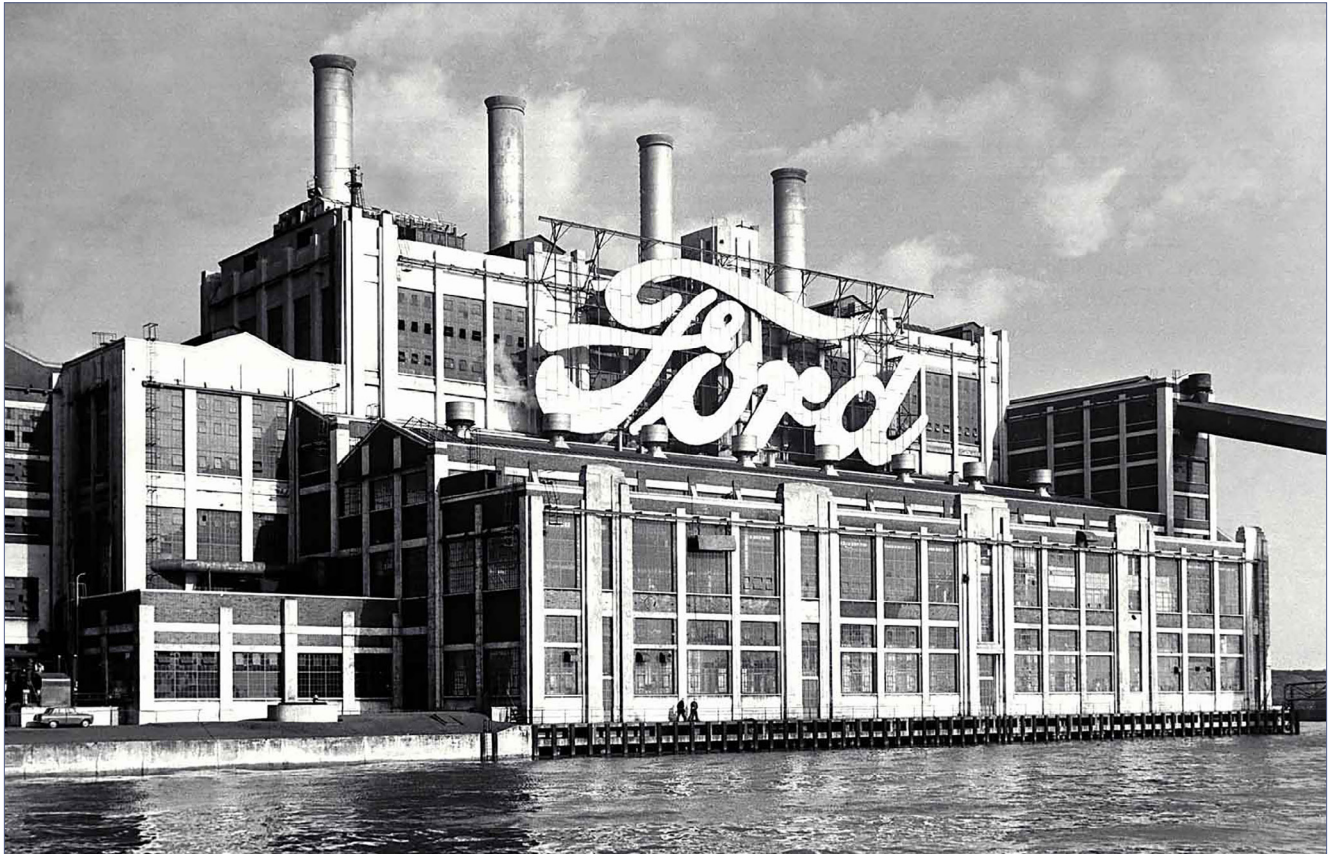
ufacturing employs only about 350 million people globally, something like 10% of the available workforce. Approximately 15% of total global GDP is accounted for by manufacturing. The figure is about 10% in the UK. In only a handful of countries is manufacturing more than 20% of the economy. Britain is not such an outlier as some people think.

The people working in manufacturing generally need high levels of skills. The sector is a big user of technology and takes up nearly half of the total R&D in the UK. It therefore requires high levels of capital. If you put more into anything, more energy, ideas etc, you should get more out of it. The same goes for manufacturing. Productivity in manufacturing is 10-20% more than in many services. For a sector employing relatively large numbers of skilled people, wages are also 10% higher than in much of the rest of the economy.

This may explain why manufacturing is – or at least should be – near the top of the priority list for politicians and others. Historically, Britain has had a very long involvement with manufacturing: it was, after all, the place where the original industrial revolution happened. For a brief period, (perhaps only about 50 years) it was the world's biggest manufacturing nation, accounting for about 20% of total manufacturing output in 1895. As recently as the 1950s, it was still high in the league table with 10% of total manufacturing output and seven or eight million people employed in manufacturing back then. Today, that figure has dropped to two and a half million and the United Kingdom is No 9 in the world league table.



Peter Marsh is a writer and lecturer on 21st century manufacturing. He is the founder of Made Here Now, a website on UK manufacturing aimed at encouraging more young people to consider technology and production as a career. He previously worked at the *Financial Times*, most recently as manufacturing editor, and at *New Scientist*. He has a degree in chemistry from Nottingham University. In recent years Peter has given talks on manufacturing opportunities in countries including South Korea, Italy and Brazil.



Big factories used to be in every city, making steel, cars, ships: everyone could understand. Today, the typical manufacturing employer is much smaller, employing perhaps 100 people in a small building on the edge of town.

That falls to No 26 in manufacturing output per person, though.

That paints a picture of relative national decline. There is a feeling that Britain used to be much better at this. There is still a feeling of nostalgia for the time when the country was No 1, it is part of our industrial history. On one level, then, there is a theory that it would be good if Britain could get back into a higher position in manufacturing, although there are doubts that it is achievable. At the same time, though, many people think of manufacturing as dirty, old fashioned and rather polluting and believe it is better that we do not do much of it.

Revealing manufacturing

One of the problems about explaining the importance of manufacturing to politicians or the person in the street is a difficulty in describing what modern manufacturing is. The big factories used to be in every city, making steel, cars, ships: everyone could understand. Today, the typical manufacturing employer is much smaller, employing perhaps 100 people in a small building on the edge of town. They will be making, in many cases, obscure components for other more complex products. Explaining the reality of 21st century manufacturing is, therefore, very much needed.

Sales of manufactured goods in 2021 in the UK came to approximately £400 billion. Of this, 60% were standard industrial products, involving a

modest level of technology – sectors like food, textiles and basic building products. Most of these are for domestic use. The remaining 40% is hardtech. The sectors include a range of industries, chemicals, industrial, scientific instruments, machinery, etc. Only half of this amount would be construed as advanced manufacturing or high tech, things like electronics, biotech and so on. The phrase ‘hardtech’ is therefore a much more useful concept here.

One reason is that there are excellent hardtech companies which would not fall within so called ‘high tech’, or advanced manufacturing. Renishaw, the metrology and healthcare technology group, employs 3,000 people. Brompton Bicycle has an annual turnover of £90 million. James Walker Group employs 2,000 people, half of them in the UK; they are specialists in sealing technology, rail track fixation and vibration attenuation.

A common feature of all these companies is the application of IT and automation. However, the main reason that they are successful and worth supporting is because of what they are doing in other areas, not IT. The ‘fourth industrial revolution’ is bandied about a little bit too much and is not a sufficient description of what is really going on. Policymakers need to understand that reality and then think about how best to help these companies. □

DOI: 10.53289/WDLC2154

The excitement and challenge of a career in manufacturing

Will Butler-Adams

SUMMARY

- Manufacturing is not just about high tech applications
- Politicians need to understand better the reality of manufacturing today
- The products may not always be high tech, but technology plays a central role in production
- Universities should inspire the next generation of engineers
- There needs to be clarity about who is – and who is not – an engineer.

There is a perception that manufacturing industry is all high tech; semiconductors, nanotechnology, graphene, cutting edge space technology. Yet here we are, a bicycle company manufacturing in London – and bicycles are not high tech, are they? And we are selling our products to China, which is about to become our largest export market. Our politicians do not understand our sector. Universities are not delivering to our sector while parents are not being given the information they really need to guide their children's career and study choices.

Politicians need to understand manufacturing – and to be educated by those doing it. Some years ago, I heard about a company that make fittings for bathrooms. Go to any plumbers' merchant and there is a plastic fitting costing just pence to replace a broken U-bend. Made in the UK, it is as cheap as chips, there is nothing high value about it. They cannot be shipped in from China because they are so cheap, it would not make commercial sense.

Under the hood

However, while there is nothing high-value about this product, examine the technology being used to make it and it is extraordinary. That is smart. That is the high-tech aspect – the manufacturing, not the application. Yet politicians cannot see it. To make our bike, we have used computers that are breathtakingly powerful to do things like Finite Element Analysis, we use robots, we use Metal Injection Moulding – just to

make a bicycle. To run our factory, we use Raspberry Pi everywhere, we write our own software in Python. In fact, we are trying to create a fully integrated company.

Then, when some celebrity in Hollywood rides one of our bikes, and suddenly people get excited about it, we can adjust our production strategy and planning. Within 10 days, we can completely reconfigure our supply chain to change what we need to buy, knowing that in three weeks' time the North American market is suddenly going to start buying that bike. That is smart engineering. That is the value that we create in the UK: a fully integrated, sophisticated business, not just the product itself but everything in between as well. That can be done very effectively in the UK because we have a multi-faceted research-university collaboration and some innovative individuals.

I went to university. I spent four years there, including one in Spain which I really enjoyed. The other three years of mechanical engineering were awful and seemingly designed to put students off a career in the subject. The university lecturers did not seem interested in students. Only one lecturer had actually worked in a real company. The rest were focussed on producing academic papers, not on the students. Today, that has changed somewhat but there is still a long way to go.

Universities need to inspire, they need to excite, they need to bring alive what an awesome career engineering is. Yet the university lecturer is not measured on the outcome of the student. He or she is measured instead on how many research papers they have published: there is not enough focus on the student and on inspiring the next generation of graduates to go into industry.

So those who study engineering typically go to work in banking, or consultancy. I had such a painful time at university, but then I discovered this wonderful world outside and it was really exciting and fascinating and brilliant. But I did not get any inkling of that while I was at university.

Going one step further back, what is the message being given to parents and school students about engineering? TV adverts offer homeowners with a plumbing, heating or electrical prob-



William Butler-Adams OBE CEng is Chief Executive Officer of Brompton Bicycle. He joined Brompton in 2002, became director in 2006, and took over as MD in 2008. Since then he has grown the company from £2 million turnover with 27 staff to £120 million turnover with over 800 staff. Brompton exports over 75% of its bikes to 47 countries through 1600 independent bike stores. He is a Chartered Engineer and is passionate about all things engineering. He was awarded an OBE in 2015 for services to Industry.

When a celebrity in Hollywood rides one of our bikes, we can completely reconfigure our supply chain to change what we need to buy, knowing that in three weeks' time the North American market is suddenly going to start buying that bike.



BROMPTON BICYCLE



BROMPTON BICYCLE

Brompton Bicycle uses advanced manufacturing and computer technology to create a fully integrated company.

lem the opportunity to have an engineer come out and fix it. Well, they are not engineers. They are plumbers or electricians. But these big advertisers spend hundreds of thousands of pounds telling every parent that engineers fix things with monkey wrenches and screwdrivers.

Status is key

That is not on. To be serious about reinvigorating manufacturing, engineers need to be recognised as the people who design, analyse and produce items: they are not the same as the mechanic that changes car tyres. Rather, they are individuals who have gone through a three-year baptism of fire, to get to a point where they have a deep understanding of their subject matter. There are Learned Societies and Institutions that could come together to tackle this perception and remove the incorrect information about the sector that is permeating all too easily today.

There is so much for us to do but there are lots of opportunities everywhere. At Brompton Bicycle, we are providing mentoring on Masters projects at Cranfield and Imperial. We are working with the Catapults, we are working with the Advanced Forming Research Centre, the Warwick Manufacturing Group and The Welding Institute. There are so many opportunities to spread the story about the excitement and appeal of manufacturing. □

DOI: 10.53289/XDTC3774

Working together to improve manufacturing performance

Katherine Bennett

SUMMARY

- Manufacturing is still being buffeted by global cross-currents that impact on industry
- Catapults exist to bridge the gap between universities and industry
- The challenge is to make economic progress consistent with our climate change goals
- Catapults act as a link between universities, national labs such as NPL and industry
- There is so much potential that we can realise by working closer together.

The High Value Manufacturing Catapult works with many sectors, from nuclear to pharma, energy to construction, automotive to aerospace. We work with initiatives such as the Faraday Challenge and on projects such as lightweight materials, medical tech, vaccines and composites.

At our Composites Centre in Bristol, we have Europe's largest advanced manufacturing capability. Since the Catapult was established, it has supported 22,000 companies. Catapults are about bridging the gap between UK universities and industries: indeed, several of our centres are affiliated with universities.

What is hardtech?

People have different views about what 'hardtech' means. I describe it as the application of engineering and science in combination with hardware and software to solve a problem, whether a specific industry issue or a particular business challenge.

In early 2023, the global pandemic and the European war continue to impact many of our industry sectors, as well as other issues such as climate change which is increasingly affecting us all. The thread running through the solution to many of the challenges is the power of high value manufacturing. This is a critical enabler in arriving at the solutions needed to move in the right direction and strengthen our national resilience – we need to be better prepared against future shocks that may hit industry.

Levelling up is an important focus across the

UK. Manufacturing in this country is worth around £180 billion a year and the average wage is 12% higher than for the economy as a whole. How do we help then to level up and contribute to bridging that income gap? One way is to focus on creating commercialisation, scaling up more low carbon and sustainable options for industry, and working with our partners to find better ways, for example, of measuring and reporting environmental factors across the whole product lifecycle.

The equation that we are trying to solve is one where we can make economic progress while also meeting our climate change goals. Deep collaboration strengthens climate action and supply-chain stability in the UK, while at the same time making it possible to coordinate performance improvements and policy decisions for entire sectors and geographic regions.

In business, there is always the bottom line. We have to demonstrate how measuring emissions can actually help improve business, creating a magnet for inward investment from international companies who are looking for simpler, easier ways to reduce their lifecycle impacts. Leveraging that global market will create long term jobs.

To give a couple of examples of projects that are very apposite at the moment, there is currently a big discussion within the steel industry about a sustainable future – sustainable steel. This affects so many sectors and the Manufacturing Technology Centre in Coventry is working with the construction sector (a big user of steel), as well as experts in composites and additive manufacturing, to help the steel industry improve their situation.

Since I joined the Catapult, I have seen very impressive results just from bringing the right people together. For example, the Ventilator Challenge brought aerospace and automotive companies together in a very short period of time to build 13,000 ventilators in just 12 weeks. People brought a huge amount of effort and dedication to that project – it really does need to be better known.

I was at the National Physical Laboratory in Teddington recently, and aside from my interest as a non-engineer at seeing the work under way in their labs (I saw their work on optical lattice clocks for example) we had a discussion about closer collaboration. The NPL is a great national asset.



Katherine Bennett CBE FRAeS joined the High Value Manufacturing Catapult as CEO in June 2021 after 16 years at Airbus where she was a Senior Vice President. At Airbus, Katherine was the UK voice and face of the global aerospace manufacturer and her responsibilities included developing the strategy of Airbus in the UK, leading the company's public affairs activities, high-profile media engagement and representing the company on various committees, boards and initiatives including Ventilator Challenge UK.

I describe hardtech as the application of engineering and science in combination with hardware and software to solve a problem, whether a specific industry issue or a particular business challenge.

It is not just a question of high-value manufacturing but also of high-value design.

Another project being pursued there is called 'Optimum' (Optical Tracking Instrument for Measurement Using Multilateration). NPL is working with the Advanced Manufacturing Research Centre in North Wales, and with Airbus, to develop a new way of measuring using a self-calibrating coordinating measurement system. It was the brainchild of two people who got together in a room and found a solution to a problem!

Another opportunity where our centres want to collaborate with industry is on offshore energy. There is so much more that can be done in the

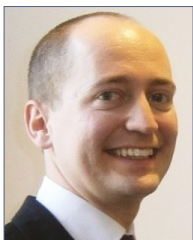
design and development of more environmentally friendly products such as more sustainable blades, etc, for offshore wind turbines.

Finally, it is not just a question of high-value manufacturing but also of high-value design. This is another area where the UK has significant expertise. There are people I worked alongside at Airbus in Bristol, who spend their lives designing more environmentally-friendly wings and helping to reduce fuel burn. That same laser-focus and dedication on improvement in design and manufacture is something that has really impressed me since I started work at the Catapult. There is so much potential that we can realise by working closer together. □

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Government's role in enabling high-value manufacturing

Edmund Ward



Dr Edmund Ward joined the Department for Business, Energy & Industrial Strategy (BEIS) in 2018, and is currently Head of Advanced Manufacturing & Resources in the recently formed Department for Business & Trade. He has worked closely with industry and across Government on the introduction of initiatives such as the Automotive Transformation Fund and in the development of the UK's first ever Critical Minerals Strategy, published in July 2022. His current portfolio includes convening expertise to understand the future of manufacturing technologies – including considering how to harness the opportunities these can bring.

Innovation is at the heart not just of current manufacturing but also the next generation of technologies. Figure 1 shows the innovation ecosystem chart as set out in the Government's Innovation Strategy. In terms of desired outcomes from this activity, we want growth, we want jobs, we want health, we want societal welfare. These are significant goals.

Government's role is to provide an enabling environment. In the UK now, the manufacturing sector has some real strengths. We have the talent and development to support innovation, four of the top 10 universities in the world and we attract not just homegrown R&D but also funding from international investors. There is also support through the R&D Tax programme and other initiatives.

Venture capital

The UK is Europe's leading nation for venture capital, with almost all going into small companies with fewer than 50 employees. The ecosystem is really important. While much of the funding is concentrated in certain sectors – quantum technology startups are a particular area of interest – the UK has more than 25% of the unicorns (startups with \$1 billion capitalisation) across Europe, which is more than France and Germany combined. R&D continues to grow and the Government is committed to supporting that, while recognising that the bulk of R&D funding comes from business, rather than Government.

SUMMARY

- Innovation will be at the heart of future economic success for the UK
- Government's role is to provide an enabling environment
- The IP environment must be right to support innovation
- Innovation is about making processes smarter as well as products
- Business can benefit from support and encouragement to adopt new technologies as they become available.

The Intellectual Property regime also has to be right in order to maximise innovation. The UK has the second best IP protection in the world, according to the US Chamber of Commerce International. In the UK, there are two spinouts per £100 million of research income which compares favourably with the US. So in this country we are starting from a solid base when we think about growing our innovation ecosystem and making it even better. Quantum projects have attracted significant investments recently, but other examples include turning carbon dioxide into plastics or developing non-combustible insulation foam.

Net zero is a major challenge involving Government, industry and society. As the recent

Skidmore Review sets out, net zero is better than 'not zero', green tape is better than red tape. There are different elements of decarbonisation and this is not just about products, but also processes. These are big challenges with significant risks attached, but they also present opportunities in high value manufacturing for innovations that will make us more resource efficient, more energy efficient and which will enable us to switch to different zero-carbon fuel systems.

The Government's Innovation Strategy identifies a number of technology families and there is a role for manufacturing in each of these. For example, there has been a Call for Evidence on quantum technologies and a full strategy will follow. The Government is also working on a UK Manufacturing Investment Prospectus.

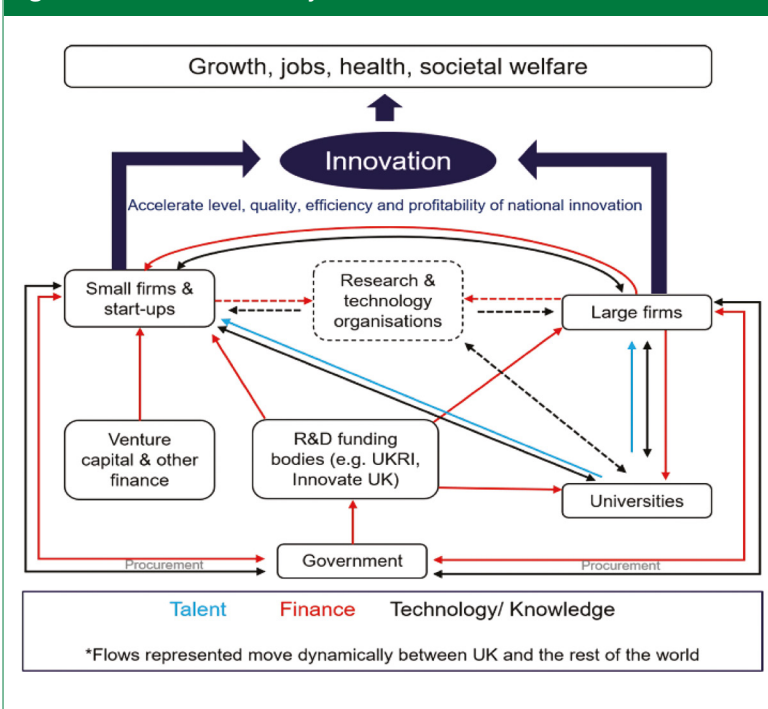
In terms of risk, the Advanced Research and Invention Agency (ARIA) will pick up on some of the opportunities where there is significant risk. The Government has a number of elements within its infrastructure that address innovation. The High Value Manufacturing Catapult has more than half of the total Catapult network funding, which signals the importance Government attaches to this topic. In addition, there are research institutes that work across sectors, such as the Advanced Propulsion Centre and the Aerospace Technology Institute. Increasingly, though, Government interventions will look across multiple sectors because that is where we need to look for future solutions, integrating insights and developments, collaborating across sectors and across boundaries. This is where we expect the next generation of innovations will come from.

Working together

There are, in fact, many examples of Government and industry working together. Zero emissions aviation is an important goal and Government has provided research funding to explore different technologies. One of the questions is the relative parts that different technologies will play, of which sustainable aviation fuels is just one. Yet, it is not so long ago when it was thought that a zero-emission flight was an impossibility. Now, though, there has been a transatlantic flight and work is continuing on aircraft that will employ batteries or hydrogen combustion. There has been real progress. In the automotive sector, electricity will power the next generation of zero emission vehicles. Halewood will be Ford's first electric vehicle component in-house assembly site in Europe with production beginning in 2024.

The journey to this stage has been about designing the right processes and products, set-

Figure 1. The Innovation Ecosystem



ting the manufacturing strategy and working out how to integrate disparate parts into an efficient process: it is not straightforward. Get it right, though, and the dividends are there. Again, smarter process is as important as smarter final product. This is a key factor, both in terms of investment and the manufacturing technologies.

There are now five UK regions where companies can access help from the Made Smarter programme (www.madesmarter.uk) designed to help them understand what technology is out there and also, crucially, how to implement these manufac-

The innovation ecosystem chart as set out in the Government's Innovation Strategy. Desired outcomes include growth, jobs, health and societal welfare.

FURTHER INFORMATION

Brompton Bicycle

www.brompton.com

High Value Manufacturing Catapult

<https://hvm.catapult.org.uk>

Net Zero Review (the Skidmore Review) www.gov.uk/government/news/net-zero-review-uk-could-do-more-to-reap-economic-benefits-of-green-growth

Made Here Now

www.madeherenow.com

UK Innovation Strategy www.gov.uk/government/publications/uk-innovation-strategy-leading-the-future-by-creating-it

Made Smarter

www.madesmarter.uk

Government, industry, academia and civil society need to come together to identify opportunities, overcome obstacles and enable innovation.

turing technologies. After all, process innovations will be of little benefit if companies are not aware of them or do not know how to deploy them.

The Government also has a role in creating the enabling environment. For example, we know the demand for batteries is going to increase. The Government has set out its commitment and ambition on electric vehicles, which will drive demand. Investors, supply chain companies and OEMs can all see this clearly and this should guide their decision-making. Of course, there is also a need for

Government, industry, academia and civil society to come together to identify opportunities, overcome obstacles and enable innovation across the supply chains to make sure that everyone has the opportunity to tackle those opportunities.

The UK is already a great place to innovate, to invest and to manufacture. There is still plenty of room for further economic growth and innovation. Where Government, industry and academia can coalesce around key opportunities and identify clear, common priorities, there should be a bright future as we continue to harness the skills and develop the technologies that we must continue to progress as an innovation nation. □

DOI: 10.53289/BKVV1207

The debate

After the formal presentations, the speakers joined a panel to respond to questions from the audience on a range of topics, including: gross margins; identifying gaps; skills; diversity; and the greening of the economy.

What should the minimum level of gross margin be? Well, it varies by sector, with high volume manufacturers tending to have smaller gross margins and high value manufacturers larger. Manufacturers are increasingly doing more than just manufacture – they may also be distributors, brand owners and retailers – which drives a better understanding of their customers, in turn holding out the promise of higher gross margins.

Government has a role in bringing different actors together (companies, universities, Catapult centres, etc) regardless of any formal ‘Industrial Strategy’. Driving improvements in productivity is a key part of this. Another Government responsibility is gap reporting, which can then identify a case for investment and stimulate strategies to produce strategically significant products and

materials. Existing companies should seek to extract the full value of their existing innovations rather than moving to other products.

In the UK there seems to be a lack of ambition among young people about becoming creators, makers, innovators. A comprehensive and cohesive plan is needed in order to address this – a plan with the aim of inspiring children from their first days at primary school. There is no short-term fix, but recent Government initiatives on T-Levels and apprenticeships will help.

Outreach

In order to address skills shortages, some large employers collectively put money into advertising and here the engineering profession could help. Companies also give time to staff to volunteer in outreach activities. Academies and professional bodies should continue to highlight the issue of specialist teacher shortages.

Greater attention should be given to diversity, for example, by appointing more women to the boards of companies. There is a shortage of women engineers coming into the workplace so more needs to be done to inspire them while they are in the education system.

To be a successful manufacturer in Britain: first, it is not always necessary to invest in new technology, but knowledge transfer and application is; second, take a global outlook; and third, recruit and retain good people. The UK also has an opportunity to leverage an important general priority – making the world greener – and inspire the next generation to contribute to solving them. Case studies can help with this. □

FST PODCASTS & BLOGS

Hardtech manufacturing in the UK – with Peter Marsh, Founder of Made here Now www.foundation.org.uk/Podcasts/2022/Peter-Marsh-Hardtech-manufacturing-in-the-UK

High-Value Manufacturing – with Katherine Bennett, Chief Executive Officer, High Value Manufacturing Catapult www.foundation.org.uk/Podcasts/2022/Katherine-Bennett-High-Value-Manufacturing

Unlocking hardtech – by Dr Amy Nommeots-Nomm, Early Stage Deeptech Investor, Octopus Ventures www.foundation.org.uk/Blog/2023/Unlocking-Hardtech

Statistics are important tools in understanding a wide range of vital elements in our society. But they are not forever unchanging: they adapt to changing societal requirements.

Keeping statistics meaningful and useful

Mike Keoghan

One of the great quotes attributed to Keynes is: “When the facts change, I alter my conclusions. What do you do, sir?”

That pure insight into the nature of uncertainty is a reason why, in addition to Keynes’ many roles, he would have made a first-rate National Statistician.

When it comes to official statistics, revision is part of the business. Normally those revisions attract little public interest. Our website gets updated, we will state where and when figures have been revised. Academics will download the new series and analysts will rerun their models. All perfectly normal, routine behaviour in the life of a user of official statistics anywhere in the world.

Inherent uncertainty

That is because we all understand the uncertainty inherent in producing official statistics. There are always balances to be struck. Some estimates can be produced quickly with high levels of confidence: others will be more uncertain. Our job is to be transparent about that, and to continue to review and improve. As decisions need to be made by policymakers, businesses and households, we can all recognise the value of making those decisions with the best information available at that time.

There are periods when this becomes more difficult. A good current example is economic growth. Historically, when the UK economy grew by 0.3-0.5% every quarter, a 0.1% revision did not change our situational understanding. However, recently the economy has sometimes been broadly flat, so a small revision has the potential to dramatically change the perspective: being reported as pitching from recession to recovery and back again, yet with no real change to underlying economic performance.

The risk-averse approach would be to wait until the uncertainty resolved itself, waiting three months for the latest GDP figure. However, the UK is one of only two countries in the world that produces monthly GDP statements. Given we have that capability, we think it is right to share

that information with policymakers and the public, even if that sometimes places us in an uncomfortable position as new data comes in.

This provides an example of ‘normal’ statistical uncertainty, albeit amplified by unusual economic times. However, there is also the challenge of dealing with uncertainty when changing the underlying statistics themselves. We have recently experienced this with our improvements to the Business Enterprise R&D (BERD) Statistics.

It is worth recapping what the revisions did. The revision moved R&D spending by businesses in 2020 from £26.9 billion to £44.0 billion: a 64% increase. Josh Martin of the Bank of England calculates that moved R&D as a percentage of GDP from 1.7% to 2.4%, which elevated the UK from being one of the international R&D laggards to a comfortable mid-table position. Not only does that bring the UK into line with the Government’s stated ambition for R&D spend, but it also exonerates one of the prime culprits for the UK’s productivity puzzle and changes a significant aspect of recent UK economic history.

This has generated a lot of interest. It is worth reflecting on why the ONS made that change because it illustrates two aspects – validity and methodological change – of dealing with uncertainty in producing economic statistics.

At the beginning of 2022, Sir Ian Diamond, the National Statistician, asked the Office to look again at how we were measuring R&D. What we discovered was that the BERD survey, while methodologically sound and robust in terms of processing, had simply failed to keep track with underlying change in the economy. The survey was conceived in the late 1980s, in a world of industrial labs where R&D was undertaken by ICI or GEC. We were, as Professor Richard Jones put it, missing out on the ‘dark matter of [smaller firms] doing R&D’.

That is the first challenge: the issue of validity. The problem ONS discovered with R&D was that our survey was no longer valid; it was no longer representing its underlying population and so it needed to change.



Mike Keoghan is Deputy National Statistician and the Director General of the Economic, Social and Environmental Group at the Office for National Statistics (ONS). Before this, Mike was the Chief Economic Adviser and Director of Analysis at the Department for Business, Energy and Industrial Strategy (BEIS). Between 2020 and 2021 Mike was also Acting Director General for Business Sectors at BEIS. During this time, he was responsible for leading the UK Government’s business policy, including the business readiness programme before the UK’s exit from the EU.

The problem ONS discovered with R&D was that our survey was no longer valid; it was no longer representing its underlying population and so it needed to change.



The availability of rich HMRC microdata highlighted the need to improve the measurement of research and development conducted by small- and medium-sized businesses.

Ensuring the validity of our statistics is something that ONS has been methodically pursuing since Sir Charlie Bean's review in 2016. Across a whole suite of measures, some of our statistics had become unmoored from the underlying economic base. There has been a huge amount of path-breaking work since Bean to improve our statistics: we have dramatically improved our measures of the digital economy and implemented double deflation in the National Accounts, thereby giving better insights into which sectors were driving our growth. We have put in place a new regime for trade statistics following our exit from the European Union which allows us to capture micro-level trade that was previously obscured and we have just published fine-grained measures of local Gross Value Added, enabling much better understanding of how growth plays out spatially. By collaborating with the Economic Statistics Centre of Excellence (ESCOE), which was incubated at NIESR and now sits within Kings College London, we have been able to make a step change in our measurement of the economy.

The second challenge that the R&D reforms illustrate is the improvement in statistical methods themselves. New methods and new data sources mean that we can secure better estimates of the underlying economic phenomena. In the case of R&D, it was the availability of HMRC's tax credit data that highlighted the widening discrepancy between measures. Although ONS did not use that data in producing the new estimates, the availability of the rich HMRC microdata did reinforce where the first stage of improvements should be focussed: namely, the measurement of research and development conducted by small- and medium-sized businesses.

Methodological improvement has not been confined to R&D. Over the next two years ONS will inject retail scanner data into the headline inflation measures. As well as the technological change of moving from thousands to billions of price points, the work has also required world-leading methodological developments.

Similarly, in leaving the EU, ONS has had to move from a Europe-wide survey-based method for calculating trade to a new administrative-based system. Looking ahead, we will be overhauling the methods and collection of the Labour Force Survey (LFS) which is the Government's single biggest survey after the Census.

All this change and innovation is exciting for ONS, but where does that leave users? The reality is that more valid statistics, better methods and richer sources of data will probably change our statistics: after all that is the point. That is what we saw with R&D – we now have our best-ever estimate, but it has changed our understanding.

That, though, leaves policymakers and other statistical users in a difficult position. We know how to handle the 'normal' uncertainty of statistical revisions: the ONS provides very clear quality information including confidence intervals for surveys. Experienced users also know the cadence of review and revision. However, what happens (as we saw with R&D) when the improvements leave the resulting revisions well outside what users would regard as 'normal'? How can we support users of trade, GDP, prices, labour force, crime, productivity and other datasets as our investments begin to come on stream?

Scientific method

Scientific method provides part of the answer here. We have to be open, transparent and submit ourselves to peer review so we can bring users along with us, but also so they can contribute to our improvements. ESCOE is part of this, along with our collaborations with the Turing Institute, the Bank of England, Southampton University and our ONS Fellows, among others. In the R&D case, the ONS produced a series of articles and bulletins, met with stakeholders and users, presented at conferences and submitted the work to peer review.

However, our experience of R&D also tells us that robust application of scientific method is necessary but not sufficient for handling the uncertainty in renewing our statistics. For that to really work, helping users navigate the uncertainty and building trust, we need a better way of communicating the size and implications of our changes. We will work even more closely with our users to understand how we can provide clearer guidance about forthcoming changes. By doing this, we will enable our policymakers and analysts to understand the implications of change, manage the downsides of uncertainty and further enhance the reputation of UK official statistics. □

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Presentations and audio recordings from all meetings of the Foundation for Science and Technology are available at: www.foundation.org.uk

In conversation with Sir Patrick Vallance

26 April 2023

Sir Patrick Vallance, Outgoing Government Chief Scientific Adviser

The Rt Hon the Lord Willetts, Chairman, The Foundation for Science and Technology

Mission Zero - Getting to Net Zero emissions by 2050

21 March 2023

The Rt Hon Chris Skidmore MP, Chair of the Net Zero Review

The Lord Turner FRSE, Chairman, Energy Transitions Commission

Professor Emily Shuckburgh OBE, Director, Cambridge Zero

How can schools and colleges prepare young people for a technological life and help tackle the technical skills gap?

22 February 2023

Professor Bill Lucas, Director of the Centre for Real World Learning, University of Winchester

Nancy Buckley, Group Director, Business Development, Activate Learning

Sharmen Ibrahim, Group Director, Digital Education

Ella Podmore MBE, Senior Materials Engineer, McLaren Automotive Ltd

Phil Smith CBE FREng, Chairman of IQE, Chair of Digital Skills Partnership and former Chair and CEO of Cisco UK

Hardtech and High-Value Manufacturing

25 January 2023

Peter Marsh, Made Here Now

Will Butler-Adams OBE, Chief Executive Officer, Brompton Bicycle

Katherine Bennett CBE FRAeS, Chief Executive Officer, High Value Manufacturing Catapult

Dr Edmund Ward, Head of Advanced Manufacturing and Resources, Department of Business

Black Scientists – Tackling Racism in UK Science & Technology

7 December 2022

Dr Alejandra Palermo FRSC, Head of Global Inclusion, Royal Society of Chemistry

Professor Ijeoma Uchegbu HonFRSC, FMedSci, Professor of Pharmaceutical Nanoscience, University College London

Sigourney Bonner, Co-Founder of Black in Cancer and PhD Student, Cancer Research UK

Dr Karen Salt, Deputy Director for Research Culture & Environment, UKRI

An Innovation Strategy for Scotland

7 November 2022

Ivan McKee MSP, Minister for Business, Trade, Tourism and Enterprise, Scottish Government

Dr Deborah O'Neil PhD OBE FRSE, Chief Executive Officer, Novabiotics

Professor Sir Jim McDonald FREng FRSE, Principal and Vice-Chancellor of the University of Strathclyde, and President of the Royal Academy of Engineering

Professor Julie Fitzpatrick OBE, Chief Scientific Adviser for Scotland

Professor Rick Delbridge, Professor of Organisational Analysis, Cardiff Business School, Cardiff University

Leadership in Tomorrow's World - Foundation Future Leaders Conference 2022

1 November 2022

Science, Climate Policy and COP27

26 October 2022

Sir Patrick Vallance FRS FMedSci FRCP HonFREng, UK Government Chief Scientific Adviser

Professor Mahmoud Sakr, President, Egyptian Academy of Scientific Research and Technology

Emma Howard Boyd, Chair of the Green Finance Institute

Professor Jim Skea CBE, Chair in Sustainable Energy, Imperial College & Co-chair of Working Group III of the IPCC

Health policy implications of climate change

13 July 2022

Sir Chris Whitty KCB FMedSci, Chief Medical Officer for England

Professor Mike Tipton MBE, Trustee, The Physiological Society, and Professor of Human and Applied Physiology, University of Portsmouth

Dr Modi Mwatsama, Head of Climate Interventions, Climate and Health, Wellcome Trust

Scenarios for a Science Superpower

6 July 2022

Professor Sarah Main, Executive Director, Campaign for Science and Engineering

Professor Graeme Reid FRSE, Chair of Science and Research Policy, University College London

Lisa Brodey, Science Counselor, US Embassy London

The Lord Rees of Ludlow OM Kt FRS, House of Lords

New Nuclear and the UK Energy Strategy

15 June 2022

Julia Pyke, Sizewell C Director of Financing and Economic Regulation, EDF

Sophie Macfarlane-Smith, Head of Customer Engagement, Rolls Royce SMR Ltd

John Corderoy, GDF Technical Programme Director, Nuclear Waste Services

Professor Paul Monks, Chief Scientific Adviser, Department of Business, Energy & Industrial Strategy

Increasing interdisciplinarity in UK R&D

18 May 2022

Professor Dame Ottoline Leyser DBE FRS, Chief Executive, UKRI

Professor Rachael Gooberman-Hill, Institute Director, Elizabeth Blackwell Institute, University of Bristol

Professor Graeme Reid FRSE, Chair of Science and Research Policy, University College London

Professor David Soskice FBA, Professor of Political Science and Economics, London School of Economics

UK-China research collaboration

27 April 2022

Minister Yang Xiaoguang, Minister and First Staff Member, Embassy of China in the UK

Rt Hon Sir Oliver Letwin FRSA, Author of *China vs America: A Warning*

Vivienne Stern MBE, Director, Universities UK International

Professor Christopher Smith, Executive Chair of AHRC and UKRI International Champion

Rebuilding the UK Electricity Grid

23 March 2022

Nick Winser CBE FREng, Chairman, Energy Systems Catapult

Dr Cathy McClay OBE, Trading and Optimisation Director, Sembcorp Energy UK

Professor Keith Bell, Scottish Power Professor of Smart Grids, University of Strathclyde

Delivering the AI Strategy – the use of new AI technologies in industry and the public sector

23 February 2022

Professor Dame Wendy Hall DBE FRS FREng, Regius Professor of Computer Science, University of Southampton

Lord Clement-Jones CBE, House of Lords

Professor Geraint Rees FMedSci, Pro-Vice-Provost, AI, University College London

Professor Tom Rodden, Chief Scientific

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Adviser, Department for Digital, Culture, Media and Sport

How can the National Science and Technology Council and the Office for Science and Technology Strategy direct S&T priorities?

26 January 2022

Sir Patrick Vallance FRS FMedSci FRCP HonFREng, National Technology Adviser & Government Chief Scientific Advisor

Professor Dame Ottoline Leyser DBE FRS, Chief Executive UKRI

Naomi Weir, Programme Director - Innovation, Confederation of British Industry

Professor James Wilsdon FAcSS FISC, Director, Research on Research Institute, University of Sheffield

Round Table on UK Technology Priorities

26 January 2022

Andrew McCosh, Deputy National Technology Advisor and Director General of the Office for Science and Technology Strategy

COP26: where do we go from here?

1 December 2021

The Lord Broers FRS FREng HonFMedSci, House of Lords

Professor Sir Dieter Helm CBE, Professor of Economic Policy, University of Oxford

Professor Sir Ian Boyd FRSE FRSB FRS, Professor of Biology, University of St Andrews

The Baroness Young of Old Scone Hon FRSE, House of Lords

Professor Sir Charles Godfray CBE FRS, Director, Oxford Martin School, University of Oxford

EU R&D Programmes – Round Table

24 November 2021

Foundation Future Leaders Conference

22-23 November 2021

Rt Hon Greg Clark MP, Chair, House of Commons Science and Technology Select Committee

Dr George Dibb, Head of the Centre for Economic Justice, IPPR

The Baroness Brown of Cambridge DBE FREng FRS, Climate Change Committee

Dr Doug Parr, Chief Scientist, Greenpeace

Dr Hayaatun Sillem CBE, Chief Executive, Royal Academy of Engineering

Professor Melanie Welham, Executive Chair, BBSRC

Indro Mukerjee, Chief Executive, Innovate UK

Dr Peter Waggett, Director, IBM UK

The UK Innovation Strategy

13 October 2021

Rt Hon Kwasi Kwarteng MP, Secretary of

State for Business, Energy and Industrial Strategy

Indro Mukerjee, Chief Executive, Innovate UK

Dr Hayaatun Sillem CBE, Chief Executive, Royal Academy of Engineering

Paul Stein FREng, Chief Technology Officer, Rolls Royce

Priya Guha MBE, Partner, Merian Ventures

Science & Public Policy - Developing Systems for Science Advice to Governments and Parliaments

23 September 2021

Louise De Sousa, British Ambassador to Chile

Dr Andrés Couvé, Science Minister of Chile

Gavin Costigan, Chief Executive, Foundation for Science and Technology

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Dr Stuart Wainwright, Director, Government Office for Science

Professor Kristiann Allen, Executive Secretary, International Network for Government Science Advice

Leonardo Muñoz, Head of Science and Government, Chilean Ministry of Science

The future of European Space Policy

15 September 2021

Josef Aschbacher, Director General, European Space Agency

Dr Alice Bunn, Chief Executive, Institution of Mechanical Engineers

Sir Martin Sweeting OBE FRS FREng, Group Executive Chairman, Surrey Satellite Technology

Dr Paul Bate, Chief Executive, UK Space Agency

Lessons from the Vaccine Programme for UK Life Sciences

19 July 2021

Nadhim Zahawi MP, Minister for Covid Vaccine Deployment

Professor Dame Sarah Gilbert DBE, Saïd Professorship of Vaccinology, Jenner Institute, University of Oxford

Steve Bates OBE, Chief Executive Office, BioIndustries Association

Developing a Systems Approach to reaching Net Zero

28 June 2021

Professor Sir Jim McDonald FRSE FREng FInstP FIET, Principal and Vice-Chancellor of the University of Strathclyde, and President of the Royal Academy of Engineering

Dervilla Mitchell CBE, Joint Deputy Chair, Arup

Guy Newey, Strategy & Performance Director, Energy Systems Catapult

Colette Cohen, Chief Executive, OGTC

Biodiversity: Economics, Science and International Action

24 May 2021

Professor Sir Partha Dasgupta FRS FBA, Professor Emeritus of Economics, University of Cambridge

Professor Yadvinder Malhi CBE FRS, Professor of Ecosystem Science, University of Oxford

Dr Stephanie Wray, Managing Director, Nature Positive, and former President of the Chartered Institute of Ecology & Environmental Management

The future of clinical trials regulation in a post-Brexit UK

30 April 2021

The Effect of the Coronavirus Lockdown on the Mental Health of Children and Young People

24 March 2021

Professor Cathy Creswell, Professor of Developmental Clinical Psychology, University of Oxford

Lea Milligan, Chief Executive, MQ Mental Health Research

Gregor Henderson, National Lead, Mental Health and Wellbeing, Public Health England

Will Hydrogen Technologies get us to Net Zero?

24 February 2021

Nigel Topping, High Level Climate Action Champion for UN climate talks, COP26

Baroness Brown of Cambridge DBE FREng FRS, House of Lords and Deputy Chair, Committee on Climate Change

Jane Toogood, Chief Executive, Efficient Natural Resources, Johnson Matthey

Creating a 'UKARPA' – and making it a success

27 January 2021

The Rt Hon Greg Clark MP, Chair, House of Commons Science and Technology Committee

Dr Ruth McKernan CBE, Former Chief Executive, Innovate UK

Felicity Burch, CBI Director of Innovation and Digital, Confederation of British Industry

Nuclear Cogeneration and Net Zero

9 December 2020

Professor Robin Grimes FRS FREng, Professor of Materials Physics, Imperial College

Jo Nettleton, Deputy Director and Head of Radioactive Substances and Installations Regulation, Environment Agency

Duncan Hawthorne, Chief Executive Officer, Horizon Nuclear Power

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The Royal Academy of Engineering
The Royal Commission for the Exhibition of
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