

fst *journal*

The Journal of The Foundation for Science and Technology

Volume 21 Number 10 March 2017 www.foundation.org.uk

Editorial

The Earl of Selborne: Developing an Industrial Strategy for the UK

The creation of UK Research and Innovation

Sir John Kingman: A champion for research and innovation

Dame Julia Goodfellow: Science is at the heart of our economy

Phil Smith: UKRI's potential – a business perspective

The implications of Brexit for UK research

Sir Venki Ramakrishnan: Planning for our future prosperity

Professor Louise Richardson: Threats and opportunities for UK research

Lord Willetts: Building the future of science and innovation

Improving national resilience to flooding

Dame Julia Slingo: Lessons learned from recent flood events in the UK

Dr Doug Wilson: Dealing with extremes

Simon Warsop: Looking for a long term strategy for flood resistance

The transition from adolescence to adulthood

Dr Joanne McLean: How effective are universal interventions for young Scots?

Dr Helen Sweeting: Evaluating interventions with vulnerable adolescents

Lord Layard: Improving mental health for all age groups

The contribution of science to overseas development

Professor Charlotte Watts: Making good use of science and innovation

Jon Ridley: New ways of getting technology to people that need it

Rowan Douglas: Connecting institutions at national and global levels

Data protection regulation

Jonathan Bamford: The shape of things to come

Obituary

Lord Jenkin of Roding

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FST Journal was redesigned in 2015 by IOP Publishing's Design Studio, under the art direction of Andrew Giaquinto. IOP Publishing provides publications through which leading-edge scientific research is distributed worldwide and is central to the Institute of Physics, a not-for-profit society.

FST Journal publishes summaries of all the talks given at its meetings. Full audio recordings are available on the website

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©2017 The Foundation for Science and Technology

ISSN 1475-1704

Charity Number: 00274727 Company Number: 01327814

fst *journal*

Volume 21 Number 10 March 2017



THE COUNCIL OF THE FOUNDATION

Inside front cover

UPDATE

New industrial strategy promises overhaul of technical education • Chief Executive of UKRI appointed • 2
 Scientists recognised in 2017 New Year's Honours list • Defra launches Plant Health Portal •
 Government acts to attack 'burning injustice' of mental ill-health • Second ESA space mission for
 Tim Peake • UK and China join for biosphere research • Definition required of 'pre-industrial'

EDITORIAL

Developing an Industrial Strategy for the UK **The Earl of Selborne** 4

THE CREATION OF UK RESEARCH AND INNOVATION

A champion for research and innovation **Sir John Kingman** 6
 Science is at the heart of the economy **Dame Julia Goodfellow** 7
 UKRI's potential – a business perspective **Phil Smith** 10

THE IMPLICATIONS OF BREXIT FOR UK RESEARCH

Planning for our future prosperity **Sir Venki Ramakrishnan** 14
 Threats and opportunities for UK research **Professor Louise Richardson** 16
 Building the future of science and innovation **Lord Willetts** 18

IMPROVING NATIONAL RESILIENCE TO FLOODING

Lessons learned from recent flood events in the UK **Dame Julia Slingo** 22
 Dealing with extremes **Dr Doug Wilson** 25
 Looking for a long term strategy for flood resistance **Simon Warsop** 27
 The implications of the Review and the next steps 30

THE TRANSITION FROM ADOLESCENCE TO ADULTHOOD

How effective are universal interventions for young Scots? **Dr Joanne McLean** 31
 Evaluating interventions with vulnerable adolescents **Dr Helen Sweeting** 34
 Improving mental health for all age groups **Lord Layard** 37

THE CONTRIBUTION OF SCIENCE TO OVERSEAS DEVELOPMENT

Making good use of science and innovation **Professor Charlotte Watts** 40
 New ways of getting technology to people that need it **Jon Ridley** 43
 Connecting institutions at national and global levels **Rowan Douglas** 44

DATA PROTECTION REGULATION

The shape of things to come **Jonathan Bamford** 46

OBITUARY

Lord Jenkin of Roding 47

EVENTS

Foundation events held since 2 March 2016 48

New industrial strategy promises overhaul of technical education

Prime Minister Theresa May used her first regional Cabinet meeting on 23 January to launch a new industrial strategy. Its aim is to improve living standards, increase the nation's productivity and ensure that growth is shared across the whole of the UK. The strategy has been published as a Green Paper and is the subject of a public consultation which runs until 17 April.

On a visit to the north-west, the Prime Minister outlined the next steps in her 'Plan for Britain', telling the Cabinet that the Government must face up to – and

tackle – 'long tails' of underperformance if the country is to close the gap between the highest and lowest performing industries, places and individuals. The strategy includes plans for a radical overhaul of technical education to address its historic undervaluation in the UK and provide a credible alternative for young people who choose not to go to university.

The strategy sets out plans which the Government says will enable everyone to develop the skills they need to do the high-paid, high-skilled jobs of the future.

It identifies 10 pillars that the Government believes are important to drive forward industrial strategy across the entire economy: science, research and innovation; skills; infrastructure; business growth and investment; procurement; trade and investment; affordable energy; sectoral policies; driving growth across the whole country; and creating the right institutions to bring together sectors and places.

beis.gov.uk/citizenspace.com/strategy/industrial-strategy

Defra launches Plant Health Portal

Defra has launched a website to improve access to data on plant pests and diseases.

The Plant Health Portal will make it easier for plant health professionals to share and use vital information on plant pests and diseases, unlocking the power of data to better assess threats and determine action to tackle them.

The portal was proposed in 2014's *Plant Biosecurity Strategy for Great Britain*, which provided an overview of UK activity to improve plant biosecurity. It gives access to a range of information about plant health from Government and non-Government sources, including charities and academic organisations concerned with protecting plant health, like the Royal Horticultural Society.

planthealthportal.defra.gov.uk

Chief Executive of UKRI appointed

Science minister Jo Johnson has announced that Professor Sir Mark Walport is to be Chief Executive Designate of UK Research and Innovation (UKRI). He is currently the Government's Chief Scientific Adviser and before that was Director of the Wellcome Trust.

In his new role, which he is due to take up at the beginning of April, Sir Mark will lead the establishment of UKRI and ensure it plays a central role at the heart of the Industrial Strategy.

Subject to the passage of the Higher Education and Research Bill, UKRI will be established as a single, strategic body that will bring together the seven Research Councils, Innovate UK and the research and knowledge exchange functions of the Higher Education Funding Council for England (HEFCE).

The Department for Business, Energy

and Industrial Strategy (BEIS) said that UKRI will deliver a strengthened strategic approach to future challenges and a maximisation of the value and benefit from government's investment of over £6 billion a year in research and innovation. It will provide a greater focus on cross-cutting issues that are outside the core remits of the current funding bodies, such as multi- and inter-disciplinary research, enabling the system to respond rapidly and effectively to current and future challenges.

UKRI will be a strengthened, unified voice for the UK's research and innovation funding system, facilitating the dialogue with government and partners on the global stage. It will create a smoother pathway for innovation, enabling improved collaboration between businesses and researchers and better alignment of research outputs with business needs.

Scientists recognised in 2017 New Year's Honours list

The director of the British Antarctic Survey, Professor Jane Francis, is one of a number of scientists recognised in the 2017 New Year's Honours. She has been made a Dame for her services to polar science and diplomacy. Professor Amanda Fisher, the director of the MRC Clinical Sciences Centre at Imperial College in London is also made a Dame. Professor Fisher's work helped to identify HIV as the virus causing Aids.

Professor Ottoline Leyser, the director of the Sainsbury Laboratory at Cambridge University, and Professor Caroline Watkins, the only nursing professor

of stroke care in the UK, also become Dames in this year's honours.

Sir Alec Jeffreys, the pioneer of DNA fingerprinting, and Baroness Mary Warnock, who chaired enquiries on Special Needs education and on human fertilisation become Companions of Honour.

Knighthoods went to: Professor Shankar Balasubramanian, a chemist and co-inventor of next-generation DNA sequencing; Professor Nicholas Black, who works in health services research at the London School of Hygiene and Tropical Medicine; and Professor Jim Smith, director of research at the Francis Crick Institute.

Professor Polina Bayvel of UCL, a Council Member of the Foundation for Science and Technology, becomes CBE, as do IBM Research director Dr David Watson, Royal Horticultural Society director-general Sue Biggs, Professor Michael Depledge, chairman of Environmental and Human Health at the University of Exeter Medical School, and John Pyle, professor of chemistry at the University of Cambridge.

Dr Bernie Bulkin, a regular speaker at the Foundation, and Professor David Vaughan, Director of Science at the British Antarctic Survey, were awarded the OBE.

Government acts to attack ‘burning injustice’ of mental ill-health

The Prime Minister has announced Government action to tackle what she referred to as “the burning injustice” of mental ill-health and inadequate treatment. Speaking at the Charity Commission annual lecture in January, Theresa May accepted that this demands a new approach from Government and society as a whole.

She noted that mental health problems affect people of all ages and backgrounds. An estimated 1-in-4 people have a common mental disorder at any one time. The annual economic and social cost of mental illness is £105 billion – roughly the same as the NHS budget.

One-in-10 children has a diagnosable

condition, and the long-term effects can be crippling: children with behavioural disorders are four times more likely to be drug dependent, six times more likely to die before the age of 30, and 20 times more likely to end up in prison.

A package of measures will be introduced to transform responses to mental illness in young people starting school. New approaches will be piloted, such as offering mental health first aid training for teachers and staff to help them identify and assist children experiencing mental health problems.

The Prime Minister has asked Lord Stevenson and Paul Farmer, the Chair of the NHS Mental Health Taskforce, to

work with leading employers and mental health groups to create a new partnership with industry. Mental wellbeing does not just improve the health of employees, she added, “it improves their motivation, reduces their absence and drives better productivity too”.

She announced the Government would also review employment discrimination laws for employees with mental health problems, to ensure they are properly supported. Alongside these reviews, a new green paper on children and young people’s mental health will be published later this year, aiming to transform services in education and for families.

See also page 31 of this issue

Second ESA space mission for Tim Peake

Tim Peake will make a second mission to the International Space Station to continue work on scientific research and broaden understanding of the space environment.

The European Space Agency (ESA) mission, which will also be available to the other ESA astronauts in the class of 2009, marks a further boost to the UK’s space ambitions and to the profile of a sector of growing economic and educational importance to the country. A crucial part of Tim Peake’s work is driving interest in science, technology, engineering and maths (STEM) in schools, and the UK’s future technical expertise.

Business Secretary Greg Clark has also

announced that UK space businesses are set to benefit from a £152 million fund, using British expertise in satellite technology for international projects monitoring and addressing problems such as flooding, drought and deforestation. Firms from Edinburgh, Oxfordshire, and Aberystwyth are among those who will use technology such as satellite communications and Earth observation data to help address significant social and environmental issues including crop loss, illegal fishing and emergency response.

This national funding follows the UK commitment of €1.4 billion (equivalent to around £300 million a year) for the ESA over the next four years.

Definition required of ‘pre-industrial’

The United Nations Framework Convention on Climate Change (UNFCCC) process agreed in Paris to limit global surface temperature rise to “well below 2°C above pre-industrial levels”. But what period is ‘pre-industrial’? This is not defined within the UNFCCC’s many agreements and protocols, notes a paper published in the *Bulletin of the American Meteorological Society* (BAMS).

Better defining (or altogether avoiding) the term ‘pre-industrial’ would aid interpretation of internationally agreed global temperature limits, it says.

There is no perfect period, say the paper’s authors, but they suggest 1720–1800 as the most suitable choice when discussing global temperature limits. By the usually quoted baseline date, of around 1850, the burning of large amounts of fossil fuels was already well under way.

After estimating the change in global average temperature since then using observations, radiative forcings, global climate model simulations and proxy evidence, they argue that this pre-industrial period was likely 0.55–0.80°C cooler than 1986–2005 and that 2015 was likely to have been the first year in which global average temperature was more than 1°C above pre-industrial levels.

journals.ametsoc.org/doi/10.1175/BAMS-D-16-0007.1

UK and China join for biosphere research

The Natural Environment Research Council (NERC) and the National Natural Science Foundation of China (NSFC) are jointly supporting a new strategic research programme entitled Biosphere Evolution, Transitions & Resilience (BETR).

This programme will focus on exploring palaeontological sites in China, which has a diverse range of well-preserved fossil localities that cover all of the main periods of biotic change in Earth’s history.

Studying the fossil record can provide insights into how the biosphere responds

to change, including if there are traits whose loss can lead to ecosystem collapse and whether there is a relationship between biodiversity and biosphere resilience. A better understanding of how ecosystems have responded to change in the past can therefore enable better predictions of how present day ecosystems will respond to future change.

The aim of the BETR programme is to support the interdisciplinary research needed to determine the rates and causes of change in the fossil record.

www.nerc.ac.uk/research/funded/programmes/betr/

Developing an industrial strategy for the UK

John Selborne



Lord Selborne is Chair of the House of Lords Science and Technology Committee and also Chair of the Foundation for Science and Technology. He has previously served as Chancellor of Southampton University, President of the Royal Geographical Society and Chairman of the Trustees of the Royal Botanic Gardens, Kew.

In the Foreword to the Green Paper published in January 2017 on *Building our Industrial Strategy*, the Prime Minister has written that the Government's Plan for Britain will help to deliver a stronger economy and a fairer society. The House of Lords Science and Technology Committee will be taking a close interest in the development of this modern industrial strategy and will be taking evidence during the consultation period on the Green Paper.

Our record of producing industrial strategies from the 1970s onwards has not been impressive. Too often we have attempted to shore up existing industries while we have failed to identify where the most innovative and competitive industries are likely to be found in the following decades.

The Green Paper has identified 10 pillars around which the Strategy is structured. Many of these pillars will merit further consideration by the Select Committee.

Science, research and innovation

The first pillar, investment in science, research and innovation, will certainly receive strong support from the science community and from business, but even with the very welcome £4.7 billion increase by 2020 in research and development funding, we will still need to note the warning of Sir Mark Walport. Currently the Government Chief Scientific Adviser, but soon to be Chief Executive of UK Research and Innovation (UKRI), he stated that there is some evidence to suggest that the UK is falling behind many of its major trade competitors when it comes to the research and development upon which innovation depends.

We proudly and accurately claim to be one of the world's leading scientific nations, both in terms of fundamental and applied research. However, we need to achieve closer coordination between scientific and commercial R&D funding streams if we are to maximise the economic potential of new discoveries and insights.

Skills

The second pillar refers to developing skills. We have particular skills shortages in sectors that depend on STEM subjects (Science, Technology,

Engineering and Mathematics) with, at the same time, a complex array of technical and academic qualifications, some of which prove unsuitable for students and employers alike.

Some of the issues which will need to be considered by the Committee include:

- what can be done to encourage more women to pursue a career in engineering;
- how can we reduce the gulf between Further and Higher Education, thereby boosting the formation of human capital;
- how can we attract more long-term investment in high-value innovative companies;
- what new technologies with commercial potential may emerge in which the UK can aspire to be a world leader?

It will be essential for the scientific community and the business sector to engage fully in the development of this new industrial strategy if we are to identify and exploit our potential strengths and opportunities outside the EU. It is critically important that the opportunities offered by science and innovation are recognised as the most important driver of productivity and economic growth.

We have benefitted greatly from scientific collaboration with countries around the world, including EU member states. If we are to retain our status as a leading scientific nation we must enhance all such scientific links. In its report of December 2016, *A time for boldness: EU membership and UK Science after the referendum*, the Committee called for an expansion and enhancement of existing programmes that attract the world's leading scientists to this country. The Committee also recommended that the UK should offer to host – in partnership with governments and funding bodies from other countries – one or more new, large-scale international facilities to signal the UK's global standing in science.

Disruptive technology

The pace of scientific advance – in life sciences, aerospace, information technology, new materials and robotics, for example – will, in the coming decades, cause major disruption to existing busi-



nesses. Yet at the same time, it will offer great opportunities to those with access to the relevant sciences and to a workforce with appropriate skills.

The potential social impact could be far-reaching and the Green Paper is right to stress how we must confront the fact that our economy is one of the most centralised in the world. Research and development must support local economies across the country. While it is true that in central London we have one of the most prosperous local economies in Northern Europe, we also have 12 of the poorest.

Productivity

Our national productivity compares unfavourably with that of France, Germany and the USA, where workers on average produce as much in four days as UK workers do in five. It was to address this longstanding national issue that the Technology Strategy Board, now known as Innovate UK, was established. When, as a response to the Nurse Review, the Government announced its intention to incorporate Innovate UK into UKRI, along with the seven research councils and Research England I wrote on behalf of the Committee to Jo Johnson MP, Minister of State for Universities and Science, to sound a note of concern. We felt the consultation with the business community had been inadequate and that there was a real danger that Innovate UK would lose its

autonomy, its funding and its business-facing focus. In the following six months, the Minister and Sir John Kingman, Acting Chairman of UKRI, were able to alleviate some of our concerns, particularly on funding.

However, the success of UKRI will depend on enlisting the business community into widespread support for this new organisation, in order for it to develop as a champion for science in the public and private sectors. We need to ensure that links between universities and business are greatly strengthened, as Professor Dame Anne Dowlings report (and many previous such reports) have urged. We need to attract increased investment in research, development and innovation from commerce and we need to attract more long term investment in start-up companies.

Addressing the issues

Since 1979, when the House of Lords Science and Technology Committee was established, we have addressed every one of these long-term issues. It is gratifying that the Green Paper now gives an opportunity to rethink how we address our failure to convert our national research excellence into more competitive productivity. If the Prime Minister's aspiration for the Strategy to deliver a stronger economy and a fairer society is to be delivered, then we must all engage fully in its development. □

Centres to support and encourage science and innovation are being established across the country, like the Cambridge Enterprise Hub.

RESEARCH AND INNOVATION

UK Research and Innovation is the new body bringing together the seven Research Councils, Innovate UK and some of the functions of the Higher Education Funding Council for England into a single body. A meeting of the Foundation for Science and Technology on 9 November 2016 considered some of the opportunities and challenges involved.

A champion for research and innovation

John Kingman



Sir John Kingman KCB is the Non-Executive Chair of UK Research and Innovation (UKRI) and a member of the Prime Minister's Council for Science and Technology. He is also Group Chairman of Legal and General plc. He was Second Permanent Secretary to the Treasury – and Acting Permanent Secretary from April-June 2016 – where he was responsible for the economics ministry functions and for policy relating to business, financial services and infrastructure. He has been involved with science and innovation funding over many years and many spending reviews.

The depth of the British science base, the international reputation of British universities and the excellence of business innovation are enormous economic strengths.

Subject to Parliament, UK Research and Innovation (UKRI) will come into legal existence in 2018, and we are advanced in our search for the CEO¹ who will shape the organisation. This discussion is therefore timely, allowing us to explore issues 'before the concrete is set'. The external context has changed significantly since my appointment as Chair of UKRI, given the EU referendum and changes in Government, and has brought into central focus the role of UKRI as a champion for research and innovation in this country. As thought is given to the UK's future outside the EU, an honest assessment is needed of the UK's strengths, and one of those is undoubtedly the extraordinary depth of the British science base, the international reputation of British universities and the excellence of business innovation. It is clear that the Government understands this argument: I have been encouraged by statements from Theresa May and Philip Hammond. I believe science and innovation has a big claim to priority.

Implementing the vision of Sir Paul Nurse

In considering UKRI's role, it is important to recall that Sir Paul Nurse² did not in any way describe a broken system in his review, or suggest merging the existing structures. He did, however, pinpoint some functions not fully undertaken currently. He suggested there is a need for further progress in bringing together the funding organisations and creating efficiencies between them. There is a clear role for a small centre that can champion research and innovation, acting as a challenging shareholder to the funding organisations as well as advising ministers on budgets and the appointment of the heads of the funding organisations. This centre should then be held accountable for the effectiveness of those organisations and for a connected strategy across the system. In order for UKRI to meet these objectives, it is important it remains a lean strategic

SUMMARY

- The political context has changed, emphasising the importance of UKRI's role as a champion for research and innovation
- UKRI will include a small, strategic centre advising ministers and acting as a challenging shareholder of the research and innovation funding bodies
- The inclusion of Innovate UK within UKRI will be beneficial, encouraging collaboration between research and innovation, and bringing Innovate UK's distinct perspective to the organisation
- Key questions to consider include how UKRI should select its areas of focus, and how it should best encourage and facilitate interdisciplinary research (a key recommendation of Sir Paul Nurse's review)

team around the CEO with clarity on what UKRI will and will not do.

Sir Paul Nurse left the Government a choice as to whether Innovate UK should be inside the new structure and the Government has decided to include it within UKRI. This did create some debate. Firstly, there was a fear that the other funding organisations could appropriate Innovate UK funding. Secondly, there was a concern that Innovate UK's distinct culture, mission, and customer base might be lost in a new structure, with Innovate UK becoming the technology transfer arm of the Research Councils only. These concerns are understandable, but I believe we are making very good progress in addressing them.

I believe it is right for the organisation to be part of UKRI for two reasons. Firstly, the world is not cleanly divided between the pure pursuit of knowledge in universities and exciting innovation in companies. Instead there is a huge and very important terrain between. Innovate UK and

the Research Councils are already active in this area, and having a single body with oversight of that complex and interesting space is important. Secondly, Innovate UK will bring a different outlook to the organisation. This is unquestionably beneficial: bringing Innovate UK into UKRI will give UKRI a more naturally outward-looking perspective and will allow a more compelling funding argument to be made for UKRI as a whole.

Issues for further debate

There are still issues to be resolved, including:

1. A big challenge for UKRI as a small strategic organisation will be prioritising, as there is a dan-

ger it will be expected to take a position on everything to do with research and innovation. That is clearly not possible, so how do we identify areas of focus?

2. At the heart of the Nurse Review is the recommendation for a strategic perspective across the whole system, including the need to make sure the most exciting interdisciplinary areas get attention. I am very keen to learn how to do this effectively from others around the world. □

¹. Sir Mark Walport has now been confirmed as Chief Executive (see page 2).

². www.gov.uk/government/collections/nurse-review-of-research-councils

Science is at the heart of our economy

Julia Goodfellow



Professor Dame Julia Goodfellow DBE FMedSci is President of Universities UK and Vice-Chancellor of the University of Kent. She is a member of the Prime Minister's Council for Science and Technology. Previously, she was Chief Executive of the Biotechnology and Biological Sciences Research Council (BBSRC) where she was responsible for Government funding of the biosciences in universities and in seven sponsored research institutes.

I want to preface these remarks by saying that they are personal views. I am speaking as an academic, but one who has had roles in both universities and Research Councils.

In December 2014, the Government published a policy document *Our plan for growth: science and Innovation*¹. It contains a useful summary of the role of science in the life of our nation:

'Scientific endeavour is inherently worthwhile. It expands the frontier of human understanding. Whether exploring the first moments of the universe, or the deep structure of matter, or the power of genetic code, Britain will continue to take the lead in pursuit of the fundamental scientific challenges of our time.'

'Science and innovation are also at the heart of our long term economic plan. The UK's science base is extraordinary – our cutting-edge research base is world-leading, our universities are world-class, we develop and attract the world's brightest minds and we are second in the world when ranked by Nobel prizes. Science is one of our clear comparative advantages in the global race.'

'However, we have to build on these advantages. The UK has historically invested less in research and development than our competitor nations. Addressing this crucial challenge requires both public and private sector commitment as we continue the broader work of economic recovery and rebalancing. Businesses that invest in research and other forms of innovation have higher productivity, create high quality jobs and are more likely to export. Our mission is to

SUMMARY

- Recent political changes have made the role of science in our future prosperity even more central
- UKRI must become the strongest possible advocate for increased investment in research
- If the UK wants a successful knowledge economy, it must increase investment
- We should expand our current international research and innovation strategy
- The research agenda should contribute to – and be part of – the UK's Industrial Strategy.

establish the UK as a world-leading knowledge economy. The UK's ability to capitalise on its cutting-edge science base will be critical to our future prosperity and societal wellbeing.'

Nothing that has happened since then has changed my view that we should take this type of strategy forward. If anything, the changes in 2016 have made that choice even more compelling.

UK Research and Innovation (UKRI) could be the engine to make such a strategy operational. It is built on the eight existing Research Councils and Innovate UK, together with a new body Research England.

The starting point has to be the current strength of the UK science base. There are well-known

Many of the global or grand challenges of our time require international and multi-disciplinary solutions.

statistics on this. However, reflecting on a recent visit to Germany, it is striking that most, but certainly not all, of our research is done in university departments. (I do of course recognise the excellence of institutes such as John Innes in Norwich, the MRC Laboratory of Molecular Biology in Cambridge and the Crick Institute.)

For many years, this excellent university research base has been funded by the dual-support system. That is the combination of the 'quality-related' (QR) monies that come through the Higher Education Funding Council for England (HEFCE) via the Research Excellence Framework (REF), together with Research Council project or programme grants. This combination of core grant together with funding targeted at specific projects has served us well, enabling us to be internationally competitive.

Dual-support system

Maintenance of the dual-support system is vitally important to the university sector. Fortunately, the Science Minister has indicated that there is no intention to change this.

The Research Councils are also respected for funding the best quality projects. The guarantee for this excellence is the long-standing Haldane Principle, which I interpret as 'decisions on individual research grants should be made by peers at arm's length from Government'. Again, the Minister has indicated that there is no intention to change this.

There is far more high-quality science than there is funding, so UKRI must become the strongest possible advocate for increasing investment in research (I have not forgotten about the need for increased funding for innovation as well).

Nurturing scientific talent requires the funding to train researchers at PhD level. There is a balance to be struck between funding for PhD, post-doctoral training and fellowships, together with project and programme grants to get the faculty right. This aspect must be kept continually under review.

Not everything in any structure needs to stay the same and UKRI must be responsive to the need for change. For example, it must facilitate and encourage the appropriate provision of researchers to tackle difficult grand challenges that require multi-disciplinary approaches. A more ambitious agenda for

UKRI might position it as a strong advocate for funding of international partnerships.

In recent visits to Japan and Germany, there was only one topic of conversation – what are we going to do about Brexit? Is the UK still going to be looking outward? Will we continue to collaborate and partner overseas? It is the only topic of conversation when we visit other countries.

The university sector has moved on following the referendum, and the world needs to know that the UK – and importantly our research institutions – remains open for business. For UKRI, this involves enabling multi-national collaborations as well as mobility for staff and research students.

Investment

The UK spend on research and development, as a percentage of GDP, is currently relatively low in comparison with the OECD average.

If the country wants a successful knowledge economy, there must be more investment. The academic world is worried about our access to the £800 million per year that UK scientists can expect to win competitively from the EU research programme Horizon 2020 (that sum is about the funding for one of the large Research Councils). It would be great if we maintained access to this fund, but my point is broader: we must encourage international collaboration, not just in Europe but beyond.

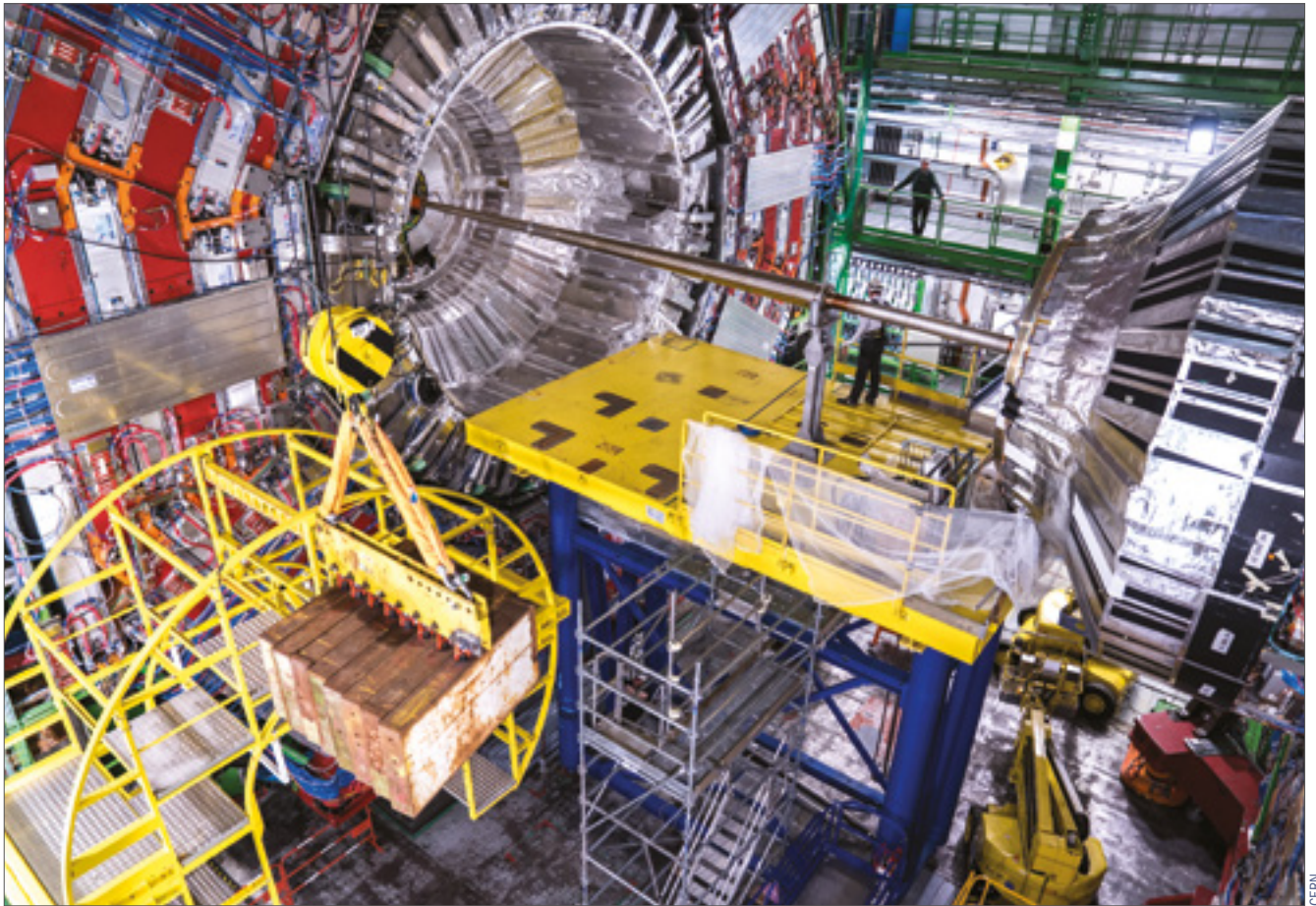
Highly-cited papers are more likely to have multiple authors. In addition, many of the global or grand challenges of our time require international and multi-disciplinary solutions. So, I very much hope that UKRI will be internationally-minded in its approach – and both lead and support such endeavours.

Our investment in science means infrastructure as well. CERN is an obvious example, but there are also telescopes, synchrotrons, etc. These have been internationally supported for many years and are often built by a consortium of countries. There are issues around planning, finances and building: it is a complex process. While there needs to be rigorous scientific scrutiny, there must also be a timescale that stretches far beyond one spending review period or one Government.

International centres in the UK

We should expand our current international research and innovation strategy. Responsibilities for programmes cross different Government departments, primarily Business, Energy and Industrial Strategy (BEIS) but also the Foreign & Commonwealth Office (FCO) and others. Those of us who visit embassies around the world know the excellent work of the Science and Innovation Networks. UKRI may be able to offer advice and

If the country wants a successful knowledge economy, there must be more investment.



CERN

Projects such as CERN have been internationally supported for years

support to build up a clearer strategy on what we are trying to achieve internationally.

The inclusion of Innovate UK within UKRI offers us the advantages of closer working between its business-focussed initiatives and the Research Councils. Business Secretary Greg Clark referred to this in his speech at the Innovate 2016 conference.

I mention this because universities too have responsibilities to support economic growth, create jobs and to improve productivity. However, our role extends far beyond the economic sphere. We have demonstrated through thousands of impact studies how society benefits more broadly from universities whether culturally or through social benefit.

Innovation

It is sometimes said that the UK is not so good at innovation as basic research, but in fact we are successful in this area too. Nevertheless, many of us recognise that we need to increase the funding for Innovate UK. However, this should not happen at the expense of the excellent basic research funding that we already have.

The universities also want to know how the Higher Education Innovation Fund (HEIF) fits into the new structures.

There are different strategies for supporting

innovation across the UK. The models of funding for the Research Excellence Framework (REF) vary across the different countries of the UK and certainly my colleagues in Scotland and Wales are very aware of the increasing differences between the positions of their administrations and England.

Industrial Strategy

Research sits in policy terms within BEIS, so it will be important to see how UKRI and the research agenda interact – and form part of – the emerging Industrial Strategy. Universities are situated in the regions, so we have a strong interest in how any strategy can support the regions and bring benefit to different parts of the UK.

I want to see UKRI ensure that Britain continues to lead the pursuit of solutions to the fundamental challenges of our time. Science must remain one of the UK's clear comparative strengths internationally, but we must build further on these advantages by providing the appropriate funding for both fundamental science and its exploitation. In that way, we can capitalise on our cutting-edge science base for the benefit of the UK's future prosperity. □

¹. www.gov.uk/government/publications/our-plan-for-growth-science-and-innovation

UKRI's potential – a business perspective

Phil Smith



Phil Smith is Chair of Cisco UK & Ireland, Chair of Innovate UK and Chair of the Tech Partnership. The Tech Partnership champions the improvement of digital skills in the UK. He is well known as a champion of innovation, having initiated Cisco's British Innovation Gateway (BIG) programme, as a legacy of London 2012, to spark nationwide ingenuity, ambition and growth through technology and entrepreneurship.

For many businesses, the idea that there is an organisation set up to help and support innovation seems incongruous and it is still not widely enough known. This represents a missed opportunity: one which Innovate UK has been working hard to tackle, although there is still some way to go.

From a business perspective, I think UKRI provides a real opportunity to genuinely engage business more. There is no doubt that, whether it is the language, the transaction costs, the ability to engage with universities directly or through research projects, many businesses find the whole process very challenging. Some segments or sectors navigate this better than others but indeed there are some that the opportunity passes by completely.

The world is changing, not just politically. No, everything in it is changing. One of the most important drivers is the digital revolution: this has been underway for many years, but it is happening at an increasing rate.

New opportunities for evolution, for revolution and for innovation are things that we really want to capitalise on here in the UK. We have seen the statistics: take the Internet of Things where we are moving from around 20 billion or so things connected to the internet to potentially over 500 billion in just a short space of time. In the first three months of 2016, there were more cars connected to the internet than mobile phones.

Exploiting change

So there is a very big change occurring and every industry has to face this – change, though, is something that business can exploit.

Look at the projections for the volume of traffic on the internet between 2014 and 2019 – it is expected to triple. Some 40% of that traffic will come from devices that are not traditional – items like sensors and so on. This is a world where data is measured in zettabytes (10^{20}) of data: we have gone from 4 zettabytes to 44 zettabytes in just a couple of years.

In order to capitalise on such changes, we will have to pull research, innovation and industry much more tightly together.

Recently, I have been involved in a project looking at the productivity challenge we face in this

SUMMARY

- Many businesses still do not understand or engage with the available innovation support mechanisms
- UKRI offers a real opportunity to engage more businesses in research and innovation
- In order to capitalise on changes happening in society, we have to bring research, innovation and industry much closer together
- A major challenge will be closing the productivity gap between the UK and the rest of the world
- UKRI must be seen to be business-relevant and not an ivory tower institution.

country. It is a big challenge: UK productivity is 17% below the EU average. It has stagnated since 2008. It means in practice that 75% of employees in the UK work for organisations below the average productivity for Europe. Now unless we can drive the necessary innovation to change this, then we are going to have a real problem. The news is even worse if looked at on a regional basis. More than half of the cities in the UK are in the bottom 25% of productivity in Europe.

Now if we can improve productivity by the smart use of innovation, driven by the great research and other assets that the UK has, we can make a big difference. Taking that bottom 75% and moving everyone up by 10 percentile points – so move those at 20% of EU productivity up to 30%, those at 30% up to 40%, etc – would create £130 billion Gross Value Added (GVA) for the UK economy.

Improving productivity for individual firms is important but improving it for the country is equally necessary. This is not straightforward as there are many challenges. To do so, we must bring together the capabilities of both the universities and the business community. While businesses will continue innovating and evolving business models in this challenging new world, thinking through some of the deeper, underlying issues – privacy and safety, security as well as skills – requires a coordinated and well-connected environment.



In the first three months of 2016, there were more cars connected to the internet than mobile phones.

© Toyota Motor Europe ("TME")

Take security: there is an organisation inside Cisco which monitors this on behalf of the company. Worldwide, we block 19.7 billion threats every day, that is a huge number and likely to grow. The digital revolution will continue but it needs to be taken forward in a much more considered way. This has to be done with support from a variety of interested parties: Government, industry, academia, the research community.

Business opportunities

It is interesting to see what can be done with a connected, thought-out approach. With the help of Innovate UK and European project funding, Cisco been able to engage with others to create the Cre8 innovation centre. Its job is to bring together the private and public sectors, big and small companies, universities and others, with the purpose of building proofs of concept demonstrating how we can address particular societal changes.

This ability to bring together diverse consortia for particular purposes is a key strength of Innovate UK. The approach is something we should apply more widely.

The centre has undertaken a whole series of projects looking at the next generation of railway stations and the associated opportunities. This is all open information which is a very powerful way of working. We are now involved in four other projects. One concerns superfast Wi-Fi on trains and its implications. Security models for Internet of Things (IoT) devices and strategic responses to flood emergencies are two of the others. Ordinarily, Cisco might not engage in these specific areas but with broad-based consortia, the opportunities and engagement widen too. That illustrates the kind of potential we see for business

over the coming years.

One notable project is the subject of a consortium based on Manchester called City Verve. This started as an Innovate UK project, looking at the ways in which the Internet of Things could be applied at city level. Some 21 companies, a university and a series of other organisations have been brought together to look at this and to share best practice in areas including: energy and the environment; transport and travel; health and social care (notifying people when air quality is not good and therefore they should not leave home, for example); and also the cultural and human aspects that help people to engage.

The breadth of these sorts of projects gives industry the possibility of making a big difference and of driving innovation forward. While I do have reservations about the integration of Innovate UK into UKRI, we need to look at it as an opportunity to create a multiplier effect. We need to get more businesses to see the absolute necessity of driving innovation and of getting the best that we can for the UK in the current environment.

UKRI, as it emerges, must present itself as business-relevant. It will need to be sensitive to what is happening in the market: responding to the many changes that are actually happening now, not ensconced in an ivory tower that does not see the changes and the dynamism needed. The organisation has to be kept very simple and accessible: this has been something business has been keen to promote in Innovate UK. UKRI has to be very impactful and visible.

If it can achieve all these things, then from a business perspective there is a real opportunity of engaging much wider swathes of business than we do today. □

The debate

The proposal that UKRI should be a powerful independent champion of science has wide support. UKRI should also be an advocate for international centres and collaboration: many existing research centres are not EU-based. It also has a role to play in the mobility of scientists and students outside the EU.

The inclusion of innovation in UKRI's remit remains controversial, but there is clear recognition that innovation and research are not completely separate activities, and much can be achieved in the areas that fall between the two.

Resourcing SME innovation

Extra resource could be given to SME innovation. The best innovation often happens in small companies or by individuals, so it is important to have continuing regard to ways of reaching out effectively to them.

The design of UKRI should assist long term strategic thinking and rigour. It should include a mapping of strengths and opportunities upon which to build. Public sector research establishments are part of the research landscape and should be included in any UKRI 'map', as should the Knowledge Transfer Networks (KTN).

The organisation should not seek to second guess the expertise of the Research Councils, though it should challenge them and hold them to

account. It is crucial that the Research Councils continue to attract high quality leadership and also that UKRI demonstrates an ability to add value. It should provide clarity of roles, data/evaluation, setting of budgets that could introduce benign incentives (e.g. for collaboration) and be a powerful independent voice on behalf of research and innovation.

Technology focus

Its priorities should focus on the opportunities that would make an economic difference. A central question is how it can help to produce a step change in UK productivity. UKRI could adopt a technology focus, on areas such as digital manufacturing, healthcare, autonomous systems/AI.

There is concern about a perceived downgrading of science in Government and the risk of the forthcoming changes diluting matters further, as the Research Council CEOs would be line-managed by the UKRI CEO. On the other hand, for nearly two decades the Chancellors of the Exchequer have shown themselves to be sympathetic to increasing funding of the science base. However, this cannot be guaranteed in the future.

The establishment of UKRI does not address some fundamental problems, e.g. how to scale up companies rather than sell them, and how to address skills shortages. □

Issues covered in the debate after the main speeches included the relationship between UKRI and the Research Councils, the need to be an advocate for UK research and innovation around the world and its role in addressing the country's productivity gap with other industrialised countries.

FURTHER INFORMATION

Nurse Review of Research Councils

www.gov.uk/government/collections/nurse-review-of-research-councils

Cityerve – Manchester Smart City Demonstrator

www.cityerve.org.uk

Arts and Humanities Research Council

www.ahrc.ac.uk

Biotechnology and Biological Sciences Research Council

www.bbsrc.ac.uk

Engineering and Physical Sciences Research Council

www.epsrc.ac.uk

Economic and Social Research Council

www.esrc.ac.uk

Our plan for growth: science and innovation

www.gov.uk/government/publications/our-plan-for-growth-science-and-innovation

Medical Research Council

www.mrc.ac.uk

Natural Environment Research Council

www.nerc.ac.uk

Science and Technology Facilities Council

www.stfc.ac.uk

Innovate UK

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

Knowledge Transfer Network

www.ktn-uk.co.uk

What does Brexit mean for science and research? A meeting of the Foundation was held at The Royal Society on 16 November 2016 to explore the threats and opportunities.

Planning for our future prosperity

Venki Ramakrishnan

SUMMARY

- The heart of any UK industrial strategy must be innovation
- The Government needs to reduce isolation and improve connectivity across the entire country
- We must send a strong message that the UK will always welcome talent from around the world
- To remain competitive the UK needs to increase investment to the OECD average
- The UK will be able to take its own regulatory position in new areas where ethics, liability and technology intersect.

In reacting to the inequalities brought about by globalisation, our world is retreating into nationalism and protectionism. This is not new. After the 1929 crash, the US Congress passed the sweeping Smoot-Hawley Tariff Act in 1930, the result of which was that trade fell from a peak of 30% of the world's economy to less than 10% by 1933. Annual US immigration levels declined from more than a million to a few tens of thousands. In other countries similar reactions prolonged the depression and economic stagnation and led to the rise of nationalism and totalitarian regimes.

Global trade did not fully recover until the 1970s with capital mobility taking until the 1990s. Today, especially since the financial crisis of 2008, globalisation is on the retreat again with increased restrictions in mobility and trade, coupled with a rise in nationalism.

Reasons for Brexit

A chief reason for Brexit was the feeling of many that they do not share in economic prosperity arising from globalisation and EU membership. Rather, they face stagnating wages and increased pressure on resources and costs. Virtually all governments – whether of the left or right – agree that retreating into protectionism would simply

repeat the mistakes of the past and cause us all to be worse off. Fortunately, the UK continues to believe in free trade.

However, if we want free trade while restricting mobility and at the same time we want people to have a decent wage and standard of living, we will not be able to compete in traditional industries. We have no choice but to increase productivity – which will require innovation. The heart of any new industrial strategy, then, has to be innovation, which in turn will require science and technology. Fortunately, the UK is a leader in research and innovation, by almost every measure.

The older industries were based on proximity to raw materials and (at the time) world-leading technology. It is doubtful that steel mills and coal will return on a large scale, either to Pennsylvania or the North of England. Even if they did, automation and other efficiencies mean they will not bring the large numbers of well-paid jobs they did in the past.

In the US, much of the innovation and resulting economic growth has occurred in the North East (the Washington to Boston corridor) and on the West Coast. This has left a vast hinterland behind, so the result of the US election is not surprising in hindsight. In the UK, similarly, much of the new economy is concentrated in areas like London and Cambridge.

Newer, knowledge-based industry relies on easy and rapid acquisition of information in order to maintain a competitive advantage. In a laissez-faire environment, the growth of these clusters will continue at the expense of other areas: it is a natural consequence of economics. A key factor is the so-called 'agglomeration effect' – small and large companies want to be in an environment where there is complementary expertise and industry all around them.

We will not be able to compete in traditional industries. We have no choice but to increase productivity – which will require innovation.



Sir Venki Ramakrishnan PRS FMedSci is President of The Royal Society. A Nobel laureate, his many scientific contributions include his work on the atomic structure of the ribosome. As the site within living cells where the genetic information is read to synthesise proteins from amino-acids, improved understanding of the ribosome has yielded many fundamental biological insights. More recently, he has been using electron microscopy to visualise ribosomes in action in higher organisms.



Willis C. Hawley (left) and Reed Smoot meeting shortly after the signing of the Smoot-Hawley Tariff Act in 1930.

This is the reason AstraZeneca moved its research headquarters from the north of England to Cambridge. Their shortlist consisted of: the Bay area or Boston (both in the USA), or Cambridge. Fortunately for the UK they chose Cambridge. This did not make sense on the basis of cost alone. Housing, operational and infrastructure costs are all much higher in Cambridge. However, the life sciences cluster in Cambridge meant that they would be ‘plugged in’ to first-rate research and innovation, be able to recruit skilled employees and benefit from the so-called ‘first mover advantage’.

A potential strategy

Given the geographical inequalities it generates, a laissez-faire approach is not sustainable, politically. So what kind of strategy can ensure that parts of the country are not left behind? It would be a mistake to artificially prop-up parts of the country with targeted investments that may simply favour existing industries which are in decline.

Instead, the Government should allocate

The presence of international workers creates a first-rate environment for training home-grown talent. Losing them would be a disaster.

resources to improving opportunities for growth. A major part of this involves reducing isolation and improving connectivity across the entire country. High-speed connectivity – both virtual through faster internet, and real through high-speed transport – will ensure that places currently left behind will be able to connect to nearby high economic growth areas.

The UK has large centres that could form the nuclei of future growth: the Manchester/ Sheffield/Leeds area could be a hub which, if appropriately connected with surrounding areas, could lift not only themselves but areas such as Grimsby and Hull as well. Similarly, large parts of East Anglia could be connected to Norwich and Cambridge, creating a much larger network.

In addition to connectivity, another requirement is the creation of large local pools of skilled workers. This needs large and sustained investment in education. In the future, this will need to be flexible and broad-based if people are to adapt to rapidly-changing and often disruptive economic conditions.

There are, however, some pressing measures to ensure that the UK remains at the forefront of science and technology: these involve mobility, funding and regulations.

Success through mobility

A major reason for the success of UK science and technology is that it has been an open and welcoming society for the best talent from across the globe. Five of the last 15 Nobel laureates based in the UK were foreign born. Three of the last five Presidents of the Royal Society were foreign born and a sixth was the son of immigrants.

Science today is global and depends on the free flow of people who bring in new ideas and expertise. Our own young scientists also benefit enormously from going abroad for training. Migration is not a one-way street – it works both ways.

Today, 30% of our academic research staff and a similar proportion of both CEOs and skilled workers in companies are from abroad. We are second only to the USA as a destination for global talent. The presence of these international workers ensures that we remain first-rate and, just as importantly, it creates a first-rate environment for training home-grown talent. Losing them would be a disaster, both for our science and for our economy. We need to take immediate steps to reassure those who are here that they remain welcome.

We need to streamline entry procedures to the UK for everyone so that they are fair, transparent and efficient. Reducing the barriers to mobility

will enhance our competitiveness and send a strong message that the UK will always welcome talent from around the world. It is worth remembering that immigration was only the second most important reason why people voted for Brexit and even then, it was control over migration that people wanted, not the complete absence of immigration.

Counting students as part of migration figures is both unreasonable and a poor strategy. Only a small fraction of them stay on beyond their studies and mostly to our benefit. If they stay on they can be counted towards migration figures at that time. The rest of them return to their home countries and remain valuable links to the UK. They become future leaders and are more likely to look at the UK as natural partners for trade and investment. We are in danger of turning away entire generations of future partners who would be well disposed towards us, by putting up unnecessary barriers to students and restricting opportunities for them.

Funding

The UK will not be perceived as an attractive global destination for talent and investment if we reduce our investment in research. We are already at the lower end among OECD countries. Nevertheless, we are so productive that increased investment in research should give an excellent return.

From 2005 to 2010, investment in science was maintained in flat-cash terms due to austerity, so in real-terms there was a decline due to inflation. However, during that time we gained increased support from the EU. Loss of these funds would be a serious problem for our research enterprise. With our departure from the EU, it is essential that our funding be at least maintained. Science is a small fraction of our overall expenditure and, moreover, in all countries, private investment in research very closely tracks public spending. So there is also a multiplier effect of government investment.

EU programmes have been valuable not just for monetary reasons, they have been the basis for collaborations and partnerships that have greatly expanded the influence of UK-based researchers. They allowed us to have a say in the future of large facilities and general scientific agendas.

In future, the UK could use those contributions to buy its way into multi-national programmes in the EU. One obvious way would be to continue with programmes such as Horizon 2020. If that were not politically possible, we could create our own body to collaborate, not only with Europe but beyond. This could be



Westminster College-Fulton MO/ CC BY-SA 3.0

administered by the new UK Research and Innovation (UKRI).

Over the long run, to remain competitive the UK needs to increase investment to the OECD average. Although we are efficient, we cannot hope to maintain our advantage while under-investing.

Regulation

The UK has benefitted from a common regulatory policy within the EU. This is useful for collaborations across the continent – for example involving animal research, genetics on humans, etc. However, the UK has its own regulatory policy for new technologies that strikes a proper balance between risks and benefits. For example, long before it was acceptable in most places, the UK pioneered IVF babies. Our approach on stem cells has resulted in leading scientists coming to work here from the USA. Currently we are much more forward-looking on areas like genome editing.

So, the UK potentially has great advantages in being able to develop its own regulatory position in new areas where ethics, liability and technology intersect. Examples include the use of large sets of personal data to drive discovery and innovation, such as in health where the NHS has a huge database of millions of patients.

Our experience in setting standards will help us to define new technologies and give us a competitive advantage.

Although most of the scientific community were for remaining in the EU, we recognise the social conditions that drove the referendum vote. With the right actions and incentives, it should be possible for us to flourish outside of the EU, while at the same time ensuring that benefits are spread throughout the country. □

We are in danger of turning away entire generations of future partners who would be well disposed towards us, by putting up unnecessary barriers to students.

Threats and opportunities for UK research

Louise Richardson



Professor Louise Richardson FRSE is Vice-Chancellor of the University of Oxford. She serves on the board of the Carnegie Corporation of New York, and of several other charities. Previously she served as Principal and Vice-Chancellor of the University of St Andrews and spent 20 years on the faculty of the Harvard Government Department, latterly as Executive Dean of the Radcliffe Institute for Advanced Study. (Photo OUIImages/John Cairns)

It seems that we are in something of a phony war at the moment as regards Brexit. As a social scientist I rely on data, but there is not much available. When someone pulls out of a job search and blames Brexit, is it really Brexit or did they really want to pull out anyway? We do not really know. When European colleagues tell their UK collaborators that they no longer want the UK academics as Principal Investigators (PIs) and claim it is because of Brexit – is this really the reason or do they really want to be the PI? Again, we just do not know. Nevertheless, stories are circulating and are having a corrosive effect on the fabric of our university communities.

The result of the referendum was received with shock and surprise. It is easy to underestimate the emotional impact. There was a real sense of anxiety. After a while people started to relax a little as it became clear that nothing was going to happen quickly. Then came reports that academics at the LSE were told non-British EU citizens would not be allowed to offer advice to the UK Government on negotiating Brexit.

This was then followed by the Conservative Party Conference at which the Prime Minister declared famously “If you believe you are a citizen of the world you are a citizen of nowhere – you don’t understand what the very word ‘citizenship’ means.” This reignited all the fears that were just beginning to be allayed.

Speaking personally, I was born and raised in Ireland, spent my academic career in the USA, then moved to Scotland and am now in England. I think of citizenship of the world as an aspiration, not as a criticism. I see no conflict between citizenship of Ireland or Britain and citizenship of the world.

British universities are one of the great success stories of our era. Three of the top ten universities in the world are British. Seven of the top 11 universities in Europe are British. What is the secret? It is not wealth. Oxford has the largest endowment of any university in Europe, yet this is just a fifth of Harvard’s and a quarter that of Stanford, Yale, Princeton and so on.

I believe it is simply our ability to attract the best faculty and students as well as our ability to create an environment in which they can thrive

SUMMARY

- There is little data currently available about the impact of Brexit
- The continued success of British universities depends on the ability to attract the best faculty and students from across the globe
- There is no template for associate country status in the EU research programmes. The UK will have to negotiate its own
- The UK has an opportunity to determine its own approach to regulation which could provide a competitive advantage in comparison with Brussels
- The Government should adopt an industrial strategy that plays to the UK’s strengths.

and do their work. This rapidly becomes a virtuous circle because top academics attract others anxious to work with them and learn from them, and so it becomes mutually enforcing. Yet we operate in a globalised marketplace and competition has become more expensive. It has just become 15% more expensive with the decline in the value of the pound and I fear it may become even more expensive again.

There are legions of examples of increasing mobility amongst academics and researchers. Some 48% of Oxford University’s academics come from outside of the UK and 63% of our graduate students. Much of the success of British institutions has been built on European foundations. During the EU’s previous framework programme, which ran from 2007 to 2013, the UK received €3.4 billion more in funding than it contributed. Horizon 2020 is making nearly €80 billion available over seven years and Oxford’s funding so far totals more than €200 million.

Brexit poses threats in three different areas.

Students

Some 15% of our students are citizens of the EU. We can guarantee, both for those who started in 2016 and 2017, that they will pay home fees into the future. After that, though, they may have to

pay international fees in which case the numbers will decline.

I cannot understand why these students are included in the net migration figures. We have lobbied assiduously for years to no effect. Maybe everyone should focus their energies on persuading the Government at least to present EU student numbers separately when they release the net migration figures.

Staff

The second threat concerns staff. Around 17% of our staff are citizens of the EU. Many European governments and universities are trying to poach them. Notwithstanding all the public talk of collaboration, UK universities are vulnerable. The recent Irish government budget has a fund purely for this purpose. Germany, Ireland and the Netherlands are likely to be the biggest gainers here.

Oxford is already losing staff, although as I said earlier it is very difficult to gather precise data. So we want the right for our staff to remain. The Government needs to clarify the position as soon as possible. We depend on migrants at all levels of the university – from lecturers to kitchen staff – and we value all of them.

So for students, we want them outside of the net migration figures and we want them to be able to stay on and work after they have graduated as contributors to our economy. For staff, we want all our European staff to have the right to remain and for movement to be as free as possible.

Research

The biggest concern, of course, is research. At present, 12% of Oxford's research funding comes from the European Research Council. We received £67 million from Horizon 2020 in 2015. There appear to be two options. The first is to distribute the £1 billion net contribution we currently make to the EU funding here in the UK. That could be done via the Research Councils. A proportion could, perhaps, be ring-fenced for international collaborations.

The other – preferred – option is to buy into the current arrangements. While the first option may be more popular in Whitehall, there are disadvantages. The kind of research that the ERC, for example, supports is relatively unfettered and it is far more generous to the humanities and social sciences than our own Research Councils. The ERC is more willing to support blue skies research, as well as research that is not tied to Government priorities.

If the money were repatriated and distributed nationally, it could be tied too closely to current Government priorities with the result that blue

skies research would lose out. Funding for humanities and social sciences might also be reduced. So the preference is to buy into the current arrangements; indeed the desire is for as little change as possible.

Associate status

Universities want the ability to shape European collaborations as well as to participate. So many of the issues, whether disease, ageing or terrorism, transcend national boundaries. To participate in Horizon 2020 and future framework programmes, the UK will have to negotiate some form of associate country status.

There is no simple template for this and the UK's position is unique as no country has formally left the EU before. The issue of free movement of people is cited as a reason why the UK may not be granted access to Horizon 2020 and future framework programmes. This is based on Switzerland's exclusion when it restricted free movement.

Yet of the current 15 associated countries, free movement only applies in some cases. Georgia, the latest country to join Horizon 2020 has an agreement that specifically mentions the need for ensuring the free movement of research workers. On the other hand, Israel first became an associated country for EU funding in 1996: there is no mention of free movement of people as a requirement for participation in their agreement.

Given the strength of UK research and our prominence in Europe it may be possible to identify a new form of association in Horizon 2020, access to research programmes, plus the ability to influence future research policy in the EU.

Those preparing to negotiate our exit from the EU have to understand that full access to Horizon 2020 and subsequent programmes, including the right to host ERC grants and coordinate projects, is critical for the continued success of British higher education.

The politics of free movement

There is no legal link between single market access, the four freedoms and participation in Horizon 2020 – it is essentially a political matter. Switzerland has one of the top 10 universities in the world and two of the top 10 universities in Europe. It has been integral to EU framework programmes for decades. However, in 2014 it voted in a referendum to restrict free movement across its borders with the EU. The EU subsequently

We depend on migrants at all levels of the university – from lecturers to kitchen staff – and we value all of them.

removed its associate country status – demonstrating a willingness to use a country's status within research programmes as a political lever.

The effect on Swiss research was dramatic. The number of programmes in which Switzerland took part peaked at 745 in 2013. Then came the referendum and by 2015 it had dropped to 307 – that is a 60% reduction. It participated in 3.2% of research programmes during Framework 7 which ran from 2007 to 2013. In Horizon 2020, which replaced Framework 7, they are taking part in 1.8%.

Opportunities

One of the drawbacks of the EU is the weight of regulation and slow speed of change. Regulation in some of the areas such as clinical trials, data protection, privacy, GM crops, VAT rules and so on, have inhibited innovation.

If the UK could adopt a lighter-touch, risk-based and speedy regulatory environment – as distinct from the heavy hand of Brussels – it could find a real competitive advantage. If the

Government opts for an industrial strategy that plays to our strengths, such as life sciences, energy and digital, and if it increases the funding of scientific research to the G8 average (which stands at 0.77% as compared to our current 0.48%) then we could see real energy and innovation driving the British economy.

The UK university community needs to reassure our EU colleagues that they are valued. The country needs to negotiate for free movement of people. Students should be taken out of the net migration figures (or at least presented separately). The UK should negotiate for associate country status. There needs to be increased public funding for research. The Government needs to adopt an industrial strategy which plays to our strengths and needs to demonstrate it is committed to greater deregulation. More generally, the research community must make the case about the value we bring to society at large.

If we manage to do all that, I am sure we will end up delighted that we voted for Brexit. □

Building the future of science and innovation

David Willetts



The Rt Hon the Lord Willetts is a former Science Minister and a member of the House of Lords. He is Executive Chairman of the Resolution Foundation and a Visiting Professor at King's College London. He is also Governor of the Ditchley Foundation and a member of the Council of the Institute for Fiscal Studies. Lord Willetts was Minister for Universities and Science, attending Cabinet, from 2010-2014. He has written widely on economic and social policy.

One of the mistakes in the referendum campaign was to focus so much on the level of EU funding for universities and science without highlighting the networks that we gained access to. Networks are so important. A priority must be to promote networks and relationships, including links with non-EU partners. The Royal Society, for example, has been doing a great deal of work in promoting the Commonwealth Science Conference.

There may be opportunities for new international projects where the UK can take the lead. Look at the role this country has in the Square Kilometre Array and, of course, we remain members of many collaborations today. Ideas for new collaborations may find a receptive ear in Government at the moment.

Then there are EU networks and collaborations, such as the Horizon 2020 programme. It seems to me that approaching these with a strong track record on wider international networks is the correct way to engage.

If Georgia, Israel and Tunisia can achieve asso-

SUMMARY

- The UK should, as a priority, focus on strengthening partnerships and networks around the globe
- There is an opportunity to shape regulations so that they support innovation that is relevant to our economy
- We must make the case for maximum flexibility of movement
- Future innovation and research will be set in the context of the UK's industrial strategy
- The research community has to convince the wider UK public of the value it delivers.

ciate status within Horizon 2020, it should not be beyond the wit of man to secure it for the UK! We are, as a minimum, geographically still in the European neighbourhood and that is an opportunity for us. Let us start, though, with doing our best to strengthen our global networks.



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Regulation

Any revision of our approach to regulation requires very careful judgements. There are areas where we have innovative sciences and technologies where we can take a lead. There are other areas where we have to take account of developing European regulation if we want to continue to access these markets.

On data, for example, I was initially enthusiastic about escaping all the EU regulations. However, if the European Commission requires that data held about EU citizens are held in a way that is compliant with EU regulations, will that mean that every server farm ends up on the Continent if we do not accede to their requirements?

These are complicated questions. I am not convinced that Whitehall has the capacity to work through all of them, but there are many individuals with relevant expertise as we look at innovative areas where we can take a lead in shaping the standards of the future. I think of the meetings I have attended with scientists from the three leading nations in synthetic biology – the UK, the USA and China. Engineering type standards for synthetic biology can be shaped by these three countries, for example.

In some areas, European standard setting has not worked to our advantage. Take photovoltaics: the energy efficiency of these cells is measured in conditions of direct sunlight, rather than the less

sunny weather we normally experience in this country. The standard was written for a Spanish photovoltaic farm – it is not a standard written for energy efficiency in the UK, so we should be entitled to develop and promote standards which stimulate innovation in conditions here.

There are definitely opportunities, but I believe the Department for International Trade is underestimating its need for expert advice. When trade negotiations get serious the key issues are not tariffs – these account for a relatively small part – but standards, regulations and mutual recognition.

A good example of the contribution that scientists can contribute concerns oysters. In the health and safety regulations, the European standard requires that one or two oysters are extracted from every batch for testing. The American standard focusses on the purity of the water in which the oysters are growing and sets a requirement to measure the purity of the water.

Now, the scientific experts have identified that both of these are valid ways of ensuring everyone eats healthy oysters that are not going to poison us. But in the deep detail of trade negotiations, different approaches can potentially result in

Visitors at an open day at Westmill Solar Park near Swindon. Leaving the EU may offer the chance to develop standards to benefit the UK photovoltaic industry.

We should be entitled to develop and promote standards which stimulate innovation in conditions here.



ML Parker/ UNC Research / CC BY-NC-ND 2.0

Oyster testing:
one area in which
scientific advice can
play a very important
role in shaping
regulations and
standards.

major difficulties. Scientific advice can be really important in resolving such problems. So scientific advice can play a very important role in shaping regulations and standards.

Free movement

The EU talks as if the free movement of people is a fundamental principle alongside the other 'pillars'. In reality, none of these principles is quite as

absolute as it is claimed to be. Many UK businesses would say that the right to sell services across the EU is more heavily compromised and constrained than it should be.

Of course, it is very important that we make the case for maximum flexibility. There is an argument that good universities should have a flexible visa regime and others should not, with 'good' and 'bad' being determined essentially by research performance and prior attainment of students.

As the Science Minister, I never liked that approach. There are universities that do an excellent job while not focussing on research. Some accept students with lower attainments, taking them on a journey which brings them up to a high educational standard. So I can well envisage a set of proposals which would provide the Russell Group with a desirable outcome while the Universities of Teesside and Coventry might be very badly hit. Yet, the latter are universities which matter for their local economies. They are also universities that have their own distinctive mission (and there is more than one way of being a good university) which they discharge excellently.

There will certainly be a test for universities as a whole: whether it represents the interests of universities as a whole or just certain subsets remains to be seen. This is a challenge but I hope the sector as a whole makes the case for the maximum mobility of people.

Industrial strategy

The UK's industrial strategy is not dependent on Brexit yet it has become caught up in the design for a post-Brexit world. In fact, I think it is justified on its own merits. Being serious about promoting the real economy means looking vertically, at technologies and business sectors, not just horizontally. That is what makes industrial strategy different from the other classic ways in which governments try to raise economic performance and promote growth.

This is an opportunity: this will provide a framework in which universities and the research community can make their case. There is always anxiety on whether such an approach reduces research and higher education to mere economic utilitarianism. Almost everyone in research hopes that what they do in some way boosts the economy, but that is unlikely to be the reason why they originally became intellectually excited and passionate about their specialist subject. It is very important that we preserve a space for people to pursue their curiosity, but nevertheless the framework for the future will be an industrial strategy.

There are practical ways in which to promote innovation and commercialisation within that

FURTHER INFORMATION

Prime Minister's speech to the CBI, 21 November 2016

www.gov.uk/government/speeches/cbi-annual-conference-2016-prime-ministers-speech

Leaving the EU: implications and opportunities for science and research. Report of an inquiry of the House of Commons Select Committee on Science and Technology, November 2016

www.publications.parliament.uk/pa/cm201617/cmselect/cmsctech/502/502.pdf

The House of Lords Select Committee on Science and Technology report on EU membership and UK science, April 2016

www.parliament.uk/business/committees/committees-a-z/lords-select/science-and-technology-committee/inquiries/parliament-2015/eu-relationship-and-science/

framework. One of the frustrations of being a board member of the Crick Institute is that if more than 5% of its space were to be used for commercial purposes, then the whole cost of the building was going to be subject to VAT. This would have inhibited the capacity of the Crick to deliver on David Cox's original vision for serving the life sciences sector as a whole.

Making the case for research

Those VAT rules need no longer apply post-Brexit. We may find we can do some things quite differently which help promote innovation. It is very important that we continue to fund venture capital (VC). One of the most startling and shocking statistics I have come across since the Referendum is that around 25% of all VC funding in Britain comes from the European Investment Bank (EIB) and the European Central Bank (ECB) – the UK is very heavily dependent on EU funding.

The referendum result showed that the nation was not listening to the messages being put forward by the research community. Now, I can tell you, coming from politics, that deference on the basis of one's position in society has long since gone. Even being a prominent academic with a position of responsibility in a university does not

We need to make a practical, direct case to the public for science and research as something that makes our country great and serves all our interests.

automatically command deference or public attention.

One way of responding is, quite simply, to look outwards and focus on making the case to lay people in their own language. In my four years as the Minister responsible, I would make the case for some exciting new technology or for investment in science and research and the response from many of my colleagues would be: "How is that going to benefit my constituents? What does it mean for the country as a whole?"

Looking towards the future, many of the next generation are going to be working in industries where even apparently low-tech companies will be transformed by advances in science and technology – look at what has happened to warehousing and distribution, for example.

So as a community we need to make a practical, direct case to the public for science and research as something that makes our country great and serves the interests of all our citizens. This approach may not be one that we are familiar with, but it is very important and much-needed now. □

The debate

The paramount need in the Brexit negotiations and post-Brexit policies is to avoid measures on immigration which would deprive UK Higher Education institutions and research institutions of access to the world's best talent and the ability to collaborate in future EU research programmes. The UK also needs to do more to encourage the supply of home-grown engineers and scientists but this should not be allowed to diminish the efforts to continue the recruitment of the best international talent.

The Brexit result should not be allowed to obscure survey findings showing public understanding of – and support for – access of foreign-born talent of benefit to the UK.

The role of the Governments in fostering innovation was scrutinised. Some speakers considered that a focus on picking winning sectors or regions are likely to be less valuable than efforts to improve basic infrastructure and connectivity.

There is a clear and urgent need for better public understanding of the contribution made by science and innovation to wealth and welfare.

However, it is equally important to avoid giving the impression that the scientific elite is simply seeking to serve its own special interests. Scientists need to convince taxpayers that they are delivering worthwhile and tangible benefits. It may be that professional communicators can help in this task. There is also a case for greater involvement of the public in science projects, especially in the social science sphere.

Complex negotiations

Could it be that, in the wake of the complex negotiations to take the UK out of the EU, the British public may reach a different judgement about the net benefits of Brexit? Could there then be pressure for a second referendum? Adverse economic developments, including rising inflation, as well as the problems of renegotiating a host of regulations and standards, may well have this consequence.

However, it was noted that, as things stand, a democratic decision has been made and the Government is determined to carry it through to completion. □

In the debate that followed the formal presentations, speakers stressed the need to ensure the UK was not disadvantaged in terms of access to world-leading talent, that innovation remains a priority and that the public need better understanding of, and involvement in, scientific endeavour.

FLOOD RESILIENCE

The impacts of storms and subsequent flooding have been the subject of a Government review which looked at ways of improving national resilience. Following the publication of the review, a meeting of the Foundation for Science and Technology on 12 October 2016 discussed its findings and recommendations.

Lessons learned from recent flood events in the UK

Julia Slingo



Dame Julia Slingo DBE FRS was Chief Scientific Adviser at the Met Office from 2008-2016. Prior to her appointment, she was the Director of Climate Research in NERC's National Centre for Atmospheric Science, at the University of Reading, where she is still a Professor of Meteorology. In 2006, she founded the Walker Institute for Climate System Research at Reading to address the cross-disciplinary challenges of climate change and their impacts.

The Flood Forecasting Centre is a working partnership between the Met Office and the Environment Agency. It was established in response to the Pitt Review, which followed the flooding of 2007. The forecasting of floods and the advance warnings which it provides have made a huge difference to this country's resilience.

Flooding still occurs though. The amount of rainfall from Storm Desmond in early December 2015 was quite extraordinary and resulted in severe flooding over parts of north-western England.

The first question that springs to mind is: 'Is this climate change?' Looking at the records, it is hard to say. Climate change may play a role, but the records do not give a definitive answer at this time.

Examining the rainfall in England and Wales over the last century for the 'Hydrological Winter' of October to March, there have been rain-rich and rain-poor periods. Rainfall in the last decade or so, with increasing incidents of flooding, is not that different from the rainfall at the beginning of the 20th Century. It is very hard to find a signal of climate change in that 100-year record.

More intense rainfall

Looking at daily and sub-daily data, there is an emerging signal of more intense rainfall in short bursts, which is to be expected from simple physics. The longer term, monthly and seasonal averages point in contrast to huge volatility. The natural variability in UK rainfall is large and it dominates the record.

The flooding in late 2015 was the first time that weather had been considered as a major factor in relation to flood risk. Prior to that, flood risk started with river-flow data.

The winter of 2013-14 saw a very strong jet stream which brought a continuous run of very

SUMMARY

- The weather record does not give a clear answer on whether the recent flooding is related to climate change
- Currently, the natural variability in the British climate dominates the climate record
- Records of the Hydrological Winter period for the last century show both rain-rich and rain-poor periods
- There is an emerging signal of more intense rainfall in short bursts
- The UK needs a more cohesive modelling system for 'weather to hydrology to flood impacts'.

deep depressions. Some of the lowest pressures ever measured in the UK swept across the North of the country. Along with severe flooding (particularly along the Thames) many coastal defences were breached. It was a very strong Westerly winter. This had come out of a disturbed jet stream that stretched right back to the Tropical West Pacific and was associated with El Niño conditions.

Storm Desmond brought a very strong South-Westerly flow, called an 'atmospheric river'. Atmospheric rivers often lead to significant rainfall, particularly in winter. In December 2015, the atmospheric river was aimed right at Cumbria and the hills of Cumbria released all the water locked up in the system.

Winter variability

The UK sits at the eastern edge of the North Atlantic, so is exposed to the weather that comes across the ocean. In addition, there is the North Atlantic Oscillation with low pressure to the north near Iceland and higher pressure to the south in the Azores. When the pressure gradient strengthens, we get very mild, wet winters, something termed the 'positive phase' of the north Atlantic oscillation.

Climate change may play a role, but the records do not give a definitive answer at this time.

THE NATIONAL FLOOD RESILIENCE REVIEW

The National Flood Resilience Review was set up in January 2016 to assess how the country can be better protected from future flooding and extreme weather events such as those that occurred during December 2015.

This review looked at how best to:

- understand the risks of river and coastal flooding from extreme weather over the next 10 years;
- assess the resilience of key local infrastructure (such as energy, water, transport and communications), and identify ways to protect it better;
- improve how we respond to flood incidents, including through new temporary flood defences.

The Cabinet Office published the results of *The National Flood Resilience Review*¹ on 8 September 2016.

This sets out recommendations from the lessons learned from recent flood events. In September Defra also published an action plan chaired by Dr Peter Bonfield – *The Property Flood Resilience Action Plan*².

¹. www.gov.uk/government/uploads/system/uploads/attachment_data/file/551137/national-flood-resilience-review.pdf

². www.gov.uk/government/uploads/system/uploads/attachment_data/file/551615/flood-resilience-bonfield-action-plan-2016.pdf

It is like looking for black swans – things that could be out there through natural variability, but which have not yet been observed.

There are a whole range of other drivers for our winter weather, from the 11-year solar cycle, potentially the changing Arctic, volcanoes, stratospheric winds, El Niño, tropical weather patterns and also the sea surface temperature over the North Atlantic. The seasonal forecast published by the Met Office in October and November last year took these into account and already noted the increased risk of a mild and very unsettled period of windy or even stormy weather.

Ed Lorenz was the pioneer of chaos theory. He argued that very tiny perturbations can radically alter the future course of the weather. What that means, of course, is that 100 years of observations describe only one of the possible paths that the world's weather could have taken in the last century. All sorts of things – the flap of a seagull's wings – could have changed its course. Can climate model simulations find plausible alternatives that are meteorologically and physically possible and result in even more extreme rainfall than anything we have observed in the past 100 years?

Looking for 'black swans'

That was the basis upon which we tackled this problem. It is like looking for black swans – things that could be out there through natural variability, but which have not yet been observed because we have only sampled one pathway of the world's weather and there exist a myriad of different possibilities.

Weather and climate simulations provide synthetic realisations of the UK's weather. They need, of course, to sample the same forcings (such as greenhouse gas forcings) as the real world, while having sufficient freedom to evolve into

different regional climate and weather regimes. So they cannot be too constrained by the observed record although they do need to be able to produce this and similar results.

Over a six-week period, some 1400 years of simulation were produced for a 35 year time-frame and examined for six climate regions covering England and Wales. The simulations indicate that it is quite possible to have more extreme rainfall than that observed in the last 35 years. Indeed, those 1400 years' worth of simulations (that is 40 times more data than the observed record) allow us to fill out the extreme tails of the distribution – both wet and dry.

The modelling shows that there is a large number of occasions where the meteorology could have given us much more rainfall than was in fact observed in the recent past.

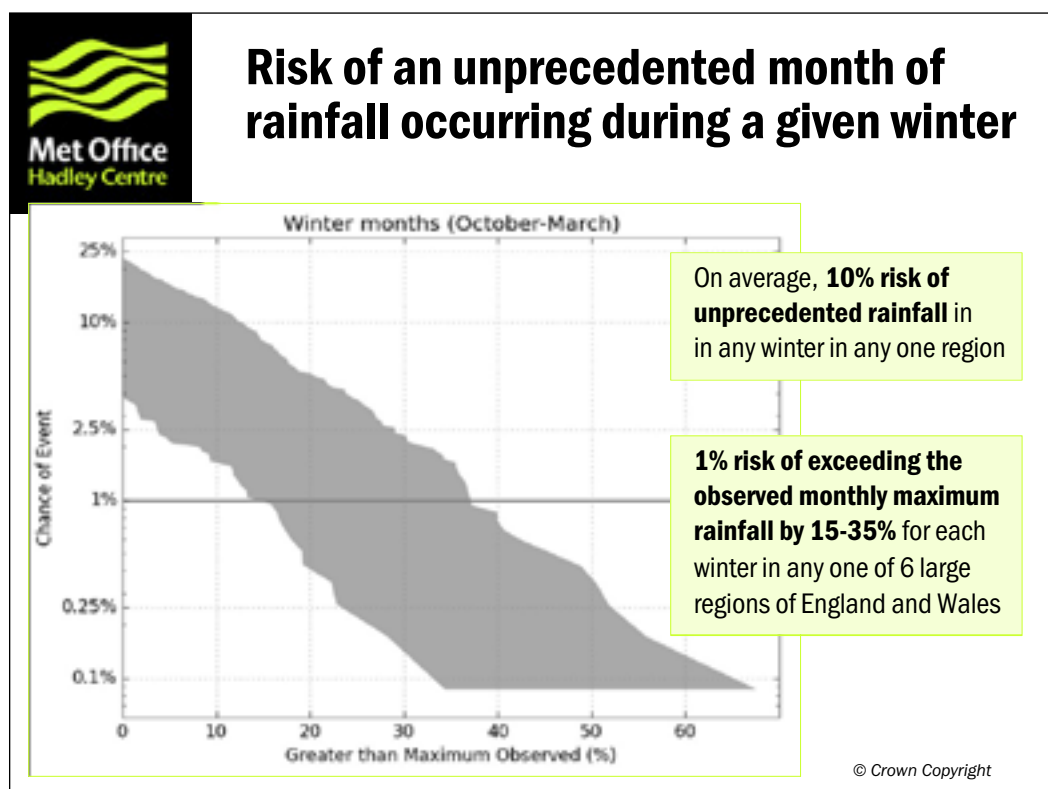
Local modelling

Flooding is often caused by high-intensity rainfall in a specific location. Over the past few years the Met Office has developed a world-class forecasting system at the kilometre scale and this was used in the National Flood Resilience Review.

Landscape and local meteorology are both crucial for the high-intensity rainfall that caused the flooding in Cumbria. Storm Desmond deposited more than 16mm an hour of continuous rain. Such heavy rates of rain are likely to result in severe flooding.

The Met Office's numerical model describes the weather patterns, these are scaled down to forecast local meteorology and rainfall. This information is then used by the Environment Agency to drive their catchment flood models

Figure 1. Risk of an unprecedented month of rainfall occurring during a given winter.



and look at the potential impacts.

The climate projections that we are developing for Defra for 2018 will be able to go seamlessly from the global to the local, and so provide improved local impact assessments.

Calculating risk

In order to respond within the required timescale of the flood review, the Met Office used a different approach to scale from the global to the local. Taking the climate model data and treating them statistically, we calculated the percentage chance of a rainfall event which is greater than the maximum that has been observed over the six climate regions of England and Wales.

Figure 1 summarises the uncertainty in enhancement in rainfall above the maximum already observed. There was enough data to statistically have a robust answer for a 1% probability. Even with 1400 years' worth of modelled data, there are not enough samples to provide an assessment at a lower probability than this. As Figure 1 shows, there is a 10% chance of beating the maximum rainfall record in any winter in any of these six climate regions.

In other words, there is always a significant possibility of a new record in any large catchment that feeds, say, the Thames or the Severn. There is also a 1% chance in any winter of exceeding the current record rainfall by 15-35%.

It is becoming clearer just how much more rainfall is likely. We have been using the figures, with

the EA, to do some case studies. We combined Storm Desmond and Storm Eva using the rainfall figures from the Met Office kilometre-scale forecasting model. We then added 20% to that rainfall to give the Environment Agency a fine scale, fine resolution rainfall scenario to run through six of their catchment flood models and provide an assessment of flood risk for the selected six catchments. This is an innovative and ground-breaking method of estimating flood risk.

Natural variability will dominate many of our risks going forward and it is vital to understand what is meteorologically plausible at the tails of the probability distribution, beyond what we have in the observed meteorological record. The tools and the models are available to study global weather patterns and can now be translated into local weather modelling, using downscaled kilometre-scale modelling.

Our forecast models now also include a probabilistic representation of rainfall, as well as storm surges (another hazard parameter assessed in the National Flood Resilience Review).

We have been discussing the development of a more cohesive 'weather to hydrology to flood impacts' modelling system with the Environment Agency and the Natural Environment Research Council (NERC) given the importance of better understanding the UK's exposure to flood risk in both the short and longer term and resultant impacts on people, property and critical national infrastructure. □

Dealing with extremes

Doug Wilson

SUMMARY

- Storm Desmond produced new records for rainfall and river flow in England
- Analysis showed that the EA's extreme flooding outline model was robust
- By sharing data with the utilities, a better understanding of the resilience risk was achieved
- There are many local sources of information about flooding
- The risk of flooding needs to be communicated in a factual, non-alarmist way to the public.

The National Flood Resilience Review was commissioned by Government after Storm Desmond in early December 2015 (which itself was followed by Storm Eva just after Christmas). The table shows some of the records from that event. These are the largest flows ever recorded in rivers anywhere in the country: 17,000 tonnes of water per second coming down the River Eden, for example.

This episode provoked a number of challenges to the Environment Agency (EA): is the modelling faulty, are the assumptions correct? There was a real sense of surprise, of something quite unexpected, especially coming so soon after the extreme flooding of the 2013-14 winter.

In its analysis, the Environment Agency used rainfall uplifts provided by the Met Office in our local, detailed flood models. Taking Carlisle as an example, the observed flooding sat within the extreme flooding outline, which is the outermost extent that we calculate flooding. Even with 20% more rainfall than we observed in December, the flooding would still have sat within the extreme flood outline.

For EA, that was reassuring, given that the original challenge was whether something was wrong with the flood models. We carried out a series of case studies. For Oxford, we took the observed rainfall in 2014 and added a 30% uplift. The modelled flooding again stayed within the extreme flooding outline. Further case studies were carried out on other areas that had previously suffered from severe flooding: the Exe at Exeter, Great Yarmouth, the Calder Valley, as well as the

lower Thames as a combined example with a storm surge, high river flow and a high astronomical tide.

In each case, even with the rainfall uplift, the extent of flooding was still within the extreme flood outline. We can do this for the local detailed models that currently exist, which were developed around particular flood schemes. The challenge now is to apply this approach more widely across the country.

Infrastructure resilience

The next question concerns the implications for the resilience of infrastructure. We have taken the information from the models and shared that both within the Environment Agency (examining the resilience of our own assets) but also with the telecoms, water supply and electricity sectors, to help them understand how resilient their assets are.

The Environment Agency has been investigating the use of temporary barriers to give some additional protection from flooding. While they do not replace schemes which employ flood embankments and control gates, these are measures that can be deployed quickly. We now have 40km of temporary barriers.

It has been of enormous benefit to work with others in order to understand the resilience of the infrastructure and its interconnectedness. From a community perspective, even if the housing remains dry, being without telecoms, water or electricity for a significant period can be very disruptive. It is vitally important to keep infrastructure running, or if that is not possible, to get it back up and running quickly.

Adding to the observed flow record

Across the whole of the country we have a very comprehensive network of river gauges which measure river levels. In December 2015, 10% of



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DECEMBER 2015 RECORDS

- 24-hour rainfall record at Honister Pass – 341.1mm
- 48-hour rainfall record at Thirlmere – 405mm
- wettest calendar month on record
- largest-ever flows recorded on English rivers – around 1700m³ per second on the Eden, Lune and Tyne



The UK has a comprehensive network of river gauges

the gauges across the whole country recorded their highest levels. But what does that mean? Gauging at Teddington on the Thames started in 1883, gauging the Severn started in the early 1900s or so. In most areas, though, it started in the 1960s, so at best there is only 50 to 60 years' worth of data. This makes it difficult to truly assess the rarity of these kind of events.

Looking at the combined risk across the country would suggest that the kind of events seen in the 2015-16 winter have a 30-40% chance of occurring somewhere in any single year. So while such events are extreme, they are not rare.

While the UK already has a good observed record of river flows and flooding, other information can add to that. Our forefathers created permanent records of notable events (such as floods) on the sides of many buildings. Local memorials commemorate a particular flood on a specific date, in some cases even the depth of water. So local community history can supplement the observed record. How do we best gather that information from a whole range of different sources in order to give us that broader picture?

This is not just about flood marks, it can be photographs, old newspaper reports, and indeed even paleontological records for sediment deposition. Using this information can help us to understand when those extreme flows have happened in the past and what it means for risk flood today.

I suspect that what we describe now as extreme events are probably even more common than recent history points to. How then to communicate that to people? So often, terms such as 'unprecedented' or 'once in a lifetime' are trotted out – yet we will have to rethink how we describe these things in future.

Local community history can supplement the observed record. How do we best gather that information from a range of different sources?

While the Review says a great deal about the role of the State, it is important to consider what individuals and communities can do for themselves. There are things that people can do to make themselves and their homes and properties more resilient – temporary barriers to protect doors and windows, and using water resistant flooring materials, for example.

Floods will happen, it is impossible to defend against them entirely. Helping people to either protect their properties or, if they are flooded, to then get things back up and running by putting in resilience measures is incredibly important.

The impact of flooding is not purely the physical effect of water in people's houses and businesses: often the psychological and mental health impacts of flooding are the worst. It is not the case that everything returns to normal as soon as the water leaves your home, people can be out of their properties for a year, the children are in different schools – there are many different aspects of disruption. So, the more rapidly that people can get back into normal life, the better.

Building Regulations

The Bonfield Review¹ has recommended ways of incorporating resilience measures into the Building Regulations. It considered how to better inform people about measures and provide them with incentives to take up property-level resilience measures. It also tackled certification – people would really like to know which products are trustworthy and which should be avoided. Now that is not something the Environment Agency can do, but some form of independent certification is really needed. People are far more likely to take action and take control of their own destiny if they know where to go for advice.

Flooding does happen, not infrequently, so why do they seem to surprise us? It is important to explain the risk of flooding in a way that is not alarmist but simply factual. Floods happen, they are extreme events, but people need to be prepared for them.

There is a role for individuals both in flood prevention and in dealing with it when it happens. This is, after all, not just a matter for Government.

Then there is the whole issue of climate change. In a volatile, changing climate, we may well see disruption not just because of flooding, but potentially drought (with implications for food supply, for example). Can the lessons learned from flood response help us here as well? □

¹ www.gov.uk/government/uploads/system/uploads/attachment_data/file/551615/flood-resilience-bonfield-action-plan-2016.pdf

Looking for a long term strategy for flood resistance

Simon Warsop

SUMMARY

- Resistance and resilience measures need to be designed with householders and business owners in mind
- It is important to get key information into the hands of the people who are threatened with flooding
- Community action is more efficient at preventing and mitigating flooding than a reliance on individual initiative
- Better building practice could reduce flooding significantly
- There must be a longer term strategy to tackle flooding.

It is estimated that 847 billion litres of water fell on Cumbria in December 2015 – the storms brought new rainfall records. Defences were breached, communities were shattered.

There are three different types of flooding. There is surface-water flooding, river flooding and coastal flooding. Recent events have predominantly been examples of the surface water and river varieties. In reality, though, coastal flooding can be even more devastating in terms of the numbers of people affected.

In general, the modelling of flood risk is quite good. At St Asaph in Wales, the model accurately predicted where the water would flow, which cottages would be flooded and which would not. But models cannot take account of every contributory factor: in Kendal, a blocked culvert meant that a host of properties were flooded against all expectations.

Aviva use drones to fly over areas (even before the water has subsided) to see which properties are flooded and so make sure care and assistance gets quickly to the people who need it most.

Homeowners do not always understand their flood risk. This may not be surprising when there are no common standards for assessing and communicating risk. What does a flood return period of 1-in-25, 1-in-100, or indeed 1-in-1000 actually mean to a customer? The Association of British

Insurers (ABI) has now proposed a traffic light system – green for low risk, amber for medium risk and amber for high risk, to try to communicate this better.

Now, individuals can help build their own resilience. They could adapt their kitchens so that, rather than having chipboard units that turn into soggy Weetabix when flooded, stainless steel units are installed, for example. Non-return valves on water inlets will prevent backflow and a bung in the toilet will stop the water coming in that way. Flood resistance is keeping the flood out of the property. Flood resilience is about getting back to normal as quickly as possible when it does happen.

The resilient home

In Lowestoft (which is at frequent risk from both coastal and river flooding) Aviva worked with Norfolk County Council to create a 'resilient home'. Non-return valves were installed, airbrick covers, door boards (to stop water getting in) and then, inside the property, ceramic floors throughout, plastic skirting, metal-lined walls covered in a water-resistant plaster. All the major kitchen appliances were raised on plinths.

A number of resilience measures were put in place and they work very well. For the Lowestoft home, the water was kept out in most cases by the resistance measures. A couple of times when water got into the property, the homeowner was able to mop out in about two hours. Her neighbours were out of their property for two or three weeks. This kind of approach really does work.

There are grants available through local authorities in areas declared as major incidents. They are only available after flooding, though, which is really closing the gate after the horse has bolted, but it is an important first step.

The allocation of grants could be made more effective: the decisions take time and insurers have often repaired properties well before grant decisions are made which means the opportunity may well have been missed. Grants are awarded where a homeowner requests them, rather than where the modelling shows a property to be at high risk.



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FURTHER INFORMATION

National Flood Resilience Review

www.gov.uk/government/uploads/system/uploads/attachment_data/file/551137/national-flood-resilience-review.pdf

Property Flood Resilience Action Plan

www.gov.uk/government/uploads/system/uploads/attachment_data/file/551615/flood-resilience-bonfield-action-plan-2016.pdf

National Risk Register for Civil Emergencies

www.gov.uk/government/uploads/system/uploads/attachment_data/file/419549/20150331_2015-NRR-WA_Final.pdf

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Association of British Insurers

www.abi.org.uk

Centre for Hydrology and Ecology

www.ceh.ac.uk

Committee on Climate Change

www.theccc.org.uk

Environment Agency

www.gov.uk/government/organisations/environment-agency

Flood Re

www.floodre.co.uk

Met Office

www.metoffice.gov.uk

Rather more importantly, the resilience measures are not always welcomed by homeowners and that, for me, was the big surprise. Reflecting on this, perhaps some of the measures need a bit more thought. Red air-brick covers have to be put on every time there is flooding. Kitchens are very constrained in terms of style. Washing machines and dishwashers are permanently mounted at eye

level, giving a daily reminder of the risk of flood. And where do you keep your toilet bung when it is not in use?

Living with resilience

In the case of the Lowestoft house, the homeowner has in fact removed all of the resilience measures from inside the house. The appliances are back on the floor. The ceramic floor has been taken out of a couple of the rooms and replaced with soft flooring. The kitchen is now a normal chipboard variety and some of the plastic skirting has been taken away. Resistance and resilience really need to be designed with the householder and business owner in mind. The measures have to be items that people can live with, day in, day out.

Flood Re, the scheme backed by Government and industry which provides flood insurance to those properties most at risk, came into being in April 2016. Many people who could not afford flood insurance in the past can do so now. If the property floods, the excess is £250, whereas before the scheme was introduced some people had to pay excesses of £5,000. When repairs are made, they can be done cost-effectively with flood resistance measures included. Flood Re is the biggest and best database of flooded properties in the UK. However, Flood Re does not help everyone. It does not cover commercial premises, nor properties built after 2008. In addition, the emotional uncertainty and psychological issues caused by flooding remain.

An alternative approach

A better approach would be to build community-level infrastructure and defences, providing protection simultaneously to many homes and many businesses – protecting both families and livelihoods. By building community defences, we can make sure that the consequences are better managed by considering the whole river catchment, rather than leave individuals to operate independently with the potential for unintended consequences. The most obvious community defence is of course the Thames Tidal Barrier.

People should only build where risk is low, where risk is understood and where risk is well-managed. Properties must also be built for resilience. Better use should be made of good building practices. We must avoid unintended consequences: everyone is now familiar with the impact of people paving over their front gardens to make driveways for their cars – perfectly understandable from an individual homeowner's point of view, but it puts extra stress on the drainage systems. □

People should only build where risk is low, where risk is understood and where risk is well-managed. Properties must also be built for resilience.

The debate

Issues raised in the debate included concerns over integrated catchment areas, the need for science-based advice on flood defence procurement, better use of technology and how best to direct funding.

Concerns were expressed that considering integrated catchment areas does not take full account of local amenities and concerns. For example, afforestation on the fells, to replace sheep farming, would reduce peak flows but would not be ecologically acceptable. But eco-management could be beneficial for peak river flows.

Defra's 25-year management plan will look at long term land management issues. Flooding is not, of course, the only issue to be considered in land management. Other climatic events such as drought could occur, or indeed market changes which may render some land use uneconomic. With a fully integrated catchment system, climate simulations can be used to explore the effect of different land management systems.

Investment decisions

Those making investment decisions need science-based advice to decide what defences – both permanent and temporary – should be procured in order to cope with variability, the changing layout of homes and commercial properties, as well as increasing population.

Each flood offers new lessons and points up the need for further research on catchment levels, on the interaction between ecological and economic aspects, and the link between rainfall and river levels. A better understanding of infrastructure liabilities is also necessary – how the damage to one part can affect other elements.

We also need to be more proactive in using



technology, such as closed circuit television (CCTV), to identify critical flow restrictions in flooded areas.

A decision has still to be taken on how much the Government is willing to invest in order to limit the impact of flooding. The National Risk

Register for Civil Emergencies¹ highlights flooding as a significant threat for the UK. Costs must be set against the damage that floods cause, not only to property but also to public health and wellbeing.

The Review recommended higher standards for infrastructure protection, but it is not clear how long it will take for these to be in force and whether there will be adequate funding.

Flood protection is expensive. Funding needs to be well-directed. The ecological benefits go wider than mere flood protection and such benefits should be incorporated into cost/benefit analyses.

It should be much clearer which Departments, agencies, regional/local or other authorities have responsibility for preparing for flood events as well as managing support to householders and business owners in response to them. □

¹. www.gov.uk/government/uploads/system/uploads/attachment_data/file/419549/20150331_2015-NRR-WA_Final.pdf

Temporary flood defences along with River Severn in Shropshire



Christopher Ewell / Shutterstock.com

During the afternoon before the evening discussion at the Royal Society, an invited group of officials and scientists met to explore the implications arising from the Review.

The implications of the NFRR and the next steps

The Director of the Civil Contingencies Secretariat at the Cabinet Office, Katharine Hammond, began by summarising the recommendations of the National Flood Resilience Review (NFRR).

After the enormous damage caused by the floods in 2007, significant progress has been made in preparing for future severe flood events: a joint Met Office/Environment Agency Flood Forecasting Centre had been set up, responsibilities within Government clarified and other measures taken to embed best practice on recovery from flooding.

The NFRR, undertaken by nine Government Departments, as well as the Met Office Chief Scientific Adviser and the Environment Agency, aimed to establish why these 'rare' events appear to be happening with greater frequency; whether the UK needs to do more to protect infrastructure; whether more temporary protection is needed; how to cope with the revised scenarios of heavy rainfall events; and the development of standards which will inform resilience in line with events.

Professor Bas Jonkman, Professor of Integral Hydraulic Engineering at Delft University of Technology, explained the position in the Netherlands, where flood protection is a national priority as 70% of the population live in flood-prone areas. Annual costs of €900 million are borne equally between national and local government. There are 3,800 km of flooding defences, but 30% are not up to standard. A risk-based approach is used to prioritise resources based on economic and life-preservation considerations.

Risk reduction interventions include the reinforcement of defences, system studies of rivers and innovative defence strategies harnessing nature. There is now a good understanding of roles and responsibilities, combined with continuing funding and sophisticated risk assessment: all this is leading to better investment and the increased use of both permanent and temporary defences.

In September, Defra published the *Property Flood Resilience Action Plan* which concluded that there should be a revision of the Building Regulations, further flood protection measures and revi-

sion of insurance policy wording. It noted that Government and the insurance industry need to agree whether an insurance policy exists purely to restore a property or whether the insurance claim can be used to incorporate resilience to future flooding events (the problem of betterment). There is a need for a one-stop-shop provision so that people know where to go for advice. The Plan also highlighted the importance of individuals, communities and authorities working together.

The Research Councils and the Environment Agency are working with the Met Office to improve forecasting and to analyse the effect of climate change, but this is a five-year research programme.

In the ensuing discussion, the issue of land management was raised. Trains have been derailed by landslips caused by water flowing from fields into an embankment, areas of farmland have been transformed into wetlands. Management is important.

The Environment Agency gives priority to saving lives and protecting domestic property. The challenge is how to prioritise the available investment funds.

There are many organisations both public and private which have an interest in flooding: for example, local authorities, water companies, utility companies and the Devolved Administrations. Their different responsibilities and relationships need to be clarified for a range of flood scenarios.

In summing up, Professor Jonkman said that there must be a balance between what the state does and what a community or private person should do to protect themselves. Coastal surges should not be neglected when considering the impact of flooding on critical infrastructure and the consequent economic effects. It must also be clear who is to take the lead in pre-flood planning, and post-flood recovery.

Katherine Hammond concluded that this complex subject needs further work. There needs to be greater clarity about the ways in which probabilities are assessed and then communicated to the public. It is important that the public both understand the risk and know what to do. □

There must be a balance between what the state does and what a community or private person should do to protect themselves.

Which mental health interventions work well for young people in Scotland and what evidence supports how funding should be allocated, particularly for vulnerable groups? A research programme organised by The Royal Society of Edinburgh on this topic was discussed at a special meeting in the city on 26 October 2016.

How effective are universal interventions for young Scots?

Joanne McLean

SUMMARY

- Adolescence is a time of major developmental transitions
- Health behaviour patterns established in adolescence impact long into adulthood
- Health inequalities among Scottish young people remain a key policy and practice challenge
- Research in future needs to be much more participatory and must keep pace with change, particularly in the digital sphere
- Universal interventions can be made more holistic, positive and inclusive for marginalised groups.

The research I want to describe focussed on a review of population-level interventions. It was led by The Mental Health Foundation in partnership with Glasgow Caledonian University, the University of Stirling and Children in Scotland.

Adolescence, a period between the ages 10 and 24, is a time of major developmental transitions. Young people are becoming independent and trying to establish control over their lives. They are moving through education and into work. It is a time when relationships are developing and changing within the family and with their peers. Young people are also embarking on sexual relationships, which constitute an important factor in their wellbeing.

Rapid cognitive and emotional development takes place. Emotions are heightened in the teenage years.

All these transitions come together and lead young people to take different trajectories on their journey into adulthood, resulting in different outcomes in terms of health, wellbeing and happiness. Health behaviour patterns established in adolescence impact long into adulthood. Adolescence is

therefore a key time to bring in interventions that promote health, happiness and wellbeing.

In Scotland, there is evidence that socio-economic disadvantage is strongly correlated with poor health outcomes among young people. There has been progress, but health inequalities remain a key policy and practice challenge. Fewer young people smoke now than at any time since 1982, but the rate in more deprived areas is much higher than elsewhere. In addition, compared to other countries, Scottish youth are more likely to experience drunkenness and poor mental health: exam stress is on the increase in Scotland, as well as obesity, teen pregnancy, etc.

The aim of the study was to systematically review the research evidence on the impact of population-wide or universal interventions intended either to improve health, happiness and wellbeing, or to reduce inequalities for adolescents transitioning to adulthood. Essentially, it looked at interventions notionally available to everybody, identifying what works and what does not. It sought to pinpoint the gaps and so influence research, policy and practice.

Stakeholder consultation

One important part of the methodology was a stakeholder consultation which is not common in systematic reviews. We asked young people at the start about their priorities. What matters to them, moving into adulthood? What helps and what hinders? We presented the emerging findings and asked the young people to give us their opinions.

There was also an expert advisory group, consisting of practitioners, policy makers and academics specialising in adolescence.

Mental health was central to everything the



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We asked young people at the start about their priorities. What matters to them, moving into adulthood? What helps and what hinders?

Interventions that enhance parenting skills and strengthen adolescent/parental relationships were often contributors to effectiveness.

young people talked about: being healthy in body and mind, feeling good about themselves, having really supportive social networks with adults and peers – importantly, having adults who understand them.

The review

Over 35,000 reviews were identified in the first search. At the end of the process, we ended up with 150 relevant reviews (we also excluded any that were at high risk of bias).

To map them, we took a holistic approach, drawing from the US National Prevention Strategy from 2011. Two categories were added: obesity and general health (the latter for reviews that did not fit elsewhere or which looked at multiple outcomes) – see Table 1.

Some features of successful interventions were common across all the topic areas. There was evidence to suggest that building skills, personal development, and social competence among young people have a generic, empowering effect and increase self-efficacy and self-belief. This prepares them to make healthy decisions, no matter what the topic area is.

There were many multi-component interventions combining, for example, policy level, taxation, price increases, mass media, face-to-face skills-building, family involvement, etc. Some were more effective than single component interventions, but not all.

Intensity and duration were also common markers of successful impact. Yet, for sexual health and alcohol, brief interventions were particularly effective.

Digital interventions are low cost, have extensive reach and utilise positive social support or peer influence to encourage young people to make healthy decisions and change behaviours. They also have relevance outside of school.

Inequality

Inequality was a key area of enquiry for this review: there is still a perception that universal interventions have universal impact which may not reflect reality.

A few reviews (but only three out of 150) focussed on equality. There is evidence that price and tax increases around smoking can reduce inequalities around smoking. There is also promising evidence in mental health pre-

vention that interventions can have an impact on inequalities.

Some school-based interventions also seemed to reduce inequalities. Some actions actually made inequalities worse. Gender was rarely considered in interventions or analysis – even when there are known inequalities, for example with self-harm, suicide, date violence. Interventions were not progressive enough – this was important for our young people, particularly on sexual orientation issues.

Overall the evidence does not provide sufficient insight into how to use universal interventions to effectively reduce inequalities, but there is some promising evidence.

Parents and family

Parental and family involvement was a key theme, which reflected the priorities of the young people we consulted with. Active parental involvement was associated with effective intervention in a number of areas.

Interventions that enhance parenting skills and strengthen adolescent/parental relationships were often contributors to effectiveness. Yet not always: in some instances, this had no apparent effect.

There was no discussion of diverse family types or the quality of family relationships in the reviews, nor how that might have an impact for different young people. The traditional models seem to have been assumed.

Peer leadership and involvement

Peer-led interventions could be effective, for example, where tobacco, cannabis and alcohol consumption were concerned, but there were some poor outcomes in sexual health.

Social reinforcement is particularly important in promoting health behaviour change and there is evidence that social-media-based interventions can be effective. Peer support is more effective in a supportive environment such as schools and communities. However, feedback from the expert advisory group suggested that many of the interventions under discussion do not take place in Scottish schools, so there may be scope for improvement here.

Supportive school environments can also help reduce health inequalities. However, the impact is lost outside of school (evidenced in the bullying literature). And if those most in need are not turning up to school or leaving early, then these interventions will not reach them.

Surprisingly, the stages of transition did not figure in the studies. There was not one review that discussed the theory and evidence of its

Table 1 Overview of included reviews

| Theme | Number of included reviews |
|--|----------------------------|
| Mental and emotional wellbeing | 20 |
| Tobacco-free living | 12 |
| Preventing drug abuse and excessive drinking | 22 |
| Sexual and reproductive health | 13 |
| Injury and violence-free living | 11 |
| Active living | 22 |
| Healthy eating | 8 |
| Obesity prevention | 23 |
| General health | 19 |

accuracy. However, a finding from substance misuse studies was that different effects can happen at different stages of adolescence.

Gaps were identified in all the topic areas. Cyber bullying and social aspects of obesity were not particularly well addressed, for example. In addition, there is no analysis of newer techniques such as mindfulness. Given that there are areas of controversial or conflicting evidence, more research is needed in order to come to a valid judgement.

The evidence base for digital and social-media-based interventions is in its infancy, but there is a great deal of promise. One of the problems with these interventions is the difficulty of sustaining engagement – so this is a priority for further research.

Adolescents' priorities

The young people that spoke to us wanted help in overcoming the inevitable difficulties and challenges that face them in everyday life. This is not covered in the literature we looked at. Instead, the focus is on trying to reduce risk rather than promoting wellbeing. For instance, sexual wellbeing was not considered at all, the emphasis was on avoiding sexual risk.

They also wanted more research about the way in which more supportive relationships can be established between adults and young people, as well as between peers. They felt that they did not know what the professionals they were dealing with actually thought of them.

Young people do not seem to have been involved in designing interventions. Self-report questionnaires are fine, but what about the qualitative feedback, what about their thoughts and feelings?

Evidence was drawn from across the world, with much of it being US-based. There was little from Scotland or the rest of the UK, which raises the issue of transferability.

There is a disconnect between the high-level evidence of the review and the real-life experience of Scottish adolescents. To bridge that gap, research will have to be much more participatory and it must keep pace with change, particularly in the digital sphere. Peer support is also very important to young people and this needs to be better explored in research. Perhaps more use could be made of e-learning environments, platforms and young people's own expertise in this area.

Evaluations should in future incorporate analyses of the impact on inequality. Within the literature, though, there is no consensus on how that should be done.

There must be a focus on the implementation process. Without the perspectives of people receiving an intervention, it will not be possible to fully understand why it works - or why it does not.

We found that some approaches empowered young people to make healthy choices across a range of topic areas. So universal interventions can be made more holistic, positive and inclusive for marginalised groups.

The potential for universal interventions to reduce inequity needs to be more deeply investigated. Very importantly, young people have great, well-informed ideas. They are incredibly articulate. The young people that worked with us were fabulous. They were a joy to work with, really energising. They must be involved fully. □

The full report will be available on the Mental Health Foundation website

Evaluating interventions with vulnerable adolescents

Helen Sweeting



Dr Helen Sweeting has worked at the MRC/CSO Social & Public Health Sciences Unit at the University of Glasgow for around 25 years. She has a long-standing interest in influences on young people's health and health behaviours. Most of Helen's work has included descriptions of the health and behaviours of children and young people and exploration of how they are patterned.

The RSE is initiating a programme of research around young people's health, happiness and wellbeing and the successful transition to adulthood. It began with two systematic reviews: one focussed on an evaluation of population-level interventions to improve health, happiness and wellbeing, or reduce inequalities; while the other – ours – concentrated on individual interventions.

The reviews covered published as well as 'grey' literature of relevance to Scotland, including both unsuccessful and successful studies and were relevant to Scotland. The overall purpose was to inform development and delivery of an intervention study in Scotland.

This review addressed the question 'What is known about the impacts of non-clinical individual level interventions on the mental health or wellbeing of vulnerable adolescents?'

Existing evidence

In the 2012 Scottish Health Survey, 13% of 16-24 year olds reported symptoms indicating possible psychiatric disorder. In one of our own studies, 7% of Glaswegian 18-20 year olds reported attempts to self-harm. A recent school-based study found that only about a quarter of 15 year olds were very happy with their lives and only 1-in-10 always felt self-confident.

Mental disorders impact on many other aspects of life such as forming relationships, completing education and getting a job. Socio-economic inequalities in adolescent mental health also tend to increase with age and so adolescence is a key life-stage for mental health-related interventions.

There is no single definition of 'vulnerable group', it depends on the context. Vulnerability is associated with many negative experiences, from marginalisation and social exclusion to abuse, prejudice and discrimination. Vulnerable young people are at risk of poor health outcomes and they face extra challenges in making transitions to adulthood. Vulnerable young people are a Scottish Government priority.

There is no single definition of 'vulnerable group', it depends on the context.

SUMMARY

- This systematic review focussed on interventions with individuals
- Evidence is insufficient to draw firm conclusions about the impact of interventions
- There is some limited evidence of benefits for specific groups
- No intervention was consistently positive across all the groups of vulnerable young people
- It is important to include health, happiness and wellbeing among the evaluation criteria of interventions with vulnerable young people.

The purpose of this review was to synthesise literature that evaluates targeted, non-clinical, individual level interventions which aim to improve the mental health, mental wellbeing or happiness of vulnerable adolescents.

Systematic reviews are very time-consuming and this one was no different. On the basis that money should only be spent on intervention development which is backed by good evidence, we aimed to prioritise the best evidence.

First, the team searched for other systematic reviews, because these are considered the highest quality evidence if done well. They provide a transparent and rigorous synthesis of existing evidence and they include a consideration of possible bias. A quality appraisal was undertaken with more weight being given to those assessed as having low risk of bias.

Next, we searched for randomised control trials (RCTs) published in peer-reviewed journals. These are considered to have the least biased study design because there is a random allocation to the intervention or control group.

Finally, we searched for unpublished – or 'grey' literature – but in order to ensure quality we restricted this to descriptions of RCTs or evaluations with a control or comparison group.

The specific vulnerable groups were chosen in consultation with RSE and a public health advisory group. Studies had to be in English so we could read them, based on OECD countries and

published since 2005. In all, 12 databases were searched, covering medicine, psychology, education, social studies and children, in addition to Planex, a well-established bibliographic database for grey literature.

The whole team helped with screening at title-and-abstract stage – 10% of these were double screened. Then two authors screened at the full text stage.

Around 7,000 systematic reviews were identified. Most were excluded on the basis of title and abstract. The full text of 208 were screened to see if they met all our inclusion criteria and we finally included 32. These were subjected to quality appraisal and 22 were finally categorised as good quality reviews and 10 as poor quality. Some 4,500 RCTs were identified, 76 of which were full-text screened, resulting in 20 papers describing 16 separate RCTs.

Finally, the team identified almost 9,000 reports of evaluations with a control group in the grey literature. After screening, though, there was none which met all the inclusion criteria which had not later been published in peer-reviewed journals.

The results

The main conclusion is that there is not enough evidence to identify individual-level interventions which clearly benefit the mental health or wellbeing of any of the vulnerable groups.

For some groups – unemployed people, those out of school or excluded, and young carers – we found no evidence. The interventions we found that involved these groups focussed on things like employability, or getting those who were excluded from school back into education. It is possible that these might well impact on mental health, but we found no studies which reported on this.

For a second set – asylum seekers and refugees, ethnic minorities, those exposed to domestic or intimate partner violence and those living in socio-economically deprived neighbourhoods – there were tiny amounts of evidence, but not enough to make definitive statements.

For a third set – looked-after adolescents, homeless young people, young offenders, sexually abused adolescents and teenage parents – there were small amounts of evidence which did allow some conclusions to be drawn.

Looked-after adolescents

There are around 15,500 looked-after young people in Scotland, representing 1.5% of under 18s. Only about 10% of this group are in residential accommodation with the rest split roughly equally between parents, friends and relatives, or foster carers. This was the group for which we

RSE RESEARCH PROGRAMME

The Royal Society of Edinburgh, funded by the RSE Scotland Foundation, has organised a research programme to address the health, happiness and wellbeing aspects of the transition from adolescence to adulthood. The meeting of the Foundation in October took as its starting point two systematic reviews undertaken by teams of researchers. These studies brought together some of the leading research organisations in this field in Scotland.

The first looked at population-level interventions. The team included: Dr Joanne McLean and Hannah Biggs from the Mental Health Foundation; Dr Pauline Campbell, Dr Alex Pollock and Dr Claire Torrens from Glasgow Caledonian University; Dr Joanne Williams from the University of Edinburgh; Professor Margaret Maxwell from the University of Stirling; Dr Anna MacIntyre of the University of Strathclyde; and Amy Woodhouse of Children in Scotland.

The second team looked at interventions aimed at individuals. This team included: Dr Helen Sweeting; Dr Gaby Vojt; Dr Hilary Thomson; Mhairi Campbell; Candida Fenton; Dr Jean McQueen and Dr Kathryn Skivington, all based at the MRC/CSO Social and Public Health Services Unit at the University of Glasgow at the time the systematic review was conducted.

found most evidence. Ten reviews and three RCTs had addressed the impact of interventions on the mental health or wellbeing of looked-after children and adolescents.

However, several reviews reported that their search had not found any studies with relevant outcomes. Some suggested the intervention they examined had no impact or a mixed impact and only one area – mentoring – gave clearer evidence of positive impacts. Our conclusions in respect to interventions with looked-after young people are that: there is insufficient evidence; the available evidence is conflicting; but there is some very limited evidence that mentoring may impact the wellbeing and mental health of these adolescents.

Homeless young people

The most recent Scottish Household Survey found that about 4% of 16-24 year olds reported having been homeless at some point. In 2015, about 1.5% of this age group were assessed as homeless and young people are over-represented in the homeless population. In fact, between a quarter and a third of the Scottish homeless population are aged 16-24. We identified four reviews and one RCT for this group.

There was evidence of a positive impact on psychological wellbeing from practical support, psychological interventions, and from a mix of these two. So we concluded that the mental health of

There is not enough evidence to identify individual-level interventions which clearly benefit the mental health or wellbeing of any of the vulnerable groups.

FURTHER INFORMATION

O'Donnell *et al* (2014) *Wellbeing and Policy*.

li.com/activities/publications/wellbeing-and-policy

London School of Economics and Political Science (LSE) www.lse.ac.uk

Mental Health Foundation www.mentalhealth.org.uk

Medical Research Council www.mrc.ac.uk

MRC/CSO Social and Public Health Services Unit, University of Glasgow
www.sphsu.mrc.ac.uk

NHS Scotland www.scot.nhs.uk

Royal Society of Edinburgh www.royalsoced.org.uk

RSE Scotland Foundation www.rsescotlandfoundation.org.uk

homeless young people is improved by practical support, especially independent living and homeless interventions (which might not come as a great surprise) but that psychological interventions, especially Cognitive Behavioural Therapy (CBT), can also have an impact.

Young offenders

About 5% of young people in Scotland are involved in offending behaviour each year. However, only a very small amount of youth offending is violent crime, so there are around 500-600 admitted to prison or a secure institution each year. The project identified four reviews.

These all focussed on psychological interventions and not practical support. We concluded, once again, that there was insufficient evidence to draw firm conclusions. There was some evidence that group-based CBT improves the mental health of young offenders, but the impact of other activities that were assessed – such as music-making, outdoor activities, or multi-systemic therapy – on their mental health was unclear.

Sexually-abused adolescents

In 2014-15, there were 3,500 recorded sexual offences against under-16s in Scotland, which is 3.8 per 1000. However, statistics based on police recorded crimes are an inaccurate reflection of actual numbers. An NSPCC study of 18-24 year

olds found that more than 1-in-10 reported contact sexual abuse while under the age of 18.

For this group, we identified four reviews and one RCT. Again, all the reported interventions were psychological and they all seemed to have positive impact, but three out of the five evidence sources had methodological issues. The conclusion was that there was again insufficient evidence, although there was some evidence that CBT can lead to reduced stress and anxiety among adolescents who have experienced sexual abuse.

Teenage parents

Around 0.5% of young women in Scotland are parents. Although this has declined recently, the country still has higher teenage parent rates than most other Western European nations. Two reviews and seven RCTs were identified. Most studies looked at the provision of practical support, particularly home visiting, but again there was insufficient evidence. There was, however, limited evidence suggesting that parenting programmes and inter-personal therapy may benefit mental health among teenage parents, but there is conflicting evidence in respect of home visiting.

Conclusions

Overall, we identified a range of non-clinical, individual level interventions aiming to improve the mental health, mental wellbeing or happiness of vulnerable adolescents. These included both provision of practical support and psychological interventions. There was evidence for positive impacts of CBT on the mental health and wellbeing of several of these groups, but this therapy is widely used so the conclusion could be a result of the fact that it has been evaluated most. There was, however, no intervention which was consistently positive for all the vulnerable groups.

There are implications for research, policy and practice. Adequate research is clearly lacking in respect of mental health impacts of interventions for specific vulnerable adolescent groups. For policy-makers and practitioners, our review cannot provide clear intervention models. It does, though, highlight the need to pay much greater attention to the wellbeing of the most vulnerable groups of young people.

There are interventions for vulnerable adolescents which focus on practical ends – such as increasing employability, or getting the excluded back into education. It is crucial that evaluations of these also focus on potential mental health, mental wellbeing or happiness outcomes. □

Adequate research is clearly lacking in respect of mental health impacts of interventions for specific vulnerable adolescent groups.

¹ www.sphsu.mrc.ac.uk/op026-health-happiness-wellbeing.pdf

Improving mental health for all age groups

Richard Layard

SUMMARY

- The biggest threat to a person's sense of wellbeing is mental illness
- A mother's mental health has a clear impact on the emotional health of their adolescent children
- The 'improving access to psychological therapy' programme introduced in 2005 is being expanded
- Digital treatments are being developed which have similar recovery rates to traditional face-to-face therapies
- A life-skills curriculum for young adults, based on successful therapies, is currently being trialled in schools.

The idea that the goal of society should be the happiness of the people – possibly the most important idea in the world in the modern period – was first formulated in Scotland. One important pupil of the Scottish Enlightenment was Thomas Jefferson. In his view: “The care of human life and happiness ... is the only legitimate object of good government.” Moving on to the present day, Angela Merkel's government in Germany has conducted a huge national consultation throughout 2015 involving 50 public meetings with government ministers and the public. There were in the region of 2,000 town hall meetings on the subject of ‘what matters to people’.

Worldwide, nearly every OECD country has an official measurement of the wellbeing of its population. In Britain, an enquiry chaired by former Cabinet Secretary Gus O'Donnell reported in 2014 on *Wellbeing and Policy*¹. One of its conclusions was that, today, wellbeing is not simply calculated by finding the sum of every individual's happiness (Bentham's view), but that particular weight must be given to the absence of misery when evaluating the outcome of a policy, or the state of a nation.

The report also argued strongly that a democratic concept of happiness is one where each person evaluates their own state. Instead of measuring and weighting pre-determined factors, the

individual makes their own judgement as to how satisfied, overall, he or she is with life.

Our group at LSE have been investigating ways of determining the life satisfaction of the population, working mainly with the British Cohorts Study of people born in 1970, so there is evidence from birth onwards.

The results are quite surprising. Poverty is not the main cause of misery in our society, although unemployment is a very important cause. Poor education and a stable income – these are not major problems. People being on their own is a problem. Physical illness is a problem. However, by far the biggest threat a person's sense of wellbeing is mental illness.

Looking back to when a person is 16, what features of their development best predict whether they will be satisfied with their life in middle age? The best predictor of whether a person will have a satisfied adult life is their emotional health. Poor emotional health at age 16 is a predictor of poor mental health later, which in turn is a predictor of poor life-satisfaction later on.

It is possible to go further back. What are the best predictors of emotional health at age 16? Looking at why some people are much more emotionally healthy at 16 than others, the mother's mental health is coming through as a very strong influence while family income is a relatively weak predictor.

Treatment

What can be done? Prevention is one avenue and treatment is another.

Only about one quarter of the people with clinically significant mental illness are in treatment, and the UK is no worse than any other country. It is deeply shocking when compared with the fact that well over three-quarters of the cases of physical illness would normally be in treatment. This is true for adults of all ages.

The Labour government in 2005 made a manifesto commitment to ‘improving access to psychological therapy’ (IAPT). The adult programme started first in England, but then from 2011 onwards there has also been a programme for children and young people.



Professor Lord Layard FBA is Programme Director of the Wellbeing Programme at the Centre for Economic Performance at the London School of Economics and Political Science. He is an economist with a special interest in the incorporation of new metrics for measuring such concepts as ‘happiness’ or ‘wellbeing’ into an economic framework. He has published widely on this topic including the acclaimed book *Happiness: Lessons from a New Science*.

Table 2. A weekly life-skills curriculum for 11–14 year olds.

| Topic | Programme used |
|----------------------|----------------------------------|
| Resilience | Penn Resilience Program; MoodGym |
| Compassion | Relationship Smarts |
| Sexual relationships | SexEd Sorted |
| Drugs | Unplugged |
| Eating and alcohol | SHAHRP |
| Mental disorders | Science of Mental Illness |
| Parenting | Parents under Construction |
| Media awareness | Media Navigator |
| Life goals | Schools to Life |
| Mindfulness | .breathe |

The Coalition Government at the end of its term agreed to increase access from one-quarter to one-third. That scale of expansion presents a challenge and there is a significant training programme underway. An equally large challenge is to improve the quality of treatment, because most child and adolescent mental health services in England are not based on approaches recommended by the National Institute for Health and Care Excellence (NICE).

The aim now is to embed well-proven therapies with a good evidence-base throughout the country. So for anxiety it would be mainly Cognitive Behavioural Therapy (CBT). For mild to moderate conduct disorder there would be a focus on parent training, which has been found to have extraordinarily long-lived effects. For depression, interpersonal therapy or CBT; for personality disorder, dialectical behaviour therapy; and so on.

Universal application

The aim is that NICE-recommended treatments should be universally applied. It is shocking that, in most mental health services until recently, there has been no measurement of outcomes. Perhaps not surprisingly, commissioners are reluctant to fund treatments as they do not know what is being achieved with the money. So there is also a target to get universal outcome measurement by 2020.

In the adult IAPT, there has been outcome measurement from the very beginning. Every person is measured at the beginning of every session – a questionnaire is filled in to see how they are doing. If they do not attend, at least it is known when they last came – an outcome measurement for drop-outs. The Adult IAPT is achieving 50% recovery rates over the periods of treatment.

So, one measurement is the percentage of a diagnosable population that is seen by IAPT. In 2015, this was 15% and there is a commitment for 25% by 2020. Hopefully, all of these people who up till now have been given pills and nothing else can be offered something which will have a longer-lasting effect on their wellbeing. In particular – and this is relevant to adolescence – a primary focus in the expansion of IAPT will be maternal depression as well as problems of co-morbid physical and mental health which are very under-treated.

One of the most interesting areas is the world of digital treatments, such as digital versions of CBT.

David Clark, Professor of Clinical Psychology at Oxford, is an expert in social anxiety disorder, or social phobia, which is very debilitating. Yet it is also amenable to treatment and the effects are permanent. Face-to-face treatment will normally take 10 or 12 sessions, with a recovery rate of over 75%. He has now produced and tested a digital version: this takes a quarter of the time yet with exactly the same recovery rate. Some very shy people prefer to start online, getting therapist support either online or by telephone.

Let me now come on to the prevention issue and look at schools. We need to find some way to measure wellbeing, otherwise it is going to be very difficult to offset the prioritisation of the exam culture. A wellbeing rating could be a mark of ‘value added’. The school would record the wellbeing value added in addition to the academic value added for all its children. In doing so, it would learn a great deal about those children, because the children with emotional problems (as opposed to behavioural problems) are not always identified correctly by their teachers.

The next step would be the development of a Wellbeing Code, which schools could sign up to.

In England, most schools have a one-hour session of Personal, Social and Health Education (PSHE) each week. What evidence is there for its effectiveness? These are the types of topics usually included under this heading: resilience; compassion; sex; drugs; alcohol; mental disorders; parenting; media awareness; life goals; and mindfulness.

We attempted to find the best, successfully-trialled modules for each of these topics and put them together in a four-year curriculum entitled Healthy Minds (see Table 2). This is currently being trialled in 26 schools. The teachers, of course, have to be trained. The reason why the SEAL (Social and Emotional Aspects of Learning) trial in England was judged to have had no effect was primarily because there was no training of teachers in how to teach it and it was not sufficiently structured. The evidence-based interventions that work are very highly structured and manualised: the teachers or the therapists have to be trained in the same way as surgeons learning a new technique.

The interventions listed have proved successful. They were very detailed in their development and testing. This has to be the way forward: the well-intentioned person just trying out some general idea is not going to be the answer for any of these problems.

This trial is continuing, so there are no results as yet. However, I am hopeful of producing a curriculum that offers a teaching specialism for secondary schools in PHSE or wellbeing.

I am very keen that we also provide parent training. The Cohen and Cohen programme has had good evaluations in the USA and I hope it will be tried in Britain.

Finally, work is a key transitional experience for young people moving into adulthood. I am a great believer in guaranteeing apprenticeships, or pre-apprenticeships, to every young person who does not want to go to university. □

¹. <http://li.com/activities/publications/wellbeing-and-policy>

The debate

It was remarked that the research concentrates solely on one section of young people – those defined as vulnerable. Yet the whole cohort of young people needs to be considered in order to judge whether problems are specific to a particular group or if some are shared across all.

Treatment must concentrate on the worst cases, but prevention must relate to the whole cohort. Yet how are the preventative measures likely to be received by those not in the vulnerable categories? It is important to understand the possible reactions, which could undermine the whole preventative programme if these are hostile – or, indeed, merely indifferent.

The presentation of preventative programmes is crucial. Effort should be put into finding out what 15 year olds think about matters and how they would design programmes. Is enough being done to involve these vulnerable young people in both the development and application of the strategy (the British Medical Journal will not now publish articles concerning patients unless they have been actively involved in the writing-up of the research)?

Although the RSE Scotland Foundation has spent two years setting up the programmes, the reviews have not found sufficient evidence upon which effective intervention programmes can be built. This undermines the intention to construct

a three-phase programme, leading from the review of the literature, to the emergence of research and on to effective intervention policies. The research base is too limited in that it considers research on mental health separately from other areas (such as housing and education) which may affect mental health. It is important to look at mental health in context.

Funding will always be a problem where new measures are required. However, there are ways of making initiatives cost-free, if care is taken to associate them with other social measures or else existing resources and staff are used in new ways.

Greater use should be made of the voluntary sector, which has more intimate knowledge of personal or local problems, and can also deal informally with vulnerable adolescents, who may trust these organisations more than official sources.

The evidence base can be widened by examining contextual reports and studies in education, housing, training, justice and elsewhere. Such materials could indicate why mental health is not given as much importance, and how it could be better prioritised.

Even if more evidence is found of effective interventions, it will be some time before sufficient positive outcomes are available to persuade politicians to devote greater financial resources. Cultural change is always gradual. □

Issues raised in the debate included the scope of the research, the involvement of young people in the design and delivery of interventions and the issue of funding new treatments.

OVERSEAS DEVELOPMENT

Science and innovation have important roles to play in overseas development programmes. How can that contribution be maximised? This formed the focus of the Foundation's Christmas Lecture and Reception, held at the Royal Society on 14 December 2016.

Using science and innovation in overseas development

Charlotte Watts



Professor Charlotte Watts FMedSci is Chief Scientific Adviser at the Department for International Development (DFID). She has been at the department for a year. She also is a professor of social and mathematical epidemiology at the London School of Hygiene and Tropical Medicine. Her research interests are in interpersonal violence, HIV, gender, complex intervention evaluation and social determinants of health.

Historically, some of the major advances in development have been driven by science. New medicines, new vaccines, the green revolution – they have all contributed to the historical successes and improvements in life expectancy seen around the world.

The challenges facing humanity are huge and complex: feeding a population of 8.5 billion in 2030; housing all those people; and ensuring an improved standard of living – all without destroying the environment and contributing to climate change.

By that date, 60% of the world's population will be living in cities, yet poverty and inequality will still be with us, particularly in the most fragile and conflict-affected states. There will be more extremes in climate, with a greater number of severe weather events. Migrant crises are likely to continue and these will need to be tackled more effectively at source.

The threat from disease is ever-present – whether from neglected tropical diseases that still affect almost a billion people, or new disease outbreaks such as the Zika virus, linked to microcephaly.

There are gender and inequality issues. Approximately 1-in-3 women around the world will experience sexual or physical violence. To achieve inclusive development, this has to be tackled head-on. Then there are challenges such as increased drug resistance which threatens to reverse the great strides made in addressing diseases such as malaria.

The strategy

DFID invests its research money in alignment with the UK Official Development Assistance (ODA) Strategy. The four main objectives are:

1. Strengthening global peace, security and governance.
2. Strengthening resilience and responses to crises.
3. Promoting global prosperity.

SUMMARY

- Some of the major advances in development have come from science
- Currently, DFID spends £390 million a year on scientific research
- Investment will often address gaps in research which other agencies are not supporting
- Investments are being made into which interventions are most effective
- DFID is committed to respond flexibly and in an agile fashion to new demands and challenges.

4. Tackling extreme poverty and helping the most vulnerable.

Investments must achieve good value for taxpayers' money, so the focus is to achieve these objectives in a way that uses resources well. The ODA Strategy has a strong commitment to underpin spending decisions with rigorous evidence.

The Secretary of State launched DFID's Research Review¹ in October 2016. It renews the commitment to invest in science, in research and in evidence, to the tune of £390 million per year within this spending period.

Over this period, the programme will continue and scale-up work on infectious diseases. Research on humanitarian innovation will double, funding in education will treble and there will be increased funding for climate, energy and water. DFID will also seek to produce new syntheses and research on migration, on cities and on adolescents.

One of the areas being discussed with other Government Departments is how to support capacity-building in the developing world more effectively. In particular, how to invest in ways that will strengthen national research capabilities to answer their own development challenges? This is not just

a question of DFID's research money, but also the Newton Fund, the Global Challenges Research Fund and other Government Departments.

In determining its research priorities, DFID considers five factors. The first is whether a proposed expenditure stream addresses one of the big development challenges. Specifically, does it lead to impact 'on the ground'?

Second, does the investment address an important gap where other donors may not be investing? For example, our research is tackling violence against women. There was very little existing literature on preventing violence, so DFID stepped in, leading in that area.

While we are particularly interested in practical research, it has to be of the highest quality. This is the only way to get the insights that will help us make progress in tackling development challenges.

Fourth, what is the timescale for seeing the findings of any research and for delivering impacts? Finally, we assess the potential for a large return from committing these resources to science and research.

That, essentially, is the framework used for evaluating investment in research within DFID.

Science in emergencies

As an example of the way DFID prioritises investment, we used different types of research to inform our response to the Ebola crisis. Science was used at all stages, from the planning to the preparation and the response. The essential insight was in using a basic epidemiological measure of how quickly an epidemic takes off. How could we drive that measure – R_0 – to a value of less than 1 which indicates that the epidemic would die out?

Modelling was used to predict the potential trajectory of the epidemic. As real-time data came in on what was happening in practice, the predictions of the weekly cases could be adjusted. The findings were used to inform the targeting of intervention responses.

Social science was also very helpful in informing the response. It enabled an analysis of the way in which a very rapid, somewhat militarised, response to an outbreak could be implemented in a way that was acceptable for communities. Social science also helped us recognise the particular risks associated with traditional burial practices. Washing and preparing the body for burial was putting people at high risk of infection. Social science enabled us to work out ways to promote safe burial, respecting the culture, and rituals of death and burial, but without increasing risk.

Research also contributed to finding better technologies to respond to Ebola. That included

work on diagnostics and improving throughput in labs. There were also investments in trials to test the efficacy of vaccines.

Science is used in other types of emergencies. Satellite data enables us to better predict and respond to extreme weather events and disasters. Satellite modelling and accurate weather projections enabled us to develop a forward plan for the predicted impacts of El Niño in 2015-16. This enabled DFID to mobilise resources quickly in Somalia, supporting riverbank reinforcement which prevented many hectares of productive land from being flooded.

We are investing into ways of gathering more rigorous evidence about which interventions are most effective. DFID funds a large portfolio of evaluation research across its health, agriculture, governance and education portfolios. In the end, policy makers need a body of evidence that informs their decisions about the most appropriate intervention responses.

In practice

One example of this kind of project applies randomised control trial (RCT) methods to intervention subjects: an approach not normally thought to be amenable to this sort of experimental design. This was a collaboration with the international Centre for Taxation and Development and the Rwanda Tax Authority. It involved an experiment with 13,000 tax payers: the intervention in this study consisted of emailed letters or text with different types of content. The control was just a very neutral message, another had a reminder of sanctions for late payment, while the third had a positive message. It was clear that the positive text messages yielded the best results. This finding in Rwanda actually replicates some of those from some similar 'nudge' experiments in industrialised countries.

In terms of return on investment, this study was cheap – it cost about £90,000. In terms of increased tax revenue for Rwanda, it gave a return of around £7 million. Tax is a really important issue for development because it enables countries to fund their own development pathways. The evidence has led to a change in practice in Rwanda as the tax authority was involved from the outset.

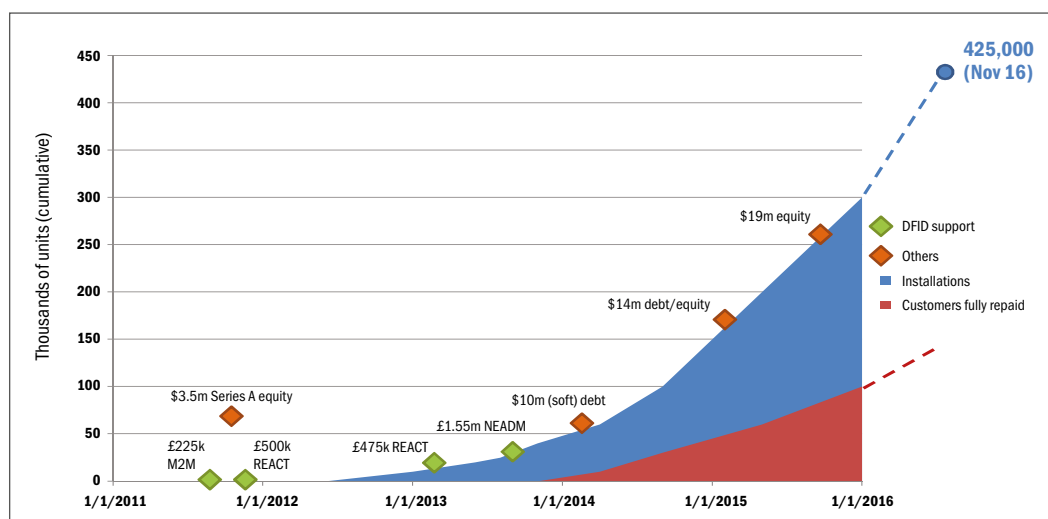
Another example of RCT was conducted in a very difficult situation. The question was how to provide improved mental health responses in Peshawar in Pakistan. The mental health consequences of conflict and violence are wide-ranging and pervasive. Globally, more than 125 million people are directly affected by armed conflict.

The trial, run in collaboration with The Wellcome Trust, tested the impact of a behavioural

Policy makers need a body of evidence that informs their decisions about the most appropriate intervention responses.

In terms of return on investment, this study was cheap – it cost about £90,000. In terms of increased tax revenue for Rwanda, it gave a return of around £7 million.

Figure 1. Scaling up of programme for M-KOPA off-grid solar technology



intervention that was delivered by lay-workers. It trained health workers in simple counselling approaches, enabling them to work effectively with adults suffering from psychological distress. The trial showed a significant reduction in clinically significant anxiety and depressive symptoms in just three months.

A final example concerns the use of digital technologies to create impacts at scale and across Government. In 2001, DFID funded research which found that mobile phone air time was used in Kenya as virtual currency. There was some interest in the development of a system where cash value could be retained in a digital form. That led to DFID engaging with innovators in the mobile industry and, in turn, to the pilot of a mobile money transfer system known as M-PESA.

There has been a rapid increase in demand and today M-PESA is used by about two-thirds of Kenyan adults. It supports 85,000 agents and about 50,000 merchants. It processes daily about eight million transactions worth about £20 million.

Mobile money has proved to be a phenomenal success and the high levels of coverage offered the opportunity to add other technical innovations. One remarkable success has been increased access to solar lighting. A pay-as-you-go platform for solar was developed using mobile money. Not only has the system enabled consumers who want solar technologies to purchase them, but it has also created new business opportunities, through the testing and use of a business model that enables small enterprises to develop around the provision and servicing of this mobile technology.

Figure 1 shows the very rapid uptake of M-KOPA off-grid solar technology with projections of getting up to 425 million units.

Purchasers pay a low unit cost for a year after which they own the unit. The red area on the chart shows the number of units that are owned and the

blue shows on-going partial ownership. The green diamonds indicate the investments that DFID made very early on the trajectory. We invested in M-KOPA because this technology has potential to be used in very resource-poor settings.

The example illustrates how early investments catalysed a self-financing model of scale-up. Bringing the right technologies and right business models together at an early stage can help lead to systems that can grow without continued investment from the UK or other donors. We are now interested in whether this business model can support continued scaling up and the addition of other new technologies, such as televisions or fridges.

DFID is continuing to think about new ways of using science to inform development, keeping a watch on new innovations and assessing their potential application to the development challenges that we face.

One current initiative within DFID is to ask country officers if any of the technologies where we have given initial funding are of interest in their situation. We are then supporting partnerships between innovators and country offices to see if there are any opportunities to start pilot projects. One example is a hybrid airship which uses alternative energy sources. The potential here is to expand access and be able to deliver commodities to areas that have very weak infrastructure. This new generation of airship requires one person to pilot and another to load/unload the cargo.

Another project responds to the challenge of water pumps not being adequately maintained and then breaking down. This threatens the continued supply of clean water. Again, using mobile technology people can essentially buy credit to access clean water. The business model is that women can create a business of selling this credit (at very low margins in terms of profit) but they have the incentive then to maintain the pump and

Using mobile technology people can essentially buy credit to access clean water.

make sure it works. In addition, it means that we can track clean water use.

DFID has also been piloting projects about the potential to use drones in emergency situations or to deliver supplies to very remote medical facilities.

So we are looking at ways of supporting innovation, while at the same time strengthening pathways to testing them in the realities of delivering development, by linking new innovations to our different country offices.

Science and innovation are crucial for develop-

ment and UK ODA is permitted to supporting research, particularly high-quality, very problem-focussed research and innovation.

The challenge is to ensure we maintain flexibility in the way that we are supporting research, in the way that we are making investments. If new opportunities arise or if new crises hit us, we must be able to respond in an agile way. □

¹ www.gov.uk/government/publications/dfid-research-review

New ways of getting technology to people that need it

Jon Ridley

SUMMARY

- Many millions of Africans still lack access to clean energy
- The prevalence of mobile communications across great swathes of the continent has made a new business model possible
- The business model exists today because of DFID's decision to invest
- These technologies have the potential to lift millions of people out of poverty.

There are 600 million people in Africa who live without access to clean energy, so there is great deal of work to do in meeting the need.

Mary is a typical enterprising woman who runs the family household in a remote part of Tanzania. Until recently she spent 20% of her income on kerosene. This is used for some cooking, but predominantly for lighting the house. She used to go to the market every day to buy kerosene in the town at a pump.

It is a dirty fuel, releasing black carbon which is a great contributor to global warming. Unhealthy fumes are emitted and contribute significantly to diseases in families. Thousands of household fires are caused each year. It is a real irony that the poorest people depend on this worst and most expensive type of fuel. So, one of M-KOPA's propositions is really to help displace the use of kerosene, redirect that expenditure to

something much better and help customers like Mary build an asset.

M-KOPA's heritage is from mobile telecommunications and, indeed, mobile money. For the solar energy system people put down a deposit of about \$30. They normally source that from their local savings group. The system comes with two lights – and radio and televisions are now becoming available.

The purchasers then owe us the rest of the value of the kit. The total is typically around \$200 so we ask them to pay 365 credits of roughly 50 cents a day, which is less than they would be paying for kerosene. After a year, not only is it fully paid off, but they no longer pay for energy. We are then able to help them acquire other productive appliances using the savings they are continuing to make.

Financial control

When I met Mary and I asked her to send the credit to get the lights on she said: "I have got to wait another couple of hours." So then, when it got dark enough Mary thought "OK, I need my lights, I don't need this 50 cents for something else, so I will send my credit".

Just how long does it take to negotiate with your mobile communications or utility provider to turn your lights on? I timed it, it was six seconds. Mary's light came on, she is saving on kerosene and her children are able to study safely for much longer.

Once people have paid off the device, the relationship with them continues. We can offer people the opportunity to buy a television, for



Jon Ridley is Director of M-KOPA Labs and responsible for research and development of new products that meet the future needs of M-KOPA's growing customer base – with a portfolio of innovative product development initiatives. M-KOPA is selling solar panels and other products through a micro-financing scheme to poor households in Africa. Previously Jon spent 15 years as a senior international development consultant with a particular focus on developing and managing a range of innovation funds for public and private donors, and for private sector businesses.

example – I think we have sold 30,000 televisions. People want to know about the world. People want to know what's going on.

We also sell things that are not electrical, like fuel efficient stoves. We are the biggest reseller of fuel efficient stoves in Kenya: people can reload their credit and pay us back over time. Repayment rates are very high.

Mobile communications are what makes this all possible. Mobile money – a direct result of investment by DFID.

In the early days, the business case was difficult: trying to do credit sales, using the technology to sell to people when 85% of our customers earn less than \$2 per day. That is not an obvious mass-market for this kind of use of technology.

It was the willingness of DFID to fund the types of research that support such initiatives, but also to take a risk and see if something would

work, that made the difference. M-KOPA is a for-profit organisation set up by some highly enterprising people, but based on really some important support and research from DFID as well as other partners such as the Shell Foundation.

A recent report, the result of a longitudinal impact assessment, estimates that the existence of mobile-phone-based money transfer has lifted about 2% of the Kenyan population out of poverty and that there has been a disproportionate advantage for women-headed households. If that research is right, it is a vindication of an investment into a for-profit business in order to do something completely new.

We hope we can keep testing extensions to this business model, particularly because of the circumstances of our customers and of the people we have not yet reached. □

Connecting institutions at national and global level

Rowan Douglas



Rowan Douglas CBE is CEO of the Capital, Science & Policy Practice at Willis Towers Watson, a leading global advisory, broking and solutions company. He was a member of the Prime Minister's Council for Science & Technology as well as the Royal Society's Working Group on Resilience to Climate Risk and Extreme Weather. He led the creation of the Insurance Development Forum (IDF) of industry, governments and international institutions to harness re/insurance capabilities in meeting the UN Global Goals and wider Post-2015 Agenda.

The structural change that the UK is effecting through DFID is quite remarkable, even if it is not very well-known. In my world, what might be referred to as the 'primary colours' are policy and law, capital and science. What makes science powerful is its impact on duties of care and finance – whether the finance of Tanzania, Kenya or the City of London.

Legal duties

Development and humanitarian work are governed by legal duties, the human rights of life, livelihood and shelter. On a structural level, these may be expressed as Sustainable Development Goals, statute law, tort or regulation. Legal duties form the framework that governs almost everything we do. Where a law intersects and influences the application and interpretation of legal duties (and our values) is absolutely critical.

The second primary colour is capital. The way science is able to incorporate risk into financial decision-making, whether in the public, private, personal or Government sector, is fundamental. The full spectrum of social science, humanities, and the natural sciences together provides the ability to make legal duties tractable and financial

SUMMARY

- DFID is achieving remarkable structural change in world of international development
- Science is helping to incorporate risk into financial decision-making
- Financial, legal and scientific communities need a coherent set of shared methodologies
- Shared metrics and models will help us deliver an integrated approach to development challenges
- The creation of international institutions such as the Insurance Development Forum will allow developing nations to access finance at a national and regional level.

decision-making risk-informed. What I see is the most exciting convergence in these areas.

If we are going to deliver on our statutory duties in the human rights of life, livelihood and shelter, then our financial, legal and scientific communities must develop a coherent set of shared methodologies to understand risk and make decisions. There must be some shared metrics which can be applied across our various communities as well as

models – and modelling frameworks – which will help integrate all our efforts.

I have been privileged to find myself in the world of reinsurance. That sector has gone from relative ruin to relative resilience in the space of 25 years, through the use of engineering-based methodologies of hazard, exposure, risk and vulnerability. These have been applied to financial regulation and decision-making across the whole spectrum of risk, from natural disasters to US lawyers. That shared language and modelling platform has allowed this specific community to intersect with many experts in other areas.

Shared language

It is this shared language and lexicon which will allow the science that DFID has been helping to drive, to integrate with policy and financial decision-making in the emerging world. In so doing, it will help to deliver the rights I have mentioned. I am proud to say that the UK is the epicentre of some of these developments.

I am pleased that Prime Minister's Council on Science and Technology is about to embark on a significant project about modelling and the modelled world. It is going to look at how this can be used to integrate different areas of research and policy in order to respond to global challenges.

Society is made up a huge diversity of institutions. I would include insurance as an institution and an organising framework of society. It allows people to understand risk, manage it, reduce it and ultimately share it locally. Institutions are also continually being created. The Insurance Development

FURTHER INFORMATION

DFID Research Review

www.gov.uk/government/publications/dfid-research-review

Department for International Development

www.gov.uk/government/organisations/department-for-international-development

Innovate UK

www.innovateuk.co.uk

Insurance Development Forum

www.theidf.org

M-KOPA Solar

www.m-kopa.com

Forum brings together the insurance industry, the World Bank, the UN and donor governments. It aims to gather together the science that we all work on, the capital that we can bring to bear, as well as the policy frameworks needed to deliver the Sustainable Development Goals.

Science will only be truly effective if we create such mechanisms and institutions at a global as well as local level. DFID is providing vital leadership in this task, creating institutions based here in the UK which can provide access to insurance and other mechanisms for developing and emerging world governments. Delivery will be absolutely dependent on science and its application. □

The debate

How can local innovation in Africa be encouraged? One barrier may be the tendency for too many local scientists in African countries to be sucked into government roles, rather than into research institutions (though having scientists in government also has advantages).

As long as corruption and ineffective local financial systems continue in many African countries, and implementation of ideas remains poor, progress in the real world will be limited. Research into how to construct genuinely effective local financial models will pay dividends.

Government ODA spending could fund more fundamental research, as well as projects focused on practical effects on the ground. However it is clear that spending has to benefit the poorest people

in the world, and is therefore inevitably mostly downstream. Other government scientific spending could be used in more upstream areas. There is a need to bring together efforts from different Government Departments.

Are there cultural barriers in some fields, such as engineering, discouraging people from going into research on development issues? The academic community as a whole should recognise the great opportunities there for good research in development, given the availability of significant new funding. Excellent science is genuinely needed, and research results can make a huge difference to the world. New partnerships are also required, and are beginning to materialise, including with institutions like Innovate UK. The prospects are exciting. □

The discussion after the formal presentations focussed on ways to increase local effectiveness and ways to increase interest in development issues.

DATA PROTECTION

The FST Learned & Professional Societies Annual Lunch took place on 30 September 2016. **Jonathan Bamford**, Head of Strategic Liaison at the Information Commissioner's Office (ICO), spoke about the new EU General Data Protection Regulation.

The shape of things to come

The EU General Data Protection Regulation (GDPR) is due to take effect in May 2018. It is up to the Government, though, to decide on post-Brexit arrangements and these extend to data protection and the GDPR. It is looking unlikely, though, that the UK will have left the EU before that date so the GDPR will take effect. We do not yet know what the relevant law will look like.

Over 30 years, there has been a significant change in the approach to data protection laws. Often regarded as red tape in early days, they are now seen as a cornerstone of the digital economy. It is now accepted wisdom that we need laws to ensure that the lifeblood of that economy – personal information – is properly safeguarded and, just as important, that the public has trust and confidence in those who use it.

Public trust

Data protection laws will remain essential as the risks we face are not going away and the need to inspire public trust and confidence is not going away. Laws will be needed that are modern and contain robust safeguards. It is not yet clear how closely these will mirror the GDPR but in order to be adequate they cannot be that far away.

The Information Commissioner's Office (ICO) has produced a set of 12 initial steps to help organisations get their preparations under way. It has also published an overview flagging key changes to the familiar existing Data Protection Act (DPA) and Directive.

There are many aspects of the new Regulation that will be recognised as tried and trusted features incorporated in current law. The new measure applies to information about individuals, has a series of standards/principles, gives rights to individuals and sets out sanctions for

non-compliance. There are limitations and exemptions and the new Regulation even specifies the need for an independent national supervisory authority.

The ICO guidance documents describe who the legislation covers, specifically the controllers and processors of data. They cover what information is covered by data protection legislation (and in particular what categories are defined as 'sensitive personal data'). Essentially these are same categories as the DPA but there is a specific mention of biometric genetic data.

The responsibilities of data controllers include the demonstration of compliance. There are sections on lawful processing of data. Note that the Regu-

**It is looking unlikely
that the UK will have left
the EU before the GDPR
takes effect.**

lation does not apply to public authorities as these should have their own legal basis for their activities in this area.

The Regulation also sets out rights for individuals to be informed about issues such as the collection, access, erasure and other aspects of data manipulation.

There are, however, a number of detailed areas where there are differences. In terms of scope, the definition of Personal Data is made clearer: it now covers online IDs and physiological information. Regarding pseudonymised data (where data is created by taking identifying fields within a database and replacing them with artificial identifiers, or pseudonyms) the approach is similar to the Data Protection Act but with a lighter touch. Data processors are also brought within scope.

Individuals will now have the right to

object to profiling and decisions on such objections will have legal effect. There are also implications for erasure and portability. Subject access requests (SAR) will be free and there will be a deadline of one month for dealing with them.

Consent will in future have to be specific, freely-given and informed – and evidence of such must be kept. Information maintained on children aged between six and 13 must have parental/guardians' consent.

International consistency

There are strengthened penalties available under the new Regulation. Maximum fines of €20 million or up to 4% of global annual turnover can be levied for the most serious infringements. There are also significant penalties for non-notification of breaches.

The view of the new Information Commissioner, Elizabeth Denham, is that data protection law does not stand in the way of business success. There is no conflict between privacy and innovation: the two can complement each other. The use of personal information is essential to modern services and can be beneficial for all.

An ICO survey earlier in the year showed that only one in four UK adults trusts businesses with their personal data. The Information Commissioner's stated fundamental objective is to build a culture of data confidence in the UK.

No matter the future legal relationship between the UK and Europe, personal information will need to flow. Whatever the changes, the need for data protection laws will not go away; it is part of modern life and essential for citizen trust. □

For more information about preparing for the introduction of the GDPR: <https://ico.org.uk/for-organisations/data-protection-reform/guidance-what-to-expect-and-when>

Lord Jenkin of Roding Hon FRSE

7 September 1926 – 20 December 2016

Charles Patrick Fleeming Jenkin, Lord Jenkin of Roding, was Chairman of the Foundation for Science and Technology from 1997 till 2006, after which he remained its President until 2015.

He was born in Edinburgh in 1926. Science and engineering flowed through the family, even though in early life his interests lay elsewhere. His father, Charles Jenkin, was an industrial chemist. Patrick spent his early life in California as his father had become Superintendent of Refineries for Shell. His grandfather, also Charles, had set up the department of engineering science at Oxford University in 1908. His great-grandfather, Henry Fleeming Jenkin, was the inventor of the cable car and professor of engineering at Edinburgh University.

In 1945, Patrick Jenkin was commissioned into the Queen's Own Cameron Highlanders and served in Trieste, northeast Italy. He took a first in law at Jesus College, Cambridge, where he met Geoffrey Howe, with whom he later shared a flat in Belsize Park.

He was called to the Bar at Middle Temple as a Harmsworth scholar in 1952, starting in divorce law but later moving to tax. That year he married Monica (née Graham), a violin teacher. She and their four children survive him.

In 1963 he was selected to fight the seat of Woodford, Essex, in succession to Sir Winston Churchill. He was elected at the 1964 election and held the Wanstead and Woodford constituency until 1987.

Edward Heath made him frontbench spokesman on finance and trade in 1965, and in 1970, with the Conservative party in government, he appointed Patrick Jenkin as Financial Secretary to the Treasury, then Chief Secretary to the Treasury. He was appointed Minister for Energy during the three-day week crisis in the final weeks of the Heath Government in 1974.

Although a supporter of Heath in the leadership election won by Margaret



The Rt Hon the Lord Jenkin of Roding

Thatcher, she made him frontbench spokesman for energy and then for health and social security. When the Conservatives returned to power in 1979, he was appointed to run the Department for Health and Social Services (DHSS). Among the reforms he initiated was to start the decentralisation of the NHS and also to link state pension increases to rises in prices.

In 1981 he became Industry Secretary, beginning the process of privatising what has become BT, the process being completed in 1984 by Norman Tebbit.

After the 1983 election, he became Environment Minister. Here his primary task was to curtail the power of local government, especially the big Labour authorities like Liverpool under Derek Hatton and Ken Livingstone's Greater London Council (GLC). However, as the clampdown on local authorities impacted equally on Conservative authorities, support was ebbing away.

While at the environment ministry, he also commissioned an inquiry into the reform of the rating system which ultimately resulted in the poll tax, a fiercely opposed policy which was eventually abandoned.

The lack of success in reforming local government led to his replacement by Kenneth Baker in 1985. Two years later, at the 1987 election, he stood down from the House of Commons and was appointed to the House of Lords.

A member of the House of Lords

Select Committee on Science and Technology, Lord Jenkin chaired the Committee's enquiry into Science and Society. The report was published in 2000.

Its introduction begins: "Society's relationship with science is in a critical phase. Science today is exciting, and full of opportunities. Yet public confidence in scientific advice to Government has been rocked by BSE; and many people are uneasy about the rapid advance of areas such as biotechnology and IT – even though for everyday purposes they take science and technology for granted. This crisis of confidence is of great importance both to British society and to British science." Substitute 'GMO' for 'BSE' and 'cyber security' for 'IT' and the challenge seems very modern.

Among the enquiry's many important recommendations was that "direct dialogue with the public should move from being an optional add-on to science-based policy-making and to the activities of research organisations and learned institutions, and should become a normal and integral part of the process."

At the end of 2014, Lord Jenkin became the first member of the House of Lords to take advantage of legislation which allowed peers to retire.

Lord Jenkin was very proud to have his contribution to science recognised by his election as an Honorary Fellow of The Royal Society of Edinburgh in 2001.

As Chairman of the Foundation, he encouraged questioners to speak about doubts they might have about scientific consensus, and to be confident that these concerns would not be disregarded if they were not experts themselves.

In an editorial for *FST Journal*, as he stepped down from the Presidency of the Foundation in 2015, he summed up his understanding of the importance of science: "I am not a scientist, but as a layman I have never doubted the importance of scientific research – and of its translation into industrial and commercial applications – for the economy of the UK." □

How can skill levels be raised to meet the needs of society and the economy?

1 March 2017

Sir Mark Walport FRS FMedSci, Government Chief Scientific Adviser, Government Office for Science
Sir Adrian Smith FRS, Chair of the Smith Inquiry into mathematics education for 16 to 18 year olds and Vice Chancellor of the University of London
Dame Judith Hackitt DBE FREng, Chair, EEF (formerly the Engineering Employers' Federation)
Stephen Metcalfe MP, Chair, House of Commons Select Committee on Science and Technology [Panellist]

Making good use of science and innovation in overseas development programmes

14 December 2016

Professor Charlotte Watts FMedSci, Chief Scientific Adviser and Director Research and Evidence Division, Department for International Development
Jon Ridley, Head, M-KOPA Labs, M-KOPA Solar
Rowan Douglas CBE, Chief Executive, Capital, Science & Policy Practice and Chair, Willis Research Network, Willis Towers Watson

The opportunities for and threats to the research and innovation communities from Brexit

16 November 2016

Sir Venki Ramakrishnan PRS FMedSci, President, The Royal Society
Professor Louise Richardson FRSE, Vice-Chancellor, University of Oxford
The Rt Hon the Lord Willetts, House of Lords
Dr Hermann Hauser KBE FRS FREng, Co-Founder, Amadeus Capital Partners [Panellist]
Professor Madeleine Atkins CBE, Chief Executive, Higher Education Funding Council for England [Panellist]

The vision for UK Research and Innovation (UKRI)

9 November 2016

Sir John Kingman KCB, Chair, UK Research and Innovation, Department of Business, Energy and Industrial Strategy
Professor Dame Julia Goodfellow DBE FMedSci, President, Universities UK and Vice-Chancellor, University of Kent
Phil Smith, Chair, Cisco UK & Ireland, Chair, Innovate UK and Chair, The Tech Partnership

Health, happiness and wellbeing: supporting the transition from adolescence to adulthood

26 October 2016

Dr Joanne McLean, Research and Development Manager, Scotland, Mental Health Foundation
Dr Helen Sweeting, Reader, MRC/CSO Social and Political Health Sciences Unit, University of Glasgow
Lord Layard FBA, Director, Wellbeing Programme, Centre for Economic Performance, London School of Economics and Political Science
Catherine Calderwood FRCP, Chief Medical Officer for Scotland, Scottish Government [Panellist]

The National Flood Resilience Review: the lessons learned from recent flood events in the United Kingdom

12 October 2016

Professor Dame Julia Slingo DBE FRS, Chief Scientist, Met Office
Dr Doug Wilson, Director, Scientific & Evidence Services, Environment Agency
Simon Warsop, Chief Underwriting Officer, Personal Lines, Aviva
Professor Charles Godfray CBE FRS, Chair, Defra Science Advisory Council and University of Oxford
Professor Bas Jonkman, Professor of Integral Hydraulic Engineering, Delft University of Technology
Katharine Hammond, Director, Civil Contingencies Secretariat, Cabinet Office

What is the value to the economy of the finance and insurance sectors?

6 July 2016

Anne Richards CVO CBE FRSE, Chief Executive, M&G Investments
John Nelson, Chairman, Lloyd's of London
Professor John Kay CBE FRSE FBA, Economist and Financial Times Columnist

How should universities and Research Councils proactively respond to gender bias in success rates in grant applications?

22 June 2016

Professor Paul Boyle CBE FBA FRSE, President and Vice-Chancellor, University of Leicester
Professor Henrietta O'Connor, Deputy Head of College of Social Science, Arts and Humanities and Professor of Sociology, University of Leicester
Linda Holliday, Director of Capacity and Skills Development, Medical Research Council

Is a paradigm shift taking place in the ways individuals and organisations access, analyse and protect data?

25 May 2016

Professor Sir Nigel Shadbolt FREng, Chairman and Co-Founder, The Open Data Institute
Dr Mike Lynch OBE FRS FREng, Founder, Invoke Capital
Professor David Hand OBE FBA, Chief Scientific Advisor, Winton Capital
Baroness O'Neill of Bengarve CH CBE FBA HonFRS FMedSci, House of Lords [Panellist]

The pros and cons of EU membership for UK research programmes in private enterprises and public sector organisations

3 May 2016

The Lord Hennessy of Nympsfield FBA, Member, House of Lords Science and Technology Select Committee, House of Lords
Viscount Ridley FMedSci FRSL, Member, House of Lords Science and Technology Select Committee, House of Lords
Dame Jocelyn Bell Burnell DBE FRS FRSE FRAS FInstP, President, The Royal Society of Edinburgh
Sir Emyr Jones Parry GCMG FInstP FLSW, President, The Learned Society of Wales

Building effective and efficient infrastructure for the UK

27 April 2016

Tony Meggs, Chief Executive, Infrastructure and Projects Authority, Cabinet Office
The Rt Hon The Lord Adonis, Chair, National Infrastructure Commission
Terry Morgan CBE, Chairman, Crossrail
Darren James, Managing Director, Infrastructure, Costain [Panellist]

Using science to authenticate, verify or assure the identity of people and things

2 March 2016

Sir Mark Walport FRS FMedSci, Government Chief Scientific Adviser
Dr Derek Craston, Government Chemist and Managing Director of Science and Innovation at LGC
Professor Dame Sue Black DBE FRSE, Professor of Anatomy and Forensic Anthropology at the University of Dundee

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