Lasers reveal the secrets of photosynthesis
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About BBSRC

BBSRC invests in world-class bioscience research and training on behalf of the UK public.

Our aim is to further scientific knowledge to promote economic growth, wealth and job creation, and to improve quality of life in the UK and beyond.

Funded by Government, BBSRC invested over £473 million in world-class bioscience in 2015-2016. We support research and training in universities and strategically funded institutes. BBSRC research and the people we fund are helping society to meet major challenges, including food security, green energy and healthier, longer lives. Our investments underpin important UK economic sectors, such as farming, food, industrial biotechnology and pharmaceuticals.

Further details about BBSRC, our science and our impact can be found at www.bbsrc.ac.uk

Strategically funded institutes

- Babraham Institute
  www.babraham.ac.uk
- The Pirbright Institute
  www.pirbright.ac.uk
- Institute for Biological, Environmental and Rural Studies (Aberystwyth University)
  www.aber.ac.uk/en/ibers
- Institute of Food Research
  www.ifr.ac.uk
- John Innes Centre
  www.jic.ac.uk
- Roslin Institute (University of Edinburgh)
  www.roslin.ac.uk
- Rothamsted Research
  www.rothamsted.ac.uk
- Earlam Institute
  www.earlham.ac.uk

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About BBSRC Business

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For regular news about BBSRC and the outcomes and impacts of BBSRC-funded research visit www.bbsrc.ac.uk/news
In this issue

Chief Executive Professor Melanie Welham emphasises how important it is for the Research Councils to collect the impacts and outcomes of research.

As you may well know, as a public body, we’ve been restricted on our communications in the run-up to the election, and so our latest version of Business magazine is a hybrid of both spring and summer. We are now clear of so-called ‘purdah’, and a lot has happened in bioscience in the last several weeks.

In May, BBSRC held our annual Innovator of the Year awards and once again we had a fantastic set of finalists. This year we introduced two new categories – one for International Impact and the other for Early Career Researchers. It was a very hard-fought competition – with the selection panel decision arriving minutes before the event began – but the overall winner’s crown went to Shelby Temple. He turned his work studying the eyes of various sea creatures into a fast, simple and affordable way to assess a risk factor for age-related macular degeneration – the leading cause of incurable blindness in the developed world.

What’s so great about Shelby’s innovation is that it is built directly on frontier bioscience discoveries, and Shelby very much deserved to win for recognising the potential for his work to improve lives. You can see more on pages 16 and 17.

A vision for UK research and innovation
Professor Sir Mark Walport, Chief Executive Designate of UK Research and Innovation, has given a speech outlining the vision, objectives and next steps in development for the organisation on 4 July. Sir Mark explained that the success of UK Research and Innovation will ultimately be measured through the impact it delivers: through pushing the frontiers of human knowledge, delivering economic impact and creating better jobs and by supporting society to become stronger, healthier and more resilient.

More policy briefs and frontiers
We were very pleased to see a positive sentiment online (“BBSRC rocks!”) in response to our new policy pages, where colleagues (in that instance a meeting with Bill Gates) detailed their work with partners and policy-makers. In this issue on page 27 I’d particularly like to highlight BBSRC’s role in supporting technicians, technical specialists and postdocs.

And, after our 8-page image-led Frontier Bioscience special last issue, it’s great to see more but with a person-centric twist. I loved the colourful cells, organisms and microscope images from the last issue, but behind every picture there are often several people! So on pages 20 to 23 you can see more human-centric examples of world-class frontier bioscience.

“I want to thank all researchers and students who are providing outcomes data for the Research Councils to use via Researchfish.”
BBSRC researchers recognised in the Queen’s Birthday Honours list 2017

Twice a year, the Queen awards honours to recognise individuals for their service to the UK. A number of members of the scientific and research community have been recognised in the 2017 Birthday Honours list, reflecting the importance of discovery and innovation to the UK.

Amongst those honoured this year is Professor Christopher Trevor Elliott, Pro-Vice Chancellor, Faculty of Medicine, Health and Life Sciences, Queen’s University, Belfast. Professor Elliott was awarded Officer of the Order of the British Empire, OBE, for services to the Agricultural and Food Supply Chain.

Charles Godfray, Hope Professor of Zoology, University of Oxford. Professor Godfray was knighted for services to scientific research and for scientific advice to the government. He has strong links with both BBSRC and NERC.

Professor Claire Alice Mary Domoney, Head of Department, Metabolic Biology, at the BBSRC strategically funded John Innes Centre, was awarded an MBE for services to crop science and improvement of the pea crop in the UK.

Professor Laura Green, Head of the School of Life Sciences, The University of Warwick, received an OBE for services to the Health and Welfare of Farmed Livestock.

Roy Stephen, Assistant Peer Review Officer, Science Group, BBSRC, received a BEM for services to the Malayalee Association, UK Kranaya Catholic Association and to the community in Swindon, Wiltshire.

British honours are awarded on merit, for exceptional achievement or service and are published twice a year – at New Year, and in mid-June on the date of the Queen’s official birthday.

Defra approves new GM wheat trial

Rothamsted Research granted permission to carry out new field experiments.

Scientists at Rothamsted Research, in collaboration with researchers at the University of Essex and Lancaster University, have developed wheat plants that convert light energy into plant biomass more efficiently, potentially leading to higher-yielding plants. The new trial is set to test whether these GM wheat plants photosynthesise more efficiently in the field for a higher-yielding crop.

The risk assessment was reviewed by the independent Advisory Committee on Releases to the Environment (ACRE), and a 48-day public consultation was carried out by Defra. In addition to the formal consultation run by ACRE, Rothamsted scientists have answered questions directly from the public and special interest groups that have been interested in the research project and the trial.
UK’s bioeconomy benefits from £319 million investment

Substantial funding keeps UK at the forefront of meeting global challenges in feeding a growing population, replacing fossil fuels and healthy ageing.

A substantial £319 million investment provided by the government is to ensure the UK’s bioscience research base remains internationally competitive.

“Through our modern Industrial Strategy, we will use all the tools at our disposal to stimulate growth in every part of the country, ensuring that prosperity is more evenly spread,” said Business and Energy Secretary Greg Clark. “Science, research and innovation are at the heart of the Industrial Strategy which is why we’re providing more than £4.7 billion of additional funding over the next five years, including the £319 million for bioscience research.”

The investments, from the Department for Business, Energy and Industrial Strategy, will allow BBSRC to back institutes across the country for the next five years. The funding will be awarded through 17 strategic programmes to institutes – in some cases across institutes and other research organisations. The awards follow a robust, independent and international peer review process.

“BBSRC’s strategic funding investments in research, people and vital national capabilities at world-leading bioscience institutes will deliver new knowledge and innovation and help realise the potential of a bio-based economy,” said Professor Melanie Welham, BBSRC Chief Executive. “The positive impacts in food, agriculture, energy, materials and health will help drive economic growth and deliver benefits to society across the UK and beyond.”

The investments have a vital role in supporting BBSRC’s mission to further scientific knowledge, promote economic growth and job creation in important sectors such as food, farming, renewables and pharmaceuticals – delivering an even more productive UK bioeconomy.

Diamond’s infrared beamline steps up to living cells research

Upgrade could help chemotherapy studies

Diamond’s Multimode Infrared Imaging and Microspectroscopy (MIRIAM) beamline (B22) is launching a new upgrade to offer researchers unique insights into cell metabolism and the effects of drugs and other compounds on living cells.

By upgrading to containment level 2 (CL2), the combination of the beamline with the associated Cell Culture Lab now provides internationally leading capabilities in cell biology and biomedical applications for both academia and industry. To celebrate, Professor Melanie Welham visited the beamline.

“Infrared light is capable of revealing the molecular structure of organic matter, which is invisible in standard microscopy, by using vibrational signals – the so-called ‘IR fingerprint’ – to identify and quantify molecules of interest at microscopic scale,” explains Dr Gianfelice Cinque, Principal Beamline Scientist.

“UK researchers across the biosciences continue to push the frontiers of our knowledge and understanding, providing opportunities to tackle the global challenges we face across food, energy and healthcare,” said Professor Welham. “Advanced, specialised facilities and capabilities are an essential part of maintaining world-leading bioscience and the addition of the Multimode Infrared Imaging and Microspectroscopy beamline will strengthen the UK as a centre of scientific excellence.”

The extremely bright synchrotron infrared light at Diamond allows fast and sensitive experiments on the inner machinery of living cells, as well as biochemical actions, for example those of a drug at the single cell level.

“This is particularly relevant for example in chemotherapy studies,” continues Dr Cinque, “as the different responses of diverse cancer types to specific drug molecules can be pinpointed at a single-cell level.”

The beamline also offers access to an adjacent cell culture lab, allowing a comprehensive approach – from sample preparation to analysis – key to helping researchers to directly detect the early stages of biochemical change in living cells in real time.
Headlines

Science Minister launches biotech spin-out Leaf Systems International

Company uses novel technology to produce useful proteins in plants.

The UK’s leading global position in bioscience innovation was further strengthened as Jo Johnson, Minister of State for Universities, Science, Research and Innovation, launched Leaf Systems International Ltd at the John Innes Centre, which receives strategic funding from BBSRC.

Leaf Systems uses a novel efficient, safe and simple system – Hypertrans – to quickly produce proteins in plants such as vaccines, antibodies or enzymes. The proteins can then be extracted through crushing the leaves and purifying the product. The speed of the system means that it can rapidly produce large amounts of protein, so it is well suited to rapidly responding to emergencies like pandemics.

The science behind Leaf Systems was developed, with BBSRC investment, at the John Innes Centre and its creators, Professor George Lomonossoff and Dr Frank Sainsbury, won the BBSRC Innovator of the Year award for the background work in 2012.

Lomonossoff says the opening represents the culmination of many years of fundamental research. “There is something rather magical about seeing these efforts being translated into the formation of a company, the construction of a building and the potential for great impact.”

Johnson says the pioneering technology is an example of British ingenuity. “Using plants to produce flu vaccines will benefit millions of people across the country,” he said, adding that science will be at the core of the Government’s new Industrial Strategy.

13 projects funded for long-term sustainable production of rice

UK researchers to collaborate on Newton Fund’s UK-China-Thailand-Philippines-Vietnam Sustainable Rice Programme.

Rice is the staple food of over half the world’s population. It is the predominant dietary energy source for 17 countries in Asia and the Pacific, nine countries in North and South America and eight countries in Africa.

The Sustainable Rice Programme has enjoyed a high profile within the Newton Fund, due to its innovative mix of regional and country approaches, addressing core challenges for global and regional food security.

The 13 projects funded cover a broad range of issues such as rice quality, resource use and photosynthetic efficiency, resilience to biotic and abiotic stresses, and novel research tool and technology development – all of which have the potential to enhance the sustainable production of rice.

Workshop: Policy Internships

Research Council-funded PhD students, including those funded by BBSRC, are being offered the opportunity of a 3-month internship to work in one of a selected group of highly influential science policy organisations.

Typically, students on these internships will be expected to: produce a briefing paper; participate in a policy inquiry; and/or organise a policy event.

Successful BBSRC applicants on four-year Doctoral Training Partnership (DTP) studentships will use this as their Professional Internship for PhD Students (PIPS). Successful BBSRC applicants from other grants must undertake their three-month internship during their four-year period of PhD funding.

The deadline to apply is 10 August 2017, 4pm.

For more information visit: ow.ly/4X9h30cTK55
Headlines

New line of fast-growing broccoli

Scientists at the John Innes Centre (JIC) are developing a new line of fast-growing sprouting broccoli that goes from seed to harvest in just 8-10 weeks. It has the potential to deliver two full crops a season in-field, or it can be grown all year round in protected conditions, adding resilience to the UK food market because growers would no longer rely on seasonal weather conditions.

Recent adverse weather in Murcia, Spain, led to a shortage of courgettes and iceberg lettuce as well as broccoli. The UK’s reliance on imported vegetables is particularly acute, with only 23% of our fruit and vegetables grown in the UK.

The innovation builds on the wealth of fundamental research carried out by Professor Dame Caroline Dean and her lab on vernalisation – the need for some plants to experience a period of cold weather before they can flower, which affects yield.

Dr Judith Irwin from JIC (pictured below) says this is a very exciting development. “It has the potential to remove our exposure to seasonal weather fluctuations from crop production. This could mean broccoli – and in future other vegetables where the flower is eaten, for example, cauliflowers – can be grown anywhere at any time, enabling continuous production and supply of fresh local produce.”

Boosting the impact of animal science innovations

Innovations that improve the health of farmed animals and raise agricultural productivity will be brought to market with the support of a £10 million investment.

The investment in the new company, Roslin Technologies, will develop business opportunities arising from The University of Edinburgh’s world-leading animal science research.

The deal will allow researchers to explore the commercial potential of technologies that enable low-cost manufacturing of new medicines using chicken eggs.

Find out more: ow.ly/gmdE30cTLn2

Priming Food Partnerships to address food and drink industry challenges

£1M awarded to stimulate technological advances to deliver healthier nutrition for consumers.

Three new multidisciplinary projects involving collaborations between academic and industry partners have been recommended for funding. The grants were funded by the Research Councils UK’s ‘Priming Food Partnerships’ initiative that is supported by four councils: BBSRC, MRC, EPSRC and ESRC. The initiative supports pre-competitive research, with the ultimate aim of stimulating innovative research and technological advances of relevance to the food industry.

The projects will develop models of digestion to inform the design of novel food products, generate multidisciplinary approaches to developing high-protein foods for healthy ageing, and investigate the effects of reducing the fat content of foods on feelings of ‘fullness’.

Speaking on behalf of Research Councils UK, BBSRC Chief Executive Professor Melanie Welham reiterated that food manufacturing is the UK’s single largest manufacturing sector. “Some of the UK’s most forward-thinking companies and researchers have come together to develop innovative research projects,” she says. “We hope that this initiative will grow, leading to more partnership working between academia and industry.”
Professor Sir Mark Walport outlines the vision for UK Research and Innovation

Professor Sir Mark Walport, Chief Executive Designate of UK Research and Innovation, has given a speech outlining the vision, objectives and next steps in development for the organisation.

UK Research and Innovation will be formed in April 2018, bringing together the research councils, Innovate UK and a new body, Research England. The organisation’s ambition is to be the best research and innovation agency in the world.

Speaking in Westminster to a broad audience of research and innovation stakeholders, Sir Mark highlighted the strengths of the UK’s current research and innovation system and bodies. He also detailed the challenges and opportunities arising from disruptive change in society, technology, research and business that mean the UK needs to develop new approaches and structures.

Sir Mark commented: “We are building on component parts of the funding landscape which, individually, are very strong, but there is considerable untapped potential for the whole to be much more than the sum of the parts. We need to stimulate and reward audacity, ambition and agility, where imagination and innovation are actively encouraged and important proposals do not fall foul of artificial divides.”

Sir Mark explained that the success of UK Research and Innovation will ultimately be measured through the impact it delivers: through pushing the frontiers of human knowledge, delivering economic impact and creating better jobs and by supporting society to become stronger, healthier and more resilient.

International research tackles global issues

Leading experts from the UK and in developing countries across the world are joining forces to tackle some of the most serious global challenges.

GCRF Research Councils UK Collective Fund is supporting one of the most ambitious international research programmes ever created, £225 million has been invested to address challenges in fields such as health, humanitarian crises, conflict, the environment, the economy, domestic violence, society, and technology.

Projects consist of UK and developing-country researchers, working together as equal partners. Several BBSRC-led projects focus on animal health, sustainable food systems and preserving biodiversity.

Speaking at the launch of the GCRF at the Sainsbury Lab in Cambridge, Jo Johnson, Minister for Universities and Science, said: “From healthcare to green energy, the successful projects receiving funding highlight the strength of the UK’s research base and our leadership in helping developing countries tackle some of the greatest global issues of our time. At a time when the pace of scientific discovery and innovation is quickening, we are placing science and research at the heart of our Industrial Strategy to build on our strengths and maintain our status as a science powerhouse.”

Pausing on a brief tour of the Sainsbury Laboratory; Professor Henrik Jönsson, Professor Howard Griffiths, Jo Johnson – Minister for Universities, Science, Research and Innovation, Dr Amanda Collis – BBSRC Executive Director, Science and Professor John Danesh.
A state-of-the-art robotics suite, worth over £1 million, will enable scientists at the Synthetic Biology Research Centre (SBRC) – University of Nottingham to engineer a number of bacterial strains and turbo charge the creation of valuable and novel chemicals and fuels from waste materials.

“It’s a fantastic addition to our research capability because the robots will allow us not only to automate many routine procedures but to carry out 100s of experiments in parallel – something we can’t do currently,” Nigel Minton, Director of the SBRC-Nottingham.

With its modular build, the robotics platform is well suited to help individual researchers at different stages of their work especially when large numbers of samples need to be processed. For example, a researcher may need to test hundreds of primer pair combinations to select a desired PCR product; or they may need to screen hundreds of bacterial colonies in search of a desired DNA fragment or a gene with specific properties.

Currently, these types of experiments can take weeks or even months to accomplish. Use of the robotics platform can reduce the timeframe to less than a week. Additionally, with built-in data acquisition, a reporting tool and a barcoding system, scientists can easily access and extract all of the necessary information on protocols or samples at any point in the future.

“This frees up our specialists and highly skilled research teams to focus on more academically challenging aspects of our work using bacteria to make chemicals and fuels for us sustainably,” Minton explained.

A focus of the SBRC is engineering a microbial chassis able to grow on single-carbon waste gases, such as carbon dioxide and carbon monoxide, to produce useful platform chemicals that are currently derived from fossil fuels. Capitalising on native bacterial CRISPR systems, a major component of the bacterial adaptive immune system, brings about defined modifications to the genetic make-up of our process organisms.

The robotics platform enables automation of common pipelines in molecular biology including plasmid assembly, transformation of bacteria, colony picking and screening. SBRC-Nottingham will work with other researchers in the university and in the wider area to fully utilise the high-throughput capabilities of the equipment. The platforms contain liquid-handling robots, thermocyclers, a colony picker and spreader, incubators, shakers and a plate reader, connected by a robotic arm.

The time taken to understand and subsequently exploit these systems for advanced engineering is considerably shortened through the use of the robots.
Secrets of photosynthesis light the way

Decade-long investment from BBSRC opens up new frontiers in ultrafast protein dynamic imaging.

“Let there be light!” This phrase, whether you’re religiously inclined or not, has equivalents in many languages and is the motto of more than 40 educational institutions across the world. It can be seen as recognition that light is the powerhouse that makes all life on earth possible via photosynthesis, the process by which plants make energy from light photons.

However, like many products of natural evolution, photosynthesis is a miraculously efficient but not perfectly efficient process. There are slightly different forms of it in different plant groups across the world: the cluster of photosynthetic enzymes from the wheat in your daily bread is different from that in maize, another of the world’s most important food crops.

For decades, scientists have taken a keen interest in elucidating exactly what is happening in these photosynthetic enzymatic complexes at the molecular level. Now, new technology and techniques are yielding results that could inform work by other researchers in everything from engineering hybrid and artificial photosynthesis to manufacturing even more efficient solar cells.

“Natural photosynthesis is extremely complicated and many individual pigments are involved to collect and eventually chemically store the energy of single photons,” says Dr Jasper van Thor based at Imperial College London. “In order to bring experiment and theory closer together, we developed the ability to find real-space, structural information of the flow of energy in photosynthesis.”

Using BBSRC funding, van Thor and colleagues have developed a unique imaging system that is unrivalled anywhere in the world, built and developed over more than seven years, together with necessary new theory, which can see photosynthetic machinery embedded in crystals for the first time. This allows imaging at the femtosecond level: that’s with a time resolution of femtoseconds – a staggering one quadrillionth, or one millionth of one billionth, of a second!

Fiat lux

The researchers wanted to answer fundamental questions about photosynthesis: where does the ‘bottleneck’ for the process occur? After that, what is it about these structures that makes this happen? How can this knowledge best be utilised for future material science and green energy research?

“Decades of photosynthesis research have divided the field, resulting in two opposing possibilities,” says van Thor.

Dr Jasper van Thor and PhD student Noura Zamzam look over their ultrafast laser imaging equipment.

Thomas Angus/Imperial College London
The debate has revolved around whether processes in parts of enzymes called reaction centres contain the bottleneck, or whether the energy transfer to the reaction centres is the bottleneck. It’s a bit like a supermarket trip: is it shuffling down the queue or the actual transaction time at the till that’s slowing up your total shopping time? (See box ‘Photonic cradle’ for more details.)

“We discovered that, with ultrafast infrared measurements of single crystals of Photosystem II core complexes [where the key photosynthetic reactions take place], we could retrieve real-space information on femto- and picosecond timescales of the energy transfer process,” says van Thor. “The overall bottleneck is the energy transfer step to the reaction centre.”

This, adds van Thor, confirms advanced structure-based theory previously developed by one of his collaborators and Nature Communications paper co-author Thomas Renger from JKU-Linz University.

**Dividing the light from the darkness**

Researchers across the world have been trying to answer this question for decades. So how did van Thor and colleagues manage it? It took time, patience and investment from BBSRC and other funders, namely the The Leverhulme Trust. Altogether, the work took more than seven years from conception, proposal, research and theory through to publication and press release.

To realise real-time dynamic images of energy transfer in photosynthesis, van Thor and collaborators brought together three areas of research. “By marrying femtosecond spectroscopy, X-ray crystallography and chemical physics theory, we showed that it was possible to orient micrometre-sized crystals with known X-ray crystallographic index,” he explains. “Then we used this to make sensitive time-resolved infrared measurements of tiny crystals, applying optical crystallography analysis in the X-ray crystallographic frame. Finally, we extended the structure-based theory of light harvesting to apply it to single crystal measurement.”

The result can be described as a ‘movie’ of energy transfer, running over a full period of a nanosecond (one thousand-millionth of a second), with femtosecond time resolution.

“BBSRC supported my proposal and vision,” says van Thor. “I developed the scientific case to construct a world-unique instrument specifically for the interesting problem of photosynthesis. Because I was proposing to construct an instrument that did not yet exist elsewhere, proof of principle needed to be shown. The resulting instrumentation constructed was world-unique for several characteristics.”

The resulting instrument is a world-first: a collection of custom lasers, systems and non-linear crystals that has the ability to provide a very brief visible light pulse, followed by a very brief mid-infrared pulse, which can obtain a measurement in a very small spot size. “All together, we can make very sensitive femtosecond infrared structural measurements of micrometre-sized protein crystals,” says van Thor.

**Tripping the light fantastic**

Now that a new frontier has been reached and breached with van Thor’s BBSRC-funded work, the ultimate goals of understanding the underlying physics of light harvesting can be utilised to design better artificial and hybrid photosynthesis and also solar cell technology, which is an area other BBSRC-funded researchers are working on.

And it’s not just limited to the proteins involved in photosynthesis. The technique and equipment can be applied to other proteins and enzymes. “Having subsequently developed the necessary theory and analysis, we now have the special capability at Imperial College London to execute and understand ultrafast infrared-optical crystallography as a structurally sensitive method to probe protein dynamics,” says van Thor.

This means it could be used for imaging and understanding cell receptors that control what drugs and molecules enter and exit cells, or in drug design to see how well compounds dock with targets, or how energy is formed in mitochondria within cells – the applications are many in the world of bioscience, because proteins are where the action is. Fortunately, van Thor’s lab has a new BBSRC grant to further explore and develop this fledgling ultrafast imaging field.

“We are also performing femtosecond time-resolved X-ray crystallography which can work for reactive systems,” says van Thor. “In the end we want to know how proteins work, and for technical reasons the crystalline environment must be chosen to answer the questions that we are asking, whether we use infrared, visible, or X-ray methods to visualise ultrafast dynamics in time and space.”
Molecular mortar of strong plant cell walls decoded

Finding could hold the key to greener paper production and future wooden skyscrapers.

A father-and-son team (see page 14) and colleagues from the University of Cambridge and the University of Warwick have used advanced imaging to unravel the secrets of plant cell walls and how the molecules within them intertwine so strongly.

The two most common large molecules (polymers) found on Earth are cellulose and xylan, both of which are found in the cell walls of materials such as wood and straw. They play a key role in determining the strength of materials and how easily they can be digested.

To make such relatively rigid structures in the plant world, scientists knew these cellulose and xylan must stick together. But how this occurs has, until now, remained a mystery: xylan is a long, winding polymer with so-called ‘decorations’ of other sugars and molecules attached, so how could this adhere to the thick, rod-like cellulose molecules?

At the University of Warwick, Professor Ray Dupree used solid-state nuclear magnetic resonance (ssNMR) imaging to reveal plant structures at the nanoscale, growing their plants in an atmosphere enriched with a special form of carbon dioxide – carbon-13 dioxide – that the scanner can better see.

“What we found was that cellulose induces xylan to untwist itself and straighten out, allowing it to attach itself to the cellulose molecule,” says Professor Paul Dupree (Ray’s son) from the University of Cambridge. “It then acts as a kind of ‘glue’ that can protect cellulose or bind the molecules together, making very strong structures.”

The findings could be of major benefit to the paper and packaging manufacturing industries, which use harsh chemicals and heat to disrupt the wood cell-wall structure. “We haven’t sufficiently understood the molecular architecture of the wood to know how to design the most efficient processes,” Paul Dupree explains. “Now we can monitor the effect of different wood treatment processes, which will help development of the improvements.”

Paul Dupree says their Centre for Natural Material Innovation is also working on new and extended uses of timber at large scales for high-rise buildings. “This will give us insight into more effective ways to modify timber as we learn new ways to make the most of the material’s potential. Timber skyscrapers are in the future, but our work may help bring them one step closer.”

This article uses elements of a Creative Commons press release on the University of Cambridge website.

Further reading
Folding of xylan onto cellulose fibrils in plant cell walls revealed by solid-state NMR.
Chemical Science
DOI: 10.1038/ncomms13902

Next steps
- Investigating biochemical enzymatic processes that can more efficiently break down and assemble xylan-cellulose structures at the molecular level.

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Discovery pipeline
Egg-free surrogate chickens could help to save rare breeds

Researchers say technique could also improve production of commercial hens.

Hens that do not produce their own chicks have been developed for use as surrogates to lay eggs from rare breeds. The advance, developed using gene-editing techniques, could help to boost breeding of endangered birds and commercial production.

A team led by The University of Edinburgh’s The Roslin Institute used a genetic tool called TALEN to delete a section of chicken DNA. They targeted part of a gene called DDX4, which is crucial for bird fertility. Hens with the genetic modification were unable to produce eggs but were otherwise healthy, the team found.

DDX4 plays an essential role in the generation of specialised cells – called primordial germ cells – which give rise to eggs. Researchers say that primordial germ cells from other bird breeds could be implanted into eggs carrying the gene-edited birds. The hens would then grow up to produce eggs containing all of the genetic information from the other breeds.

The surrogate chickens are the first gene-edited birds produced in Europe. Experts say they could potentially be used to help breed birds of other species, as long as a supply of primordial germ cells is available from a donor bird. Further research will be needed to investigate this, and scientists from the US biotechnology company Recombinetics also worked on the project.

Lead researcher Dr Mike McGrew of The Roslin Institute says the chickens are a first step in saving and protecting rare poultry breeds, “in order to preserve future biodiversity of our poultry from both economic and climate stresses.”

Dr Jef Grainger, Associate Director, Science, at BBSRC adds that UK researchers excel in this kind of frontier bioscience, “Which is a key challenge area in the industrial strategy to promote growth.”

Further reading
Efficient TALEN-mediated gene targeting of chicken primordial germ cells.
Development
DOI: 10.1242/dev.145367

Next steps
• Experiments to address the function of DDX4 in chicken germ cell meiosis.

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Discovery pipeline
Microbes living on African ant species produce potent chemical against antibiotic-resistant ‘superbugs’.

Researchers at the University of East Anglia (UEA) and the John Innes Centre (JIC) have discovered a new member of the bacterial genus *Streptomyces*, isolated from the African fungus-growing plant-ant *Tetraponera penzigi*. They have named the new species *Streptomyces formicae* and the antibiotics *formicamycins*, after the Latin *formica*, meaning ant.

Lab tests have shown these new antibiotics are effective against meticillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE), bacteria that are resistant to a number of common antibiotics and which can cause life-threatening infections.

Professor Barrie Wilkinson from JIC, which is strategically funded by BBSRC, says the findings highlight the importance of searching underexplored environments. “When combined with recent advances in genome sequencing and editing, this enables the discovery of new species making natural product antibiotics which could prove invaluable in the fight against antimicrobial resistance.”

Almost all of the antibiotics currently in clinical use come from a group of bacteria called actinomycetes that were isolated from soil between 40 and 80 years ago, the ‘golden age’ of antibiotic discovery. Inappropriate use of these antibiotics since then has led to widespread antimicrobial resistance (AMR), where disease-causing bacteria and fungi have become resistant to one or more antibiotics.

Professor Matt Hutchings from UEA says they have been exploring the chemical ecology of antibiotic-producing bacteria and fungus-growing insects, exploring them as a new source of anti-infective drugs.

He says Kenyan ‘plant-ants’ live in symbiosis with thorny acacia trees. “They live and breed in domatia – hollowed-out structures which the plant evolved to house them – and grow fungus in them for food. In return, they protect the plants from large herbivores including elephants, which won’t eat plants covered in ants.” It is likely that the ants benefit from their formicamycin-producing bacteria, which can keep their eggs free of harmful bacteria.

Further reading
Formicamycins, antibacterial polyketides produced by *Streptomyces formicae* isolated from African *Tetraponera* plant-ants.
*Chemical Science*
DOI: 10.1039/C6SC04265A

Next steps
• Further work to ascertain the spectrum of action of formicamycins against different bacteria, leading to clinical trials.

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Discovery pipeline
New study links antibiotic resistance to common household disinfectant triclosan

Bacteria that mutated to become resistant to quinolone antibiotics also became more resistant to disinfectant found in domestic products.

Scientists from the University of Birmingham and Norwich Research Park have discovered a link between a major mechanism of antibiotic resistance and resistance to the disinfectant triclosan, which is commonly found in domestic products.

Researchers made the unexpected finding that bacteria that mutated to become resistant to quinolone antibiotics also became more resistant to triclosan.

The scientists showed that the quinolone-resistance mutation altered the way the bacteria package their DNA inside a cell and that these mutants had also turned on various self-defence mechanisms – together these gave triclosan resistance.

Quinolone antibiotics are an important and powerful group of human medicines, and this new discovery raises concerns that the use of triclosan can give antimicrobial resistance.

The research, carried out at the Institute of Microbiology and Infection at the University of Birmingham in collaboration with The Quadram Institute and John Innes Centre based at Norwich Research Park, was published in the Journal of Antimicrobial chemotherapy.

Corresponding author Dr Mark Webber, from the Quadram Institute, said: “We think that bacteria are tricked into thinking they are always under attack and are then primed to deal with other threats including triclosan.

“The worry is that this might happen in reverse, and triclosan exposure might encourage growth of antibiotic-resistant strains.

“We found this can happen in E. coli. As we run out of effective drugs, understanding how antibiotic resistance can happen and under what conditions is crucial to stopping selection of more resistant bacteria.”

Co-author Professor Laura Piddock, of the Institute of Microbiology and Infection at the University of Birmingham, said: “The link between quinolone and triclosan resistance is important as triclosan has become ubiquitous in the environment and even human tissues in the last 20 years.”

“Given the prevalence of triclosan and other antimicrobials in the environment, a greater understanding of the impact they can have on bacteria and how exposure to these antimicrobials may impact the selection and spread of clinically relevant antibiotic resistance is needed.”

Professor Tony Maxwell, from the John Innes Centre, said: “This work shows the power of combining the expertise from the different teams working in Norwich and Birmingham to achieve a better understanding of the mechanisms of antimicrobial resistance, which is a serious and increasing problem in the UK and elsewhere.”

In the last decade there has been an explosion in the marketing of products aimed at the home market labelled as ‘antimicrobial’.

There is also largely a lack of evidence for additional benefits of these products over traditional cleaning and hygiene products (e.g. bleach, soap and water).

There has, however, been concern raised that the active antimicrobial ingredients for some of these products are accumulating in the environment, where they are altering ecosystems and potentially promoting selection of antibiotic-resistant bacteria.

Triclosan, in particular, has been the cause for some concern which has led to a ban across the EU and now USA in its use in hygiene products (hand, skin and body washes). Many other antimicrobial agents are, however, still used in these products.
This year’s competition celebrated international success and marked early-career academics’ achievements for the first time.

Named Innovator of the Year seeks to prevent vision loss worldwide

The inventor of a new tool that identifies people at risk of a leading cause of incurable blindness worldwide, affecting more than 600,000 people in the UK alone, has been named the BBSRC Innovator of the Year 2017.

Dr Shelby Temple accepted the prestigious award at a joyous night at Canary Wharf which saw a celebration of the UK’s best bio-scientists, whose research is leading to life-changing innovations throughout the world.

The event, now in its ninth year, highlighted the fantastic work of 12 finalists shortlisted from an array of entries, from across the UK, by an independent panel.

Finalists were nominated for awards in the categories of Commercial Impact, Social Impact, International Impact, and Early Career Impact, with each winner presented with £10,000 to help towards future research projects, and the Overall Winner – Innovator of the Year – receiving a further £10,000.

“The Innovator of the Year competition recognises the significant impacts of bioscience research and the difference the innovative solutions make in the world,” said Professor Melanie Welham, BBSRC Chief Executive. “I’m honoured to be surrounded by such pioneering individuals and teams who continue to push the boundaries of bioscience. Congratulations to all named winners of the Innovator of the Year competition.”

After receiving the Commercial Impact category award, Dr Temple was then announced as the Innovator of the Year for his work in tackling age-related macular degeneration (AMD), the leading cause of incurable blindness in developed countries, which is expected to affect an estimated 196 million people globally by 2020.

Studying the eyes of octopuses, cuttlefishes, and fishes led Dr Temple to invent a unique tool to examine how eyes perceive polarised light. By adapting the approach for humans, the University of Bristol academic created a
fast, simple and affordable way to assess macular pigments, low levels of which are a risk factor for AMD. The device is scheduled to be ready within a year.

Commenting on his success, Dr Temple, from the School of Biological Sciences at Bristol, said: “I was overwhelmed with excitement and pride that all the hard work had led to this fantastic recognition, but I also felt bashful because there were so many great and deserving projects.”

In addition to helping to solve the international AMD crisis, another award recipient’s research was equally global in its thinking. Professor Juliet Osborne and team received the Social Impact award for the study in helping build pollinator resilience through informed land management and beekeeping.

“Whilst it was my name that was called, it is a team win. I am really proud of my colleagues – Dr Matthias Becher, Dr Grace Twiston-Davies and Prof Volker Grimm – who have worked with me,” said Professor Osborne from the University of Exeter. “It is really important that the research we do is applicable and useful to a wide range of users.”

This year’s awards were the first to specifically recognise the ‘International Impact’ of BBSRC-funded projects. The category highlighted those researchers and teams who have driven impact in an international context and addressed overseas development aid goals.

The winner of the prize was Professor Sarah Cleaveland, whose research has informed the development of new strategies to control livestock diseases in Tanzania, including foot-and-mouth and malignant catarrhal fever.

“We were genuinely stunned, but also thrilled to hear we had won the International Impact Award. The achievement reflects the work of a fantastic team of researchers from the University of Glasgow and Tanzanian institutions, alongside the other UK and international partners,” said Professor Cleaveland.

Another new prize for this year’s competition was the Early Career Impact category, which celebrated early-career researchers who have driven impact in a commercial, social or international context in the six years beyond their PhD or prior to securing a permanent research position.

The winner was Dr James Field, who co-invented a directed evolution technology for the development of new materials.

A “delighted and immensely humbled”, Dr Field, who represents LabGenius, said: “I have spent several years leading a group of truly talented scientists in the development of a highly disruptive gene synthesis technology and being recognised is a real credit to the team’s hard work.
Managed by LEAF (Linking Environment and Farming), Open Farm Sunday allows over 250,000 people to visit farms and find out what vital work farmers do from producing nutritious food to managing our natural resources.

“LEAF’s Open Farm Sunday is a tremendous opportunity to engage people with the relevance of research to farming and, ultimately, the food on our plates,” said Dr Patrick Middleton, Associate Director of Communications and Engagement, BBSRC.

During this year’s event, new BBSRC ‘Science on the Farm’ posters debuted at over 150 events to inspire and educate people about the science behind farming and food production. The sets of ten large, attractive posters, developed with help from scientists across the UK, covered topics including: soil science, water, biodiversity, grassland management, animal welfare and wheat. The posters received positive feedback from farmers at various host farms throughout the UK. They were delighted to have new resources which helped illustrate scientific components of the farming story.

“Connecting people with their food, where it comes from and how it’s grown is a fundamental part of delivering more sustainable food and farming. The more we understand about our food and how it is produced, the more we come to value it and the work farmers do. LEAF’s Open Farm Sunday enables people to discover the world of farming first hand,” said Annabel Shackleton, Manager of LEAF’s Open Farm Sunday.

A number of farms also offered demonstrations and practical activities to showcase how science feeds into the farm. At Leckford Estate, Dr Malcolm Hawkesford from Rothamsted Research and Dr Ryan Waters from the Pirbright Institute were on hand to explain drone technology and animal farm health. The event was attended by 3,500 visitors including Her Royal Highness The Countess of Wessex (below).
“We are delighted to be working together with BBSRC to showcase some of the fascinating science which the UK is undertaking to help meet the challenges of climate change, a growing global population and rising health issues,” said Shackleton.

Since 2006, over 1,500 farmers across the UK have opened their gates and welcomed over two million people onto farms. The activities funded by BBSRC focus on egg production and soils, as well as ‘whole farm’ science to enable visitors to understand the importance of farming within the context of food security and raise awareness of how UK bioscience underpins the agricultural industry.

For more information on Open Farm Sunday visit: www.farmsunday.org
Frontier Bioscience is about pushing the boundaries of knowledge to make amazing, surprising and potentially life-changing discoveries.

Research and the people we fund is helping society to meet major challenges, including food security, green energy and healthier, longer lives.

By inspiring the brightest minds, supporting teams, enabling far-reaching collaborations and funding curiosity-driven science, bioscience can generate knowledge leading to game-changing solutions and technologies.

Frontier Bioscience research is already making a real difference.

Frontiers in structural cell biology

Father-and-son team Professor Ray Dupree from the University of Warwick (right) and his son Professor Paul Dupree (left) have discovered fundamental knowledge about how xylan and cellulose, which make up the xylem of plants, combine to make such strong structures. See page 12 for more.

Frontiers of immunology

Dr Vivian Turner from Professor Neil Mabbott’s research group at The Roslin Institute examining aged spleens using a confocal microscope.
Frontiers of molecular imaging

PhD student Noura Zamzam inspects the unique ultrafast laser imaging equipment in Dr Jasper van Thor’s BBSRC-funded Imperial College London lab to measure molecular aspects of photosynthesis. See feature on pages 10-11.

Frontiers in ‘pharming’

Dr Pooja Saxena, then working at the John Innes Centre, injects virus-derived vector into plants that will then produce compounds according to the genetic code introduced. The development of RNA plant virus-based vectors for expression of high-value proteins of pharmaceutical interest in plants is sometimes known as ‘pharming’. See news on page 6 for more.
Frontiers in human nutrition

Newcastle University postdoctoral researcher Dr Matthew Wilcox uses a gut model in the lab to test the effects of various food additives prior to human testing. See an animation video of this research at: youtu.be/0HnrpmXcGJc

Tim Gander

Frontiers in stem cells (and public engagement!)

Professor Richard Oreffo of the University of Southampton wows visitors at the BBSRC Great British Bioscience Festival with 3D glasses that allow people to see his stem cell work in 3D. See a video of the festival at: youtu.be/nQpsG75AFIc

Joel Knight
Frontiers of automatic imaging

Dr Andrew Riche and March Castle inspect the octocopter drone before field trials at Rothamsted Research. This demonstrator technology can image growth and plant stresses with a suite of onboard cameras. See a video feature on this at: ow.ly/21gy309XI7B

Frontiers in virology

Dr Linda Dixon prepares samples for analysis. Her research is focused on the functional genomics of African swine fever virus (ASFV), which causes a devastating haemorrhagic fever of pigs in affected countries. The lack of a vaccine limits options for disease control. See a video feature on Pirbright virology at: ow.ly/XXVO309XIIb
Finding new cancer targets in the neighbourhood

Aiming at the neighbours of cancer-causing proteins may be as effective as hitting the proteins themselves.

Computational biologists are looking at the complex networks of interacting proteins that drive cancer formation.

“Increasingly, we are seeing cancer as a ‘systems’ disease,” says lead researcher Dr Tamás Korcsmáros from the Earlham Institute and Institute of Food Research. “This calls for a systems-level approach to really understand how normal cells are transformed into cancer cells at the molecular level.”

Cancer is caused by an accumulation of genetic changes in a cell that overcome the normal checks and balances, leading to uncontrolled growth. Scientists have identified which proteins are changed in different cancers, and targeted these with drugs that block their activities. But this approach does not work for all cancers.

So, working with colleagues in Hungary and the University of Cambridge, the team led by Korcsmáros used databases of genes known to be involved in cancer, or that show major differences between healthy and diseased tissues. They paired them with other resources detailing protein interactions in the cell to create computational models of protein networks in different types of cancer cells.

They found that cancer-related proteins tended to be well connected at the centre of these networks, like a spider at the middle of its web. This was expected, because only the proteins in these key super-connected positions have the ability to rewire the cell from a healthy to a cancerous cell.

Korcsmáros and his team were specifically interested in the neighbours of these proteins. Could the proteins next to cancer-related proteins at the centre of these cellular signalling networks be useful drug targets themselves, even though they are not directly involved in carcinogenesis?

“In colon cancer, we could see that the cancer-related proteins weren’t interacting with each other directly, but instead through their first neighbours in the network,” says Dr Módos, first author of the paper from the University of Cambridge. “These neighbours were significantly amplifying the rewiring effect of the cancer-related proteins.”

The importance of neighbour proteins was also seen in networks for breast cancer, hepatocellular carcinoma and non-small cell lung cancer. New drugs that target first neighbour proteins could disrupt the cancer-specific networks, making them extremely useful for novel chemotherapies. In fact, Korcsmáros says there are over 200 drugs already on the market that act against first neighbour proteins, but haven’t been used for cancer treatments.

Further reading
Neighbors of cancer-related proteins have key influence on pathogenesis and could increase the drug target space for anticancer therapies.

Systems Biology and Applications DOI: 10.1038/s41540-017-0003-6

Next steps
• Further refinement of computer models to select neighbouring proteins for clinical trials.

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Discovery pipeline

Aiming at the neighbours of cancer-causing proteins may be as effective as hitting the proteins themselves.
Neuroscientists at the University of Bristol are a step closer to understanding how the connections in our brain which control our episodic memory work in sync to make some memories stronger than others. The findings reveal a previously unsuspected division of memory function in the pathways between two areas of the brain, and suggest that certain subnetworks within the brain work separately, to enhance the distinctiveness of memories.

The team studied the hippocampus and prefrontal cortex – two regions of the brain critical to memory function – as damage in these areas can induce severe memory loss. However, the two areas are connected by a complex network of direct and indirect pathways, and until now the challenge has been to identify the precise routes through which these brain regions interact in memory formation.

Researchers from the University of Bristol used a new novel pharmacogenetic technique to deactivate specific neural pathways from the hippocampus to the prefrontal cortex in rats. They then tested the rats’ memory for objects presented at specific points in time, and in specific locations, to model episodic memory function in humans.

The team found that one pathway from the hippocampus controlled the ‘temporal’ aspects of the memory, such as those which enable a subject to remember when they had encountered an object, while a separate pathway enabled subjects to remember an object’s location. They found that, by deactivating specific neural pathways and preventing the hippocampus from talking to the prefrontal cortex, episodic memory function was significantly disrupted.

Professor Clea Warburton says that episodic memory stores an individual’s unique recollection of a specific event and is important for remembering significant events in our lives, and works by linking different types of information. “For example, even remembering routine things such as where we parked the car requires our brain to store and link different types of information. We must remember what kind of car we have, when, and where we parked it. Linking these different components of memory depends on clear communication between different brain regions which work together forming complex memory networks. “These findings reveal, for the first time, an important aspect of memory function critical to episodic memory and could help with developing new therapeutics to alleviate memory loss,” says Warburton.

Further reading
Separate elements of episodic memory subserved by distinct hippocampal-prefrontal connections.
Nature Neuroscience
DOI: 10.1038/nn.4472

Next steps
• Replicating the study’s findings in humans.

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Discovery pipeline

How do the precursors of sperm and eggs form during human development? It’s a question that has puzzled scientists for over two centuries. Now researchers at The University of Nottingham and the Gurdon Institute, University of Cambridge, have uncovered the origins of these elusive cells.

Their research ‘Principles of early human development and germ cell program from conserved model systems’, published in *Nature*, could lead to a paradigm shift in our understanding of how early development occurs in mammals.

They have shown, for the first time, that the interplay between two key genes is critical for the formation of the germline precursors – the cells that are key to the preservation of a species – and this ‘genetic cocktail’ changes in different species. As a result, scientists have discovered clear differences between the early development of humans and mice and a much closer relationship between humans and pigs. These findings could change the way we study early human development and improve our understanding of genetic diseases.

The study shows that this mechanism is conserved in humans, monkeys and pigs.

The combination of human-pig models for early development and cell fate decisions likely reflects critical events in early human embryos in the womb. Altogether, knowledge gained from this approach can be applied to regenerative medicine for the derivation of relevant human cell types that might be used to help understand and treat human diseases, and to understand how mutations that disrupt early development can result in human diseases.

Dr Ramiro Alberio, from the School of Biosciences at The University of Nottingham, said: “We’ve shown how precursors to egg and sperm germ cell arise in species with similar embryo development. This suggests that the pig can be an excellent model system for the study of early human development as well as improving our understanding of the origins of genetic disease.”

Professor Azim Surani, in the Gurdon Institute at the University of Cambridge, said: “Animals with conserved embryology can inform on the genes involved in human embryo development and these mechanisms can be recapitulated in the laboratory using embryonic stem cells. Using this system, we were able to uncover the fundamental principles of how specific genes can influence cellular identity.”

**Culmination of 10 years’ work**

For Dr Alberio, this is the culmination of 10 years of work on embryo development. When he started these studies, very little was known about the molecular aspects of pig embryogenesis. Since then his research group has developed tools and novel understanding of how early embryos form. His research focuses on the very early decisions made by the cells in the embryo – the very early switch of an embryonic cell towards differentiation, and on how similar these processes are in different mammals.

Dr Alberio said: “We show how studying the pig embryo can help us design new methods for the differentiation of human sperm and eggs in a dish. The findings of our research will help scientists improve our understanding of the origins of genetic diseases such as germ cell tumours, fetal abnormalities and certain types of infertility.”

The research was supported by Wellcome and the Biotechnology and Biological Sciences Research Council.
Supporting the wider scientific workforce

Technicians, technical specialists, experimental officers, facilities managers, non-faculty researchers. Call them what you like (and, according to the Software Sustainability Institute, there were almost 200 different job titles for research software engineers alone), this group of highly trained and highly skilled people are essential to the research effort in UK universities, research institutes and research-intensive private sector. Until now, they have been a relatively invisible group to research funding and policy organisations, but this is changing.

In March, BBSRC and the Science Council convened a workshop looking at the challenges facing these ‘non-faculty researchers’ (NFRs) in the biosciences, and asked the question: what can be done to help this group?

In a highly energised discussion, delegates were keen to emphasise the importance that NFRs have in supporting an efficient, effective and productive research base, and to ensure that investments made by the Research Councils (particularly in infrastructure and equipment) have maximum impact. Access to continued professional development, formal training and mentoring and recognition on research outputs (including papers and patents) were seen as essential to ensure NFRs remain motivated and recognised as professional researchers in their own right, rather than in support of the research efforts of others.

Professional recognition of NFRs at the highest strategic level within research organisations was seen by the delegates as essential to providing a clear career route, and strong voice, to this group, ensuring that the needs of technical specialists, as well as senior academics and directors of professional services, are considered within institutional strategies.

The possibilities that the new apprenticeships levy and degree/Masters-level apprenticeships offered to NFRs were highlighted, but there was some concern that this new focus on apprenticeships must not be at the expense of professional development and provision of opportunity to existing NFRs. With the focus on technical up-skilling within the UK Government’s new Industrial Strategy, there is a need to ensure a cohesive strategy in this area, spanning all stages of education and career stages, and NFRs potentially have an important role in this.

So what happens now? The outputs from this workshop will shortly be published, alongside a new RCUK Statement of Expectations on Technical Specialists, the BBSRC Vision for Postdoctoral Researchers, and will complement a refreshed Concordat to Support the Career Development of Researchers, which will be published in early 2018, to coincide with its tenth anniversary.

We have already published an associated guidance note to the Concordat highlighting the support institutions should give to people engaged in research. As the Research Councils and HEFCE move closer (with Innovate UK) into UK Research and Innovation (UKRI), there is a great opportunity to join up the vocational, technical and academic education and skills, and produce a cohesive talent strategy to support a productive UK research base.
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