Advanced Agriculture
How technology and innovation can transform food production

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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

The Quadram Institute
www.quadram.ac.uk

John Innes Centre
www.jic.ac.uk

Roslin Institute
(University of Edinburgh)
www.roslin.ac.uk

Rothamsted Research
www.rothamsted.ac.uk

Earlham Institute
www.earlham.ac.uk

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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 Melanie Welham underlines the importance of continuing to support exciting frontier bioscience.

Frontier bioscience continues to be an important priority for us here at BBSRC. In this issue you can read more about some of the exciting research we are supporting, including Dr Berthold Hedwig and his team at the University of Cambridge, where they are using crickets to understand how patterns of sound are recognised and processed by nerve cells in the brain.

Our Innovator of the Year, Shelby Temple, is featured – find out how he is tackling the challenge of turning science into a commercial product. He is focusing his attention on making a device that could be used by opticians as part of the normal eye test. Read more about Dr Shelby Temple on page 12.

Our featured examples of the frontier bioscience that BBSRC supports just scratch the surface. Research which expands our knowledge and understanding of fundamental biological processes is the lifeblood on which our understanding of all living systems depends, and it is of huge importance to me that BBSRC continues to encourage and support frontier bioscience.

Tackling serious global challenges
In this edition you can also find out more about one of the most ambitious international research programmes ever created. Leading experts from the UK and in developing countries across the world are joining forces as the Global Challenges Research Fund (GCRF) invests £225 million across 37 projects to address challenges in health, humanitarian crises, conflict, the environment, the economy, domestic violence, society, and technology. See page 18 for more information.

The big question is where can and should biology take us in the next 20 years and what needs to be done today to make it happen.

Genome conference success
It was pleasing to hear that hundreds of the world’s leading bioscientists and researchers gathered in Norwich for the first Genome 10K conference to be held outside the United States. Combined with the Genome Science 2017 conference, it presented the latest research and technological developments in genomics, with more than 300 delegates from 44 nations.

Many projects funded by BBSRC were represented and discussed in a programme of fast full sessions with a wealth of speakers presenting the latest frontier developments in genome editing. You can see more about the event on pages 8 and 9.

Strategy for UK biotechnology and biological sciences
Finally, thank you to everyone who submitted their views to the strategy. The big question is where can and should biology take us in the next 20 years and what needs to be done today to make it happen.

At BBSRC we take our role as a major investor in bioscience very seriously and we seek to work with our community to champion and lead bioscience in the UK. The strategy for UK biotechnology and biological science is a key part in helping us set out the promise of bioscience research and the steps needed to make good on that promise.
### Industrial Strategy fund bioscience investment

BBSRC will be investing £16.5 million from the government’s flagship Industrial Strategy Challenge Fund (ISCF) to develop new agricultural technologies and industrial bioprocesses to drive the bioeconomy.

The funding will be used to further advance new technologies, processes and practices to advance the production of food, chemicals, materials and energy.

The ISCF accelerates commercial exploitation of the most exciting technologies the UK has to offer the world to ensure that scientific investment truly delivers economic impact, jobs and growth right across the country.

Universities, Science, Research and Innovation Minister Jo Johnson said, “This significant investment will support pioneering bioscience research and development projects that will reduce our reliance on carbon, boost the productivity of our nation’s crops and develop new world-leading agricultural technologies.”

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### Banana crop study seeks to address global challenges

Research focusing on the Ethiopian banana could help improve food security in Ethiopia and other parts of Africa, especially in areas affected by drought.

Researchers at the University of Leicester, the Royal Botanic Gardens, Kew, and the University of Addis Ababa will work together to better understand the banana crop species and its genetics.

The project is part of the Global Challenges Research Fund (GCRF) to address key global development challenges in securing future food supplies.

A total of 35 individual projects – including this one involving the University of Leicester – were awarded to 27 lead organisations. The awards connect the UK’s world-class research base with partners in low- and middle-income countries to address key sustainable development challenges.

Dr Amanda Collis, BBSRC Executive Director of Science, said, “This investment will address a number of different threats to the sustainable production of safe and nutritious food, ranging from tackling pests and disease, examining human behaviours, and improving food safety and nutrition, through to the sustainability of agricultural soils and the wider cultural and social context of food and farming. The complexity of the research requires collaborative effort from a range of disciplines, and this is an exemplar of research councils coming together to address broad international development research challenges.”

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### Plant-produced vaccines could help eradicate polio

Plants have been used to produce a new vaccine against poliovirus in what is hoped to be a major step towards global eradication of the disease.

A team of scientists at the John Innes Centre has produced the novel vaccine with a method that uses virus-like particles (VLPs) – non-pathogenic mimics of poliovirus which are grown in plants.

Genes that carry information to produce VLPs are infiltrated into the plant tissues. The host plant then reproduces large quantities of them using its own protein expression mechanisms. VLPs look like viruses but are non-infectious. They have been biologically engineered so they do not contain the nucleic acid that allows viruses to replicate.

This means that they mimic the behaviour of the virus, stimulating the immune system to respond, without causing an infection of poliomyelitis.

Laboratory tests demonstrated that the poliovirus mimics provided animals with immunity from the disease, paving the way for human vaccines to be produced by plants on a major scale with the input of pharmaceutical industry collaborators.

Professor Lomonossoff, from the John Innes Centre, said, “This is an incredible collaboration involving plant science, animal virology and structural biology. The question for us now is how to scale it up – we don’t want to stop at a lab technique.”
**Headlines**

**GM plants promise fish oils aplenty**

Metabolic engineers have moved a step closer to sourcing fish oils from fields rather than from the oceans with a trio of successful research findings that support the commercial cultivation of a transgenic variety of *Camelina sativa*, one of Europe’s oldest oil seed crops. They have reproduced results showing that the transgenic plants can grow in the field, they have matched the seeds’ biosynthetic products more closely to those of their marine counterparts, and they have identified the potential for even greater oil storage in the seeds. The work, published online by Nature in *Scientific Reports*, comes from collaboration between Rothamsted Research and the University of North Texas and appears as...  

**Study highlights fat absorption from plant-based foods**

Preserving the natural structure of plant-based food during processing can limit the amount of fat and energy absorbed by the body. Focusing on almonds, which contain 50% fat, researchers investigated the effects different processing methods had on how almonds are ingested by the body. Despite being a high-fat food, it has been shown previously that eating whole almonds doesn’t result in weight gain. Researchers from the Quadram Institute, King’s College London, the University of Surrey and the University of Messina studied how almond muffins were digested.

One muffin was made with almond chunks (2 mm) and one made with almond flour, which has much smaller particles (at less than half a millimetre). After 60 minutes in the model stomach, which is the time calculated for this meal to pass through in humans, over 40% of the total fat content had been released from the muffins made with almond flour, but just less than 6% had been released from the muffins made with larger almond chunks. Samples taken from the simulated small bowel showed that, after nine hours of digestion, almost all (97%) of the fat from the muffin made with flour was released, and only 60% of fat in the muffin made with almond chunks was released.

The researchers concluded that maintaining the structural integrity of the tough cell walls, which form dietary fibre, surrounding the fat-rich cells in almonds was the main factor in determining the digestibility of fats.

**Agreement strengthens US collaboration**

A new UK-US Science and Technology Agreement will strengthen research collaborations between the two nations. The treaty outlines a commitment to collaborate on world-class science and innovation, building on existing successful research co-operation and recognising the value of open data to further research and strengthen both economies.

On signing the agreement, Science Minister, Jo Johnson said, “The UK is known as a nation of science and technical progress, with research and development being at the core of our Industrial Strategy. By working with our key allies, we are maintaining our position as a global leader in research for years to come.”

The first major project of the UK-US Science and Technology Agreement is a £65 million UK investment in the Long Baseline Neutrino Facility and Deep Underground Neutrino Experiment (DUNE). Accompanying Jo Johnson on a visit to the US, Chief Executive Designate at UK Research and Innovation, Sir Mark Walport, said, “Research and innovation are global endeavours. Agreements like the one signed today by the United Kingdom and the United States set the framework for the great discoveries of the future.”
UK collaboration could increase farmed Scottish Salmon

A project to address one of the key challenges faced by Scotland’s salmon farmers is underway, supported by grant funding from the Scottish Aquaculture Innovation Centre (SAIC) and BBSRC. Saprolegnia – a type of water mould that can harm fish eggs and juvenile fish – is thought to significantly reduce stocks at Scotland’s salmon farms every year.

Now, multi-partner cross-sector collaboration is seeking to minimise those losses and boost the availability of farmed Scottish salmon by compiling a ‘big data’ resource that will increase understanding of Saprolegnia and its causes.

Robot learns tricky technique for studying brain cells

Imperial College scientists have successfully taught robots to perform a challenging brain technique only previously mastered by a handful of humans.

Whole-cell recording (WCR), is the gold-standard technique for studying the behaviour of brain cells called neurons under different brain states such as stress or learning.

For the first time, a team of scientists led by Professor Simon Schultz and Dr Luca Annecchino at Imperial College London has developed a robot and computer programme that can guide tiny measuring devices called micropipettes to specific neurons in the brains of live mice and record electrical currents, all without human intervention. This is the first reported fully automated platform to do this.

The team compared their technique with the conventional approach and found that the robot was faster and more accurate than its human counterparts. The findings are published in the journal Neuron. The automation might mean the technique can be performed much more widely around the world, and even in labs with no expertise in the technique.

Older wombs cause complications in pregnant mice

Research led by Dr Myriam Hemberger at the Babraham Institute and the Centre for Trophoblast Research in Cambridge, UK, is among the first to look at the effects of age on womb health, and it is expected to lead to new research into human pregnancies.

The risk of complications during pregnancy increase, with age, and many of the effects have been linked to the deteriorating quality of ageing egg cells. This new research, published in Nature Communications, reveals that older wombs also have more trouble adapting to pregnancy.

By examining first pregnancies in aged mice, the team showed that, for mice as for humans, the risk of complications increases with age. Closer examination revealed that the wombs of older mothers are less able to support the growth of a placenta, meaning the developing young have poor blood supply, which slows their growth and can cause birth defects.

Understanding the potential risks of pregnancy with age is an increasingly important issue. In the UK, more and more women are starting families later, and these new results will help to guide long-term studies in humans. It is clear that other factors besides egg quality may need to be considered when planning a family.
New software collaboration makes biological databases more accessible

Data mining and visualisation software to help scientists design better crops can now support less-specialist users and be used in a range of disciplines, including human disease research.

KnetMiner, with a silent ‘K’ and standing for Knowledge Network Miner, is a suite of open-source software tools developed at Rothamsted Research for integrating and visualising large biological datasets.

The software mines myriad databases describing an organism’s biology to present links between relevant pieces of information, such as genes, biological pathways, phenotypes or publications.

With security-conscious corporations keen to use the software, KnetMiner has now advanced from being a research tool to a commercial product by joining with the Genestack software platform that is designed to overcome the challenges of bioinformatics in research enterprises.

Fresh insights into the genetic code of sheep could aid breeding

Scientists have mapped which genes are turned on and off in the different tissues and organs in a sheep’s body.

The findings shed new light on the animal’s complex biology, including insight into the function of genes linked to immunity and meat quality. Researchers say the insights could eventually inform animal breeding programmes aimed at improving farmers’ stocks.

Sheep have more than 20,000 different genes but not all of these are expressed in each tissue type in the body. The team focused on genetic material called RNA, which is produced as an intermediate step when DNA code is translated into the proteins and molecules that make up cells and tissues.

RNA serves as a functional read-out of exactly which genes are expressed in which tissues at any one time.

Researchers at The University of Edinburgh’s Roslin Institute analysed the total RNA produced in each tissue of the sheep’s body. The results represent a major step towards understanding how the sheep’s genetic information influences its physical traits. The findings also shed light on the function of hundreds of genes whose role was previously unknown.

Lab-grown bone cell breakthrough benefits orthopaedics

Technology originally developed to detect gravitational waves is being used to generate tissue-engineered bone graft for future use in orthopaedic medicine.

The latest development in a technique known as ‘nanokicking’ has allowed scientists from the Universities of Glasgow, Strathclyde, the West of Scotland and Galway to grow three-dimensional samples of mineralised bone in the laboratory for the first time.

Bone is the second most grafted tissue after blood and is used in reconstructive, maxillofacial and orthopaedic surgeries. Currently, however, surgeons can only harvest limited amounts of living bone from the patient for use in graft, and bone from other donors is likely to be rejected by the body. Instead, surgeons must rely on inferior donor sources which contain no cells capable of regenerating bone, limiting the size of repairs they can affect.

Some of the technology which underpins the nanokicking technique was originally developed by astrophysicists working on the search for gravitational waves, ripples in space-time caused by massive events such as the collision of black holes.
Genome conferences discuss latest discoveries

Hundreds of the world’s leading bioscientists and researchers gathered in Norwich for the first Genome 10K conference to be held outside the United States.

Combined with the Genome Science 2017 conference, it presented the latest research and technological developments in genomics.

More than 300 delegates from 44 nations attended the event at the Norwich Research Park.

The conference was organised by the Earlham Institute under the leadership of director of science, Prof Federica Di Palma. Also professor of biology and medicine at UEA, she said, “Bringing these two conferences together will open so many opportunities for development of collaborations, advancement of genomics and informatics technologies and we are proud to have been offered the opportunity to host these prominent international conferences.”

The conferences provided a unique opportunity for experts to explore a broad range of topics, from understanding how complex animal life evolved through changes in DNA and how we can use this to help save dying species, to engineering plant genomes using synthetic biology and genome-wide association studies in bacteria. The annual event also explores the latest advances in genomics technologies, genetic resources and computational methodologies essential to driving forward genomics research.

The event featured a packed programme of fact-full sessions and a wealth of speakers presenting the latest frontier developments, including in genome editing.

Many projects funded by BBSRC were represented and discussed at the event with scientists representing major research centres and universities, zoos and museums around the world.

Amongst those speaking at the event were Professor Alan Archibald from the Roslin Institute at the University of Edinburgh, speaking about his research into the porcine reproductive and respiratory syndrome virus (PRRSV) in pigs, and Lindsay Hall of the Quadram Institute, speaking about her research into early-life microbial communities.

Amanda Collis, Executive Director of Science at BBSRC, agrees the event was great for sharing the latest advances in this important research: “The conference was an important opportunity for researchers to get together and discuss the very latest advances made in genomics and bioinformatics. BBSRC funds a large number of ground-breaking projects in these areas that contribute to advancing frontier bioscience and deliver impact in agriculture and human health.”
Genome conferences discuss latest discoveries

Genome editing is a type of genetic engineering in which DNA is inserted, deleted or replaced in the genome of a living organism. Specific issues with genomes in plants and animals can mean the editing removes those problems, perhaps removing the potential for a specific disease or infection, improving the growing or harvesting potential.

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Frontier bioscience is pioneering, innovative and creative research that can lead to far-reaching discoveries. The support for this area is central to BBSRC’s mission to advance knowledge and technology. Frontier bioscience gives high priority to world-class discovery research, recognising it as essential to ensuring the UK remains a global leader and that we deliver ‘bioscience for the future’.

Frontier Fellow

Dr Estrella Luna-Diez, a BBSRC Future Leader Fellow, is leading research into enhancing plant immunity.

Luna-Diez’s frontline research will contribute to the fundamental knowledge of genetics and could have potential agricultural impacts, in the UK and globally. As plant pathogens acquire resistance to pesticide and fungicide treatments, there is a growing need to find alternative methods to deal with current and emerging diseases.

Luna-Diez is researching the effect of β-amino butyric acid on the immunity of tomato crops to the pathogen Phytophthora infestans. The use of amino butyric acid provides protective broad-range immunity to several plant diseases.

Luna-Diez’s pioneering work aims to tease apart the mechanisms behind these advantageous trait changes.

Genetic Mystery

Research from Professor Sir David Baulcombe at the University of Cambridge could change the future of crop breeding strategies.

Offspring inherit DNA from each parent. For certain genetic traits, there are alternative inherited forms known as alleles.

An example in humans is dry earwax and wet earwax. Each sort of wax is determined by a gene and two different forms exist (alleles) – one encoding dry earwax and one for wet earwax.

Wet earwax is dominant and so, if one copy is inherited, the offspring will have wet earwax regardless of the other inherited allele. Whereas, for dry earwax, both inherited alleles from the parents must be present. However, paramutation is a genetic phenomenon that changes the way these traits can be inherited.

Paramutation is a change that leads to the spread of a trait throughout the population regardless of the trait being dominant.

This is because the paramutation effect is ‘infectious’ and able to spread from affected to non-affected alleles.

Professor Baulcombe will exploit these effects in tomato pigmentation resulting in the spread of yellow colouring in the offspring. This work will identify vital mechanisms, expanding our critical understanding of the epigenetic effect and gene drive at a much greater depth.

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Insect Symphony

Cutting-edge research by Dr Berthold Hedwig into sound pattern recognition could lead to advances in machine-hearing development and improving hearing aids.

Pattern recognition is an important feature in many key aspects of life, from mating in insects to complex communication in humans. Understanding this process is the goal of Dr Hedwig, from the University of Cambridge, using an elegant model system – the cricket.

Crickets rely on sound recognition via calling songs during mating, recognising specific chirp durations and intervals. Specifically, female crickets undergo a behaviour change on recognition of a preferred pattern, moving towards the source of the sound.

Dr Hedwig’s research, funded by BBSRC, will make significant contributions to the understanding of pattern recognition in crickets, leading the way towards understanding this process in other classes of life.

Illuminating Research

Dr Neil Kad and his research team, funded by BBSRC, are currently studying all the components of DNA repair at the single molecule level simultaneously for the first time.

Dr Kad, from the University of Kent, recognised the growing need to improve imaging technologies to study complex systems.

Dr Kad’s primary research is working to understand the essential process of DNA repair in bacteria, known as nucleotide excision repair.

Using advanced imaging techniques, Dr Kad challenged the traditional views of DNA repair and this led to the discovery of novel enzyme interactions during the repair process.

The development and use of novel research technologies is of utmost importance for the future, increasing and challenging our current knowledge.
Shelby Temple is a man with a real passion for science. BBSRC’s winner of the ‘Innovator of the Year’ title is now focused on turning his invention into a viable commercial product that could hugely benefit everyone undergoing their normal eye test.

The 45-year-old grew up on a small farm in Canada, and now lives with his family in Bristol. He’s recently made the transition from science into the commercial world in a bid to ensure the success of a device that assesses eye health and risk of blindness.

The elegantly simple device uses a person’s ability to perceive different levels of polarised light to measure the density of macular pigments in the retina.

Dr Temple is now working to make his discovery and the tool to deliver it an everyday, affordable product that could be in every optician’s shop up and down the country and, perhaps, even be a part of many people’s essential medicine cabinet, in much the same way that blood pressure testing devices are now common place.

“I was originally inspired by a David Attenborough series featuring archer fish and proboscis monkeys. I started collecting and breeding fish and I knew I wanted to be a biologist but didn’t really know what that meant”, explains Dr Temple.

Shelby says that, although he’s had success with his discovery, there have been years of hard research to get this far. He draws attention to the fact that behind the closed doors of the labs there are researchers and scientists busy with their work and, even when they make a discovery, there is never a champagne eureka moment. Often the results of their labours are only known months or years later, when papers are published.
His aquatic interest and a masters in aquaculture led to a PhD on ‘Vision in fish’, important because he understood the link between vision and how it affects behaviour.

Experiments in ‘polarisation in vision’ led to some really important moments. He explains, “We took apart and played with LCD monitors, we pulled them apart and turned them into polarisation devices. Humans can’t see it but we thought fish could, so we did a series of experiments.

“There had been research to say that fish could see polarisation so we tested every kind of fish we could get our hands on or fit into our tank, and we tried different ways of presenting stimuli”. He goes on to explain that a serendipitous catch was instrumental: “We were looking for fish on a beach in Australia and captured a cuttlefish, so we decided to try it. When we started the experiment and put our polarised stimulus on the screen… Whoosh! The animal flew across the tank. It was clear they could see polarisation. That was a pivotal moment.”

While studying the limits of polarisation vision in cephalopods and crustaceans, Dr Temple noticed that he could see the stimuli he was presenting much more easily than he expected despite the fact that humans ‘don’t really see’ polarisation. “Humans see polarisation as a phenomenon that occurs inside the eye called Haidinger’s brushes”, explains Dr Temple. “There were various hypotheses to explain how humans could see the effect”, but Shelby’s research confirmed the role of macular pigments and his novel approach provided an entirely new way of measuring these difficult-to-measure molecules.

In 2015, BBSRC funding helped build a small portable prototype device that was used in comparison trials to prove the effectiveness of assessing macular pigment density.

Having built a device that worked, he was faced with the challenge of delivering it to consumers. Concerned about commercial organisations using the device to help market their own products, and therefore not be of benefit to the wider community, he has decided to pick up the challenge and has set up his own company to further develop and deliver the tool.

It means he has had to make the transition from science into the commercial world. Dr Temple explains, “I have essentially found a faster and more affordable way to measure macular pigment. Commercial companies are interested and there are various pathways to commercialise university research. I could have licensed it to an existing company, but who is better placed to realise the full potential than the person who has invented it?”

“I did research for 20 years, thoroughly enjoyed it and did all the things I ever wanted to do. This change feels like a midlife crisis. I wrote lots of papers but I’m now ready for the next challenge.”

So what is the next challenge? He explains, “It’s all about marketing. I’m proud I had the idea, I tested it, and it worked. The challenge is now to get others to understand what this device does, and how to get it to market”.

His company, Azul Optics Limited, is now working to build 20 desk-top units that, by the New Year, can be tested by opticians to provide real feedback. Long term, the plan is to create a smaller device that people could add to their medicine cabinet, much like home blood pressure monitors.

Dr Temple is clear that the device is important not just for vision testing: “My machine is valuable in providing information that empowers people to make decisions about their lifestyle. It’s not just about eye health; although it tests vision, vision is affected by diet and other behaviours like smoking, drinking and fitness.”

So what is the test? Essentially, it’s a threshold test to measure macular degeneration. People look into a polarised light source and perceive the Haidinger’s brushes effect, and then it is made more difficult until the point that they can no longer see the effect. Like the best ideas, it’s easy and simple.

While there’s still plenty of work to do, Dr Temple is still able to look to the future. “I’ve always been a dreamer and inventor and a dabbler. When this project becomes self-sufficient, I still have plenty of other ideas!”

### What is macular degeneration?

Age-related macular degeneration (AMD or ARMD), is a medical condition that may result in blurred or no vision in the centre of your field of view. It typically occurs in older people and can be influenced by genetic factors, exercise and diet. An affordable and accessible device to help alert people that they may be at risk due to low macular pigments would help provide an early warning for eye care and other general health issues.

In 2015 BBSRC funding helped build a prototype small device.
We spoke with Professor Simon Blackmore, Head of Precision Farming at Harper Adams University, to find out whether there was some truth in this mantra. With a slight chuckle and smile, he enthused about his research into precision farming, and how drones, satellite data, and robotics could make a real difference in agriculture. The technology is sweeping through many sectors across the UK and around the world, improving established procedures by delivering more accurate information and targeted solutions, such as destroying individual weeds with lasers rather than wasteful and potentially harmful chemicals.

"Technology is not altering agricultural progress; technology is offering us the ability to transform the future of farming," said Blackmore.

The 1989 film ‘Field of Dreams’, starring Kevin Costner, is based on the life of an Iowa corn farmer. While walking through his cornfield one evening, he hears a voice whispering, encouraging him to build a vision of the future: “If you build it, he will come.”

"Another key challenge today is to quickly determine the right timing and amount of fertilisers and chemical applications in response to changeable growing conditions," said Dr Ji Zhou, Project Leader at Earlham Institute.

The Agri-Tech projects led by Dr Zhou are utilising remote sensing, computer vision and machine-learning modelling to monitor and estimate crop–climate interactions, so valuable information can be provided to farmers on the ground, helping them make decisions to optimise agronomic inputs and crop management.

“Sustainable agriculture is about producing healthy and economically viable food whilst preserving farmland for generations to come,” said Dr Zhou.

Food and farming are set for a revolution through the use of big data and new technologies. With multidisciplinary approaches, there’s an unprecedented step change in how the UK will produce food sustainably. It appears researchers have already built it and, if farmers adopt the new technology, it really could be a case of, ‘If you build it, they will come’.
Agricultural experts, economists and representatives from global companies and government departments from across the world have met in Delhi to focus on effective decision making in agriculture that integrates science, technology, innovation and the farm ecosystem.

The meeting took place as a result of the Indian Prime Minister Narendra Modi’s desire for improvements in farming, especially for small and marginal farmers. Improving the decision-making capability of small and marginal farmers has the potential to increase the competitiveness and income of rural areas, resulting in a great impact across India.

India is in a particularly unique position, because it contains all of the agri-climatic zones which are found in the developing world, from the steep slopes of the Himalayas, to the Indo-Gangatic plains, to the coastal plains and hills. Thoughts and ideas exchanged at the conclave, along with future pilot projects, therefore have the potential to have a positive impact on the rest of the world.

Food security is a global concern, and the livelihoods of hundreds of millions of families depend on small-scale agriculture.

The conclave worked to address this challenge collectively and showcased the enormous research strength of India and its international partners in a global context, to achieve impact and build strong and sustainable research and innovation partnerships.

The conclave helped establish a commercial model or ‘FarmerZone’ on meeting farmer and farming needs. It is planned that this could be a ‘cloud’-based service, accessible through smart phones and personal computers, which cater for all farmer needs, from dealing with climate change and weather predictions, to soil, water, seed and marketing. The aspiration is to develop a multipurpose window that would be available to farmers anywhere.

Over two days, national and international experts in policy and IT, agritech companies, academics, farmers and representatives, along with research and innovation agencies from India, the UK and other countries, brought ideas and implementable solutions and discussed their potential role in building new partnerships that will help co-design and develop ‘FarmerZone’, an initiative that could be scaled up and applied across a number of different agro-climatic zones across the world.

Nearly three-quarters of India’s families depend on rural incomes: that’s 770 million people or about 70%.

(According to the World Bank)
Biology Week showcases the important and amazing world of the biosciences, getting everyone from children to professional biologists involved in fun and interesting life science activities.

Biology week runs from 7 to 15 October and is organised by the Royal Society of Biology. The annual event is now in its sixth year and sees events take place all over the world, celebrating biology, getting people involved and encouraging people to embrace their enthusiasm for the subject.

I guess I’ve always been interested in science, which stemmed from the enthusiasm and support I received from my parents; mum is a biology teacher and dad is a Professor in Geology. In fact, we often did ‘fieldwork’ on family holidays in Scotland! However, it wasn’t till I was at school and studying science that I really began to realise that biology was for me, as I could begin to see what new discoveries could potentially do for human and animal health. This wonder and enthusiasm has stayed with me throughout my career and has led me to my current role, and leading a fantastic team studying beneficial bacteria and their impact on our health.

Dr Lindsay Hall
Microbiome Research Leader, Quadram Institute

Biology is everywhere and affects us all. At BBSRC it’s what we are all about. We are one of seven research councils that work together as Research Councils UK. We are funded by the government’s Department for Business, Energy and Industrial Strategy and we invested £469 million in world-class bioscience in 2016-17. We support around 1,600 scientists and 2,000 research students in universities and institutes across the UK.

To celebrate Biology week, we’ve been asking scientists and researchers to talk Biology!

I think of Biology as a network that holds everything together: it’s a delicate fabric and it’s changing rapidly. The more we can learn the more we can use it to our advantage, but the future holds some real challenges. We are now doing things on a global scale and we really are putting the entire planet at risk.

As a biologist, it’s important that we do what we do; it’s about caring for life on the planet. One of the really important things is that we continue to do crazy ‘blue sky’ research: dabbling in other work has discovered great things. I love biology, I love teaching and I love dabbling!

Dr Shelby Temple
Co-founder and Chief Technology Officer, Azul Optics

Discover more about Biology week and the work
I cannot pinpoint an exact moment in time when biology first sparked my interest; it is something that developed over time. As a child I loved nature and animals, which is why I chose to study for a science degree. In particular, I have always been fascinated by DNA and how it carries all the information necessary for every single living organism on earth. This led me down the path to my PhD in genomics.

Alicia Bertolotti
PhD Student, Institute of Biological and Environmental Sciences, University of Aberdeen

I enjoyed the practical elements, the hands-on stuff. I remember in my A-level biology classes we had a vat full of large rodents, formalin-fixed, and I asked my biology teacher if there was a spare one I could take home! My mother banished me to the bottom of the garden, but having practised it really helped during my practical dissection exam.

I had a truly inspirational biology teacher and a wonderful chemistry teacher and they encouraged me to combine the two and study biochemistry, which was perfect for me. No one in my family had been to university before – it was a whole new experience.

Professor Melanie Welham
Chief Executive, BBSRC

Did you know?
Biology was the 3rd most popular subject for A-level students in 2016, second only to Maths and English.

Did you know?
More than 140,000 students received a GCSE in biology in 2017, with 90.4% receiving an A* to C grade.

of the Royal Society of Biology: www.rsb.org.uk
Will I ever live forever?

In the 1800s, the average lifespan was around 40 years; today it has almost doubled. We ask some BBSRC researchers working at the frontiers of bioscience if living forever could be a possibility. From cellular metabolism to ageing and cognition they are working on frontier bioscience projects that will help us understand whether people will ever live significantly longer and healthier lives than we do now.

How can epigenetics help longevity?

Professor Wolf Reik, based at The Babraham Institute, heads a world-leading research group that looks at epigenetics – the way molecular markers can turn genes on and off in cells – which can affect gene expression and the destiny of cells, especially the stem cells that are the source of adult tissues. Understanding how stem cells develop is critical to increasing longevity and healthspan.

“We are working on an epigenetic clock which predicts chronological and biological age, so that we can understand better what factors accelerate or slow down ageing,” says Reik. “However such a clock is only known in humans so far, hence experimental opportunities have been limited.”

His group are working towards unravelling such a clock in the mouse, which he says will open many exciting research avenues in terms of changing the ticking rate and age-reprogramming.

But Reik doubts whether humans will achieve significantly longer longevity: “Although progress is being made in understanding the ageing process and underlying mechanisms, there isn’t yet a unifying principle that you could think of tinkering with in humans.”

Won’t my bones be brittle and break in old age?

Professor Richard Oreffo, based at the University of Southampton and Director of the Centre for Human Development, has developed a way to create hip replacements using a patient’s own stem cells.

Key to additional years of life accompanied by years of good health is the ability to repair damaged tissue, such as bone. “We are harnessing stem cells including a patient’s own bone stem cells with appropriate scaffolds and have delivered molecular growth factors (messenger RNA, microRNA, protein cues, etc.) to aid functional bone and cartilage repair,” Oreffo explains.

Reprogramming cells to create specific cell and tissue types is a powerful tool to regenerate and repair body parts. Add that to the ability to harness additive manufacturing techniques like 3D printing so that a patient’s own stem cell-derived cells can sit on bespoke scaffolds – think a hip joint-shaped matrix – and we have the ability to make tissues. But not just tissue in a flat Petri dish, but bone-muscle-tendon complexes, or bone-cartilage constructs).

“This will allow us to repair damaged and diseased tissue and create bespoke and tailored tissues that will dramatically improve quality and function and improve patient outcomes and, ultimately, a patient’s quality of life,” says Oreffo. But he adds that it’s unlikely we’ll see a significant extension in lifespan in the next 50 years: “Rather, research will offer us the opportunity for a healthier and longer life, in contrast to current advancements in longevity often accompanied by frailty and disability.”
Will my immune system still protect me in very old age?

Professor Neil Mabbott is based at the Roslin Institute at the University of Edinburgh. He investigates host-pathogen interactions in the mucosal immune system, including how the immune system functions with increasing age.

It has been known for some time that as we age our immune systems become less effective, and we are much more susceptible to microbial infections, as well as cancer and inflammatory diseases, than we were when we were younger.

“We call this process immunosenescence,” says Mabbott. “We are trying to understand the factors which cause the immune system to become less efficient as we get older.”

Mabbott’s group have been using BBSRC funding to look at how ageing affects the organs of our immune system, and how the ageing gut responds to pathogens, including prions. They have found that ageing dramatically affects the structure and function of certain immune system components.

“The ageing immune system can less easily recognise foreign particles (antigens) and pathogens and mount an immune response against them,” Mabbott explains. “If we can identify why this happens we may be able to develop a novel treatment to help repair or reverse these changes and improve the immune systems of the elderly.”

So how does Mabbott rate our chances of living forever? “I think the ability of humans to live longer than 200 years or so is probably not biologically achievable. Of course, ageing research should help us to find novel ways to ensure we can live healthier and active lives as we age.”

How healthy will I be in old age?

Professor Alison Woollard presented the Royal Institution Christmas Lectures in 2013. Based at the University of Oxford, she is now using BBSRC funding to develop novel approaches to understand what determines healthspan.

The last 100 years have seen almost a doubling in average lifespan in the UK due to medicines, nutrition and social care. Can we match that over the next century? “I suspect improvements in the traditional approaches to extending life will probably slow down – the ‘low hanging fruit’ may have been picked,” says Woollard. “If we can understand why and how we age – in the biological rather than chronological sense – then it may be possible to treat ‘ageing’ itself, targeting several diseases of ageing at once.”

Woollard works with much-studied nematode worm Caenorhabditis elegans, which shares many of its genes with people and so also shows recognisable signs of biological ageing. She explains that mutating either the wrn-1 gene (equivalent seen in people as Werner syndrome) or the p53 gene results in shortened worm lifespan. “Yet, if worms carry both of these detrimental mutations, surprisingly they live even longer than a normal worm – and this increase in lifespan is accompanied by an increase in healthspan.”

These genes produce proteins in people, as well as in the worms, which could be targets for intervention through lifestyle changes or drugs. “We are investigating the mechanisms behind this novel phenomenon – which we call synthetic superviability – and whether there are other combinations of genes and environmental factors that can also be harnessed to improve the health span of worms, and hopefully that of humans.”
Could our muscles work forever?

From 2010 to 2050 there will be a projected 350% increase in the number of people over 85.

Some animals, planarian worms and jellyfish like Hydra, avoid the ageing process altogether, demonstrating that it is not inevitable for animals to age. These animals are also capable of amazing feats of regeneration, able to regenerate their entire body parts from small starting fragments. This ability to regenerate is fuelled by the presence of many stem cells in adult animals.

The accuracy of the human epigenetic clock – a way of estimating the biological age of a tissue, organ or organism by measuring DNA methylation levels in a specified set of genomic positions – is within +/- 3.6 years in humans.

1 in 2 women and 1 in 5 men over the age of 50 will experience an osteoporotic fracture in the UK.

Some octogenarian athletes are able to maintain aerobic capacity close to the median of those 40 years younger. In one case study, a man was able to increase aerobic capacity by 13% through exercise training between the ages of 101 and 103.
Crop scientists have confirmed another tool in the armoury to control plant diseases whose pathogens can mirror the evolution of antibiotic-resistant bacteria in humans.

Carolan continues, “Some farmers already use more than one method to contain disease within their crops; they may use cultivars with one or more resistance genes but still apply fungicides for peace of mind. Our research provides evidence for such an approach, and for similar approaches using a combination of other methods, and indicates how the timing and degree of dosing, for instance, will affect resistance to disease.”

He adds, “We’ve shown that certain doses of fungicide will make the problem worse, and other doses will slow the evolution of the pathogen, therefore protecting genetic resistance in the cultivars.”

Carolan says, “Our findings will help agronomists and advisory boards to develop a toolkit for designing the best dose to apply to a given cultivar, such as Cara or King Edward, that will not only provide immediate containment of the pathogen but also slow its evolution, so controlling the disease for generations to come.”

Carolan stresses that the findings represent a general technique to maintain the effectiveness of cultivar resistance. Combining other methods of disease control could also reduce the growth rate of epidemics, methods such as biological control organisms, changes to soil fertilisation levels or agronomic measures, including planting date, planting density and intercropping.

Furthermore, Carolan says, “We chose a model of the evolution of Phytophthora infestans but the principle could be applied to many different crops and pathogens. In fact, in principle, it would be applicable to the evolution of drug resistance in the medical fields.”

Funding for the work came from BBSRC with additional support from Syngenta, BASF and Belchim.

Further reading:
http://rspb.royalsocietypublishing.org/content/284/1863/20170828

Extending the durability of cultivar resistance by limiting epidemic growth rates: bit.ly/2h2dGVd

Contact:
Bill O’Neill, Communications, Rothamsted Research, bill.oneill@rothamsted.ac.uk
Evidence provided by BBSRC- and DFID-funded researchers from the University of Warwick has helped cut the number of lame sheep in the UK by half, saving the industry £700M over ten years and preventing 7.5 million sheep from becoming lame every year.

The researchers, led by Professor Laura Green of The University of Warwick, found that a single injection of antibiotic helped 95% of sheep suffering from footrot recover, compared with 25% of those treated using traditional methods.

In 2004, approximately 10% of sheep in the UK were lame — that’s more than 2M animals in distress. 80% of lameness cases were due to the bacterial disease footrot (*Dichelobacter nodosus*) that causes inflammation in the feet and results in substantial weight loss, chronic pain and stress for diseased animals which can exacerbate other conditions.

“The infection goes under the [hoof] horn, like going under a nail, and the horn will pop away, so you can imagine how painful that is,” Professor Green explains.

Farmers typically managed lameness through twice-yearly foot-trimming of the whole flock, cutting away overgrown hoof horn (equivalent to nail in people) and spraying any infection with a disinfectant. However, causing feet to bleed during foot-trimming leads to chronic lameness, and affected sheep often have to be killed because they do not recover. Use of these techniques is often rooted in tradition rather than scientific evidence, and now more than half of sheep farmers no longer routinely foot-trim their sheep.

Professor Green collaborated with colleagues at Warwick as well as Dr Jasmeet Kaler at the University of Nottingham and Dr Rose Grogono-Thomas at the University of Bristol. The researchers worked with industry partners such as the Sheep Veterinary Society to disseminate their results, and via the AHDB Better Returns Programme, providing this new information on lameness to 18,000 farmers.

BBSRC funding for the research included £902K through the CEDFAS initiative, as well as a travel award, Industry Interchange Programme funding and two recent CASE studentships.

**DATA BREAKOUT**

£70-210M
Estimate cost of lameness in UK annually

23.1M
Number of sheep in UK flock in 2015

<2% by 2021
Lameness target level in sheep population. (The 2016 target of 5% has already been met)
Open-source bone biology software brings benefits

BBSRC-funded research into the relationship between bone structure and animal movement has led to the creation of free, open-source software called BoneJ. Developed by scientists undertaking biomechanics research at the Royal Veterinary College (RVC), the software has been downloaded more than 28,000 times by users across 56 countries.

Supported by a £336K investment from BBSRC, the work is used in fields from marine biology to food science, and also led to a collaboration with architecture firm Foster + Partners that focused on understanding the self-repairing and structural properties of bone for use in new building materials.

The research was led by Professor John Hutchinson at the RVC and Dr Sandra Shefelbine at Imperial College London. BoneJ was developed by Dr Michael Doube, the post-doctoral researcher on the project and now a Lecturer at RVC. It arose from the researchers looking at how bone structure changes between closely related species of different sizes. They used motion-capture video systems and pressure plates to capture behavioural data from groups of animals, combining these with detailed CT scans of bones to provide estimates of the physical forces and loads placed on bones in animals of different sizes as they move.

However, their image-analysis software was unable to handle the data. So Doube took existing plug-ins for open-source imaging software ImageJ and created the first version of BoneJ. Unlike many expensive commercial image packages, it can be modified, allowing researchers to adapt it to meet specific needs. The software’s flexibility has also led to the creation of a supportive online community.

“Before this, if you wanted to image bone data, you either had to write your own software, which is laborious, or you had to use expensive, limited commercial software,” says Hutchinson. Increasingly, funders and academic publishers require researchers to share data and software tools as part of their methods. Doube has continued to develop BoneJ with support from the Wellcome Trust, and in late 2016 Doube received additional funding from BBSRC to develop new capabilities for the software.

**DATA BREAKOUT**

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

The Global Challenges Research Fund (GCRF) is one of the most ambitious international research programmes ever created, with £225 million being invested across 37 projects to address challenges in fields such as health, humanitarian crises, conflict, the environment, the economy, domestic violence, society, and technology.

GCRF Research Councils UK Collective Fund is supporting projects in the range of £2-8 million over four years. It will build upon research knowledge in the UK, and strengthen capacity overseas, to help address challenges, informed by an expressed need in developing countries.

The funding was announced during a visit to the Sainsbury Laboratory at Cambridge University by Jo Johnson, Minister for Universities, Science, Research and Innovation.

Dr Amanda Collis, BBSRC Executive Director, Science, said, “The announcement of this international multidisciplinary programme ensures we will continue to build capacity both in the UK and in developing countries, and that our collaborative research partnership will be strengthened so together we can work to tackle the challenges faced by developing countries.”

“From healthcare to green energy, the successful projects receiving funding today 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.”

Jo Johnson, Minister for Universities, Science, Research and Innovation, said, “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.”

About the Global Challenges Research Fund (GCRF)

GCRF is a £1.5 billion fund that supports cutting-edge research which addresses the global issues faced by developing countries. It harnesses the expertise of the UK’s world-leading researchers, focusing on: funding challenge-led disciplinary and interdisciplinary research; strengthening capacity for research, innovation and knowledge exchange; and providing an agile response to emergencies where there is an urgent research need.

It forms part of UK government’s Official Development Assistance (ODA) commitment and is overseen by the Department for Business, Energy and Industrial Strategy (BEIS), and delivered through 17 delivery partners including the research councils, the UK academies, the UK Space Agency and funding bodies.
Global Challenges Research Fund projects:

- How animal health affects humans
- Designing climate-smart policy for growth
- Research and empowerment for sustainable food supplies
- Capacity building for bioinformatics in Latin America
- Safeguarding the future of seaweed aquaculture in developing countries
- Preserving, restoring and managing Colombian biodiversity
- Biopharmaceutical and animal vaccine production in Thailand and beyond

More details about GCRF can be found at: www.rcuk.ac.uk/funding.GCRF
A new University of Oxford collaboration could significantly increase the economic productivity of one of the UK’s largest crop yields, the Sitka spruce conifer tree.

‘Sitka Spruced’ is a forestry research project awarded funding by BBSRC. Scientists from the University of Oxford, in partnership with The University of Edinburgh and Forest Research (an agency of the Forestry Commission), will use advanced genomic testing to identify rare individuals which combine fast growth rate with good timber quality to improve the economics of Sitka spruce plantations in the UK.

UK forestry relies heavily on Sitka spruce and, although native to the Pacific North West, over 35 million trees are planted in the UK each year. It is the third largest crop by area of cultivation in the UK (after wheat and barley), and accounts for around £1 billion of the industry’s £2 billion annual revenue. The tree is fast growing in the moist climate of western and northern Britain, producing a versatile white wood with uses from paper making to construction-grade material used in buildings. It takes around 40 years from planting before most of the Sitka spruce trees are harvested, and only a proportion of those trees make the stronger, higher-value construction grades.

Using a new breeding technique called ‘genomic selection’, the team hope to accurately identify, at a very early age, fast growing trees, which will meet the higher construction specifications needed to build houses.

The project will scan hundreds of trees for variations in their DNA make-up and then associate those variations with fast-growing trees that produce superior timber. This will enable scientists to screen the DNA of other trees to identify at a very young age those they predict will grow quickly and yield higher quality timber. Genomics exploits the huge variation that occurs naturally within the species. If successful, the project paves the way to apply the same genomics technology to screen trees for other properties such as adaptation to drier or nutrient-poor sites, or resistance to insects and disease.

Professor John MacKay, Project lead and Wood Professor of Forest Science at University of Oxford, said, “I am really excited to be part of such a research landmark, breeding to increase the economic return of Sitka spruce. The funding from BBSRC is testament to the project’s long-term value.”
Making the most of collaboration

BBSRC promotes international collaborations for bioscience research in universities and research institutes throughout the UK. International partnerships are essential for strengthening and maintaining the vibrancy of the UK bioscience research base. BBSRC receives a specific allocation from government to strengthen research and innovation partnerships between the UK and emerging knowledge economies under the Newton Fund.

One Newton Programme BBSRC has funded with China, Thailand, Vietnam and the Philippines is The Sustainable Rice Research Programme, which launched 13 projects at the International Rice Research Institute in the Philippines in January.

The workshop brought nearly 70 project participants together and identified common approaches and synergies, looking at how to maximise the benefits from collaborative approaches to data collation and sharing. The participation from the funding partners from all countries also enabled plans for future programmes to be discussed to build on successes in the rice programme.

The workshop helped strengthen and build new collaborations between individuals, research groups and project teams. It also helped to ensure that projects are able to share best practice, and identify opportunities to add value and enhance impact.

Across four countries, researchers are now looking to increase resilience to diseases in swine and poultry that have the epidemic and or zoonotic potential to spread disease. They aim to do this by addressing microbiological pathogens, and also investigate other food security challenges in the production of pigs and chickens.

Research Councils in Europe

BBSRC is the managing partner of the UK Research Office (UKRO) in Brussels – the European office of the UK Research Councils. UKRO’s mission is to maximise UK engagement in EU-funded research, innovation and higher-education activities. It delivers a subscription-based advisory service for research organisations in the main UK higher-education institutions and provides the National Contact Point services on behalf of the UK Government.

As part of UKRO’s governance, Research Councils, subscriber representatives and Universities UK form the UKRO Board and agree UKRO business plans, budgets and longer-term strategy. A recent board meeting commended UKRO’s work throughout the year, especially after the UK referendum, and the important role in liaison within the UK and with our important European stakeholders, and discussed how UKRO might operate within UK Research and Innovation (UKRI), the organisation that will encompass the present seven Research Councils, plus Innovate UK and Research England.

We benefit from a presence in Brussels by holding meetings with colleagues from the UK Representation to the EU and with European Commission (EC) officials working on research policy and research for development. It’s reassuring to know that research and innovation are key areas as Brexit negotiations progress, and how the EC is incorporating emerging outputs from the interim evaluation of Horizon 2020 into future planning. The UK recognises the added value of the EU funding for frontier research, mobility programmes, collaborative research, research infrastructures and contribution to the knowledge economy and the importance of identifying excellence in funding decisions.

More information about the UK Research Office can be found at: www.ukro.ac.uk

Tim Willis, BBSRC Associate Director, International, reviews multinational partnerships in rice research and maintaining relationships with European partners.

Tim Willis, BBSRC Associate Director, International.

Tim Willis prepares to address the international rice workshop.
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