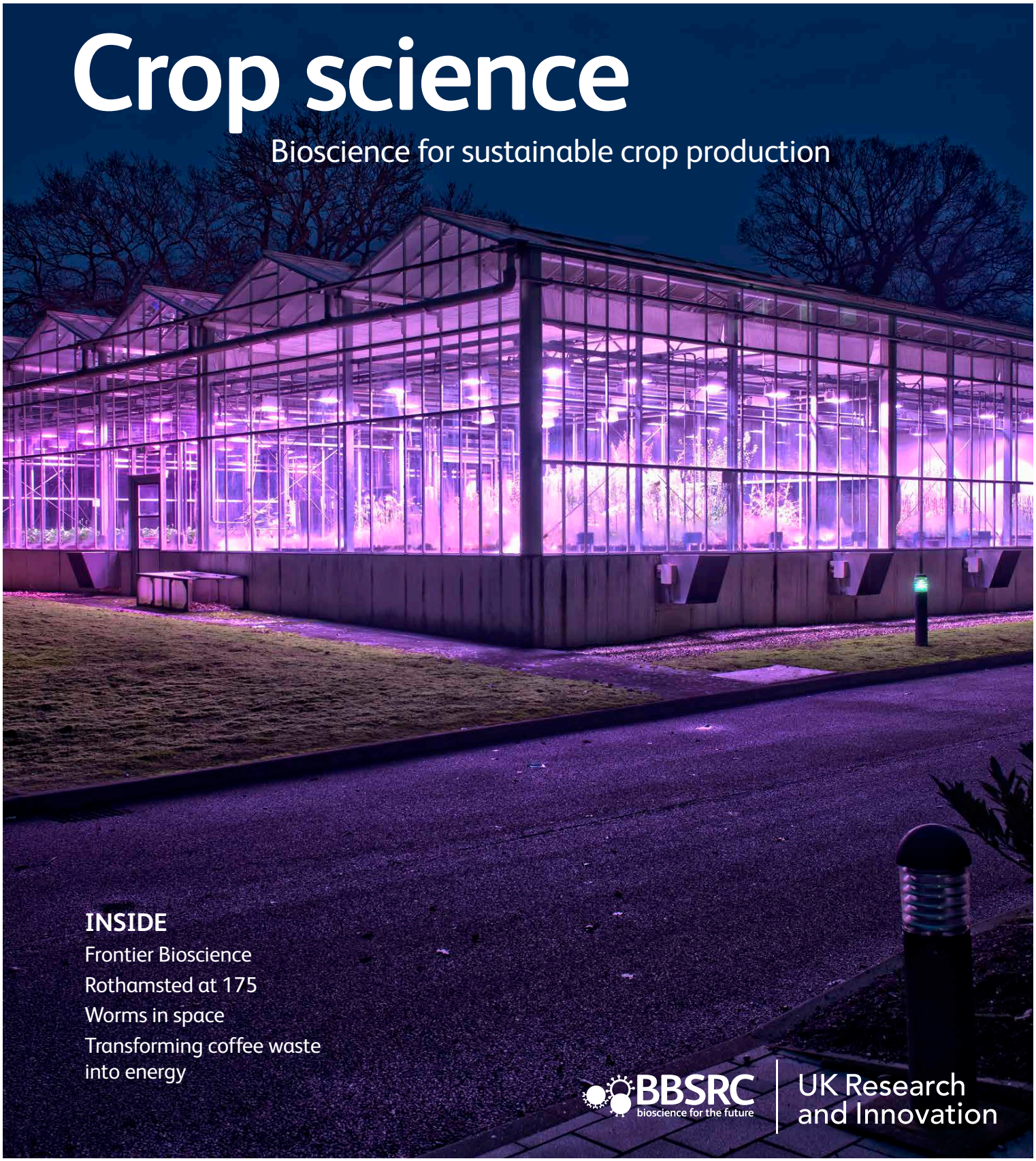
BBSRC Business

Winter 2018

BBSRC is part of UK Research and Innovation

# Crop science

## Bioscience for sustainable crop production



**INSIDE**



BBSRC bioscience for the future | UK Research and Innovation

# About BBSRC-UKRI

**BBSRC is part of UK Research and Innovation and 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 **£498 million** in world-class bioscience in 2017-18. 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.ukri.org**

### 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

*Front cover:* Speed breeding using enhanced LED lighting at the John Innes Centre.
Andrew Davis/John Innes Centre

## Contacts

| | |
|---|---|
| **Plant health and agriculture** | brian.harris@bbsrc.ac.uk |
| **Animal health** | ceri.lyn-adams@bbsrc.ac.uk |
| **Bioenergy** | colin.miles@bbsrc.ac.uk |
| **Food** | brian.harris@bbsrc.ac.uk |
| **Human health** | ceri.lyn-adams@bbsrc.ac.uk |
| **Industrial biotechnology** | colin.miles@bbsrc.ac.uk |
| **International** | tim.willis@bbsrc.ac.uk |
| **Research technologies** | rowan.mckibbin@bbsrc.ac.uk |
| **Skills and training** | david.mcallister@bbsrc.ac.uk |
| **Innovation and business** | lynne.guppy@bbsrc.ac.uk |

## About BBSRC Business

**BBSRC Business is a controlled circulation magazine which is distributed free of charge to end users of research and to individuals with an interest in BBSRC.**

**For enquiries about Business contact the communications team:**
BBSRC
Polaris House, North Star Avenue,
Swindon, SN2 1UH.
Tel: 01793 442810
Email: press.office@bbsrc.ac.uk

For regular news about BBSRC and the outcomes and impacts of BBSRC-funded research visit
www.bbsrc.ukri.org/news

# Introduction

## From India to Innovators and Worms in Space

### Melanie Welham, UKRI Executive Chair

A warm welcome to the winter edition of BBSRC Business.

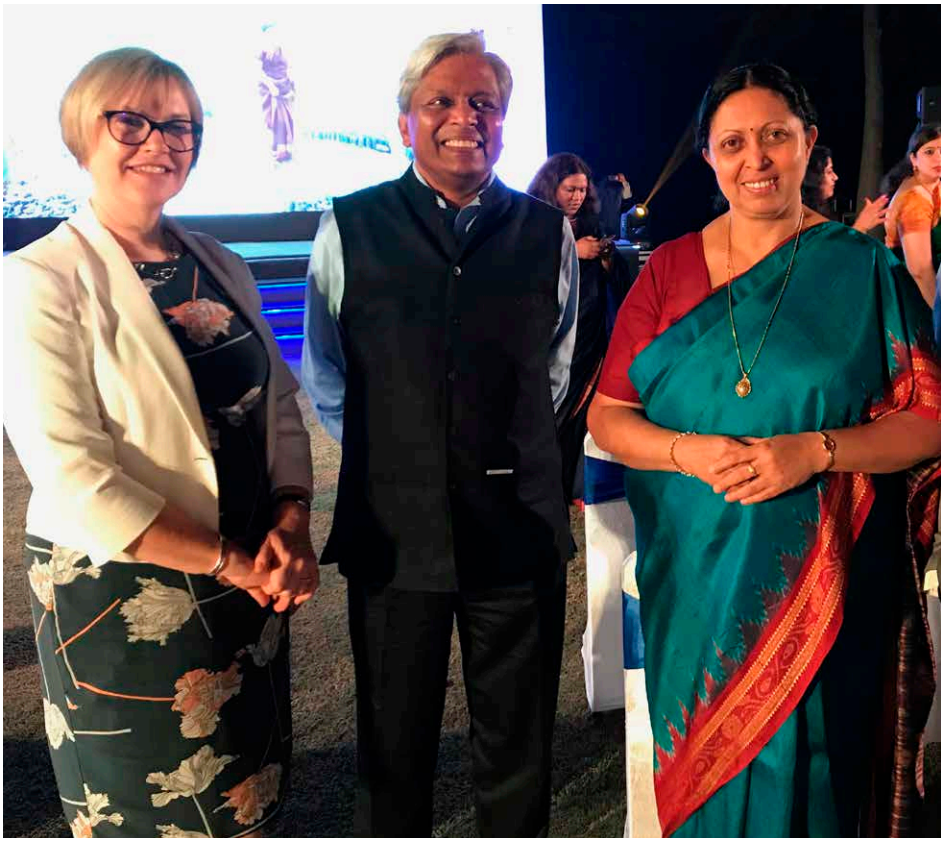
I was delighted to make my first trip to India recently, representing UK Research and Innovation (UKRI) at the 'Together for Impact' celebrations marking a decade of the India-UKRI partnership and to officially launch UKRI India.

BBSRC has been building relationships with our Indian counterparts, the Department of Biotechnology (DBT) in particular, for the past two decades. With DBT we have funded joint research in bioenergy, livestock disease and crop production. I was very struck by our partner DBT's enthusiasm, and flexible approach and our strategic alignment around many of the global challenges that are important to both countries.

One of the more unusual projects in BBSRC's portfolio has caught the imagination of the media. The Molecular Muscle Experiment, often referred to as 'Worms in Space', is a collaboration between scientists at the Universities of Exeter, Nottingham and Lancaster.

On 5 December thousands of *C. elegans* worms were launched into space. The research saw the worms living and reproducing on the International Space Station, in an effort to understand the molecular changes that occur during muscle wastage. The similarity between worms' muscles and our own makes them a common model species for neuromuscular research and the loss of muscle during spaceflight is a major barrier for long-term missions, but is also a problem for those on earth afflicted with muscular dystrophies, diabetes, injuries and age-related declines in strength. This project is a great example of national and international collaboration and you can find out more on pages 8-9.

Since our last edition we have published the *Forward Look for UK Bioscience*, which sets out how pushing back the frontiers of biology can contribute to delivering a healthy, prosperous and sustainable future.



Top: Melanie Welham on a recent trip to officially launch UKRI India.

Right: Some of the BBSRC Board members at a recent meeting.

Development of the *Forward Look for UK Bioscience* has been led by BBSRC, in consultation with a wide range of key stakeholders and partners. I am personally very grateful to all of those who have contributed and excited that we have a new framing upon which BBSRC, within UKRI, will build its strategic delivery plan. The latter, under development now, will set out in more detail the actions we will take to support and deliver elements of the Forward Look and contribute to UKRI's strategic prospectus. You can read more on page 27.

Finally, a reminder that BBSRC's Innovator of the Year competition is open for recommendations and applications until 30 January 2019. Categories include: International Impact, Social Impact, Commercial Impact and Early Career Impact. Details on how to apply or recommend a colleague are available on the BBSRC website. We had a really strong and very diverse field of applications last year and I am hoping for a repeat in 2019. Read the story behind the 2018 overall winners, Professor Rob Honey and Sabrina Cohen-Hatton, on pages 12-13.

# Scientists identify key step in production of body odour

Researchers have unravelled a key part of the molecular process by which armpit bacteria produce the most pungent component of the noxious smell we recognise as body odour.

The findings could result in more effective deodorants with targeted active ingredients.

The role of microbes, specifically bacteria, in the production of body odour has been known for some time, and scientists at the University of York recently made the discovery that a small number of species of *Staphylococcus* bacteria are responsible for the formation of the most pungent component of body odour.

Researchers from the University of York, in partnership with colleagues at the University of Oxford, have deciphered the first step in this process by identifying and decoding the structure of the molecule – known as a "transport" protein – that enables bacteria to recognise and swallow up the odourless compounds secreted in sweat.

Solving the structure of the protein means that a new generation of deodorants could now be developed to disrupt its function.

The research was partly funded by BBSRC.

# 'Artificial embryos' may reduce the need for animals in research

A team of scientists at the University of Cambridge have developed a new technique that could reduce the number of mammalian embryos used in research. The technique allows scientists to create an 'artificial embryo' that goes through several important developmental stages like a real embryo.

Working with researchers from the University of Geneva and the Swiss Federal Institute of Technology Lausanne (EPFL), the team at Cambridge have shown that mouse embryonic stem cells can organise themselves into structures called gastruloids.

Gastruloids share several important features and behaviours with embryos, and can be experimented on in the same way, but they are made from stem cells that can be grown in the lab instead of being taken from a pregnant mouse. Mice do not survive the procedure to remove embryos, so this could significantly reduce the number of animals used in developmental research.

"These results significantly extend our earlier findings. We were surprised to see how far gastruloids develop, their complex organization and the range of different tissues and organ primordia that they contain," says Professor Alfonso Martinez Arias, leader of the University of Cambridge team, at its Department of Genetics.

The researchers say these artificial embryos will provide a viable alternative to animal research.

Micrograph of Methicillin-Resistant Staphylococcus aureus (MRSA).

NIAID

# Gene study pinpoints superbug link between people and animals

Scientists have shed light on how a major cause of human and animal disease can jump between species, by studying its genes.

Experts say the research could help improve the use of antibiotics and design better strategies for limiting the spread of disease.

*Staphylococcus aureus* bacteria usually live harmlessly in our noses. If the bacteria get into a cut, however, they can cause infections that, in rare instances, can be deadly.

Antibiotic-resistant strains of the bacteria, such as MRSA, are a major cause of hospital-acquired infections, and the bacterium is also a major burden for the agricultural industry as it causes diseases such as mastitis in cows and skeletal infections in broiler chickens.

A team led by The University of Edinburgh's The Roslin Institute analysed the entire genetic make-up of more than 800 strains of *Staphylococcus aureus* that were isolated from people and animals.

The researchers sought to investigate the evolutionary history of the bacterium and key events that had allowed it to jump between species.

They found that humans were the likely original host for the bacteria. The first strains capable of infecting livestock emerged around the time animals were first domesticated for farming.

The Roslin Institute receives strategic funding from BBSRC.

# A new 'promiscuous' enzyme helps turn plant waste into sustainable products

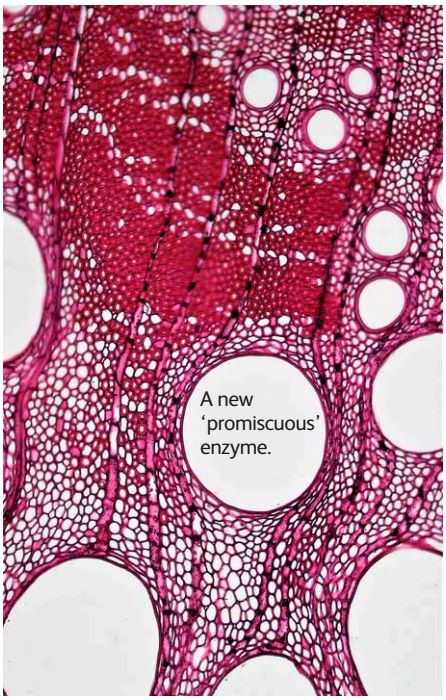
A new family of enzymes has been discovered which paves the way to convert plant waste into sustainable and high-value products such as nylon, plastics, chemicals, and fuels. The discovery was made by members of a UK-US enzyme engineering team.

The new family of enzymes are active on the building blocks of lignin - one of the main components of plants, which scientists have been trying for decades to find a way of breaking down efficiently.

They found a way of releasing a key bottleneck in the process of breaking down lignin to its basic chemicals. The results provide a route to making new materials and chemicals such as nylon, bioplastics, and even carbon fibre, from what has previously been a waste product.

Professor McGeehan, Director of the Institute of Biological and Biomedical Sciences in the School of Biological Sciences at Portsmouth - one of the lead researchers, said: "To protect their sugar-containing cellulose, plants have evolved a fascinatingly complicated material called lignin that only a small selection of fungi and bacteria can tackle."

"It's an amazing material," Professor McGeehan said, "cellulose and lignin are among the most abundant biopolymers on earth. The success of plants is largely due to the clever mixture of these polymers to create lignocellulose, a material that is challenging to digest."




University of Portsmouth

The research was partly funded by BBSRC.

**Read more about enzyme research on page 22.**

# The hidden story of wheat

An international research team have uncovered the hidden genetic secrets that give wheat its remarkable ability for local adaptation – revealing a previously untapped resource for breeding better, more resilient wheat.

Globally, wheat, together with maize and rice, provides the most human nutrition. It can thrive in a whole range of different environments, even within a similar geographical region.

Exploring one hundred different wheat lines worldwide, the research team led by the Earlham Institute in collaboration with HelmholtzZentrum München, University of Liverpool and the John Innes Centre have revealed a trove of epigenetic variation that was previously unknown to current genotyping methods.

The new findings link crop evolution and phenotypic change to agricultural conditions – allowing us to protect future yields with a climate-resistant armour through new breeding methods – contributing to the success of this global crop as well as significant implications for the wheat community.

The research could enable farmers to keep on growing the best possible crop for their local environment.

**Read more about crop science on pages 14-15.**

# Insects inform next generation of miniature drone design

Curious about how insects have mastered moving, experts at the University of Oxford, the Royal Veterinary College (RVC) and the University of Leeds studied the aerodynamics of insect flight in depth.

By comparing the flight of over 50 different species, they were able to identify the precise ways in which wing shape affects flight performance and efficiency.

"The next generation of Unmanned Aerial Vehicles (UAVs) is likely to feature solutions to the tricky challenges of flight control and endurance that have been informed by research into insects," said Professor Richard Bomphrey, who led the work at RVC.

The project's findings were presented to NATO and the Ministry of Defence, and sparked a collaboration with Animal Dynamics, a spinout company that is designing a flapping miniature UAV inspired by dragonflies. Further BBSRC-funded research is now taking place into how insects use sensory feedback when flying, and how their muscles allow them to steer and turn, with further potential to influence UAV design.

Peter Burlinson, BBSRC lead for frontier bioscience, said: "Curiosity-driven research often leads to insights that are unexpectedly relevant to other fields. There is increasing interest in biologically inspired design and it is exciting to see BBSRC-funded science finding application in such an innovative area."

# Headlines

## Genomics holds the key to unravelling history of life

Molten lava and ash.

A new study led by scientists from the Universities of Bristol and Bath has used a combination of genomic and fossil data to explain the history of life on Earth, from its origin to the present day.

"Fossils do not represent the only line of evidence to understand the past," explained co-author Professor Philip Donoghue. "A second record of life exists, preserved in the genomes of all living creatures."

By combining fossil and genomic information, the team are able to use an approach called the 'molecular clock'. This approach is loosely based on the idea that the number of differences in the genomes of two living species is proportional to the time since they shared a common ancestor.

By making use of this method the team were able to derive a timescale for the history of life on Earth that did not rely on the ever-changing age of the oldest accepted fossil evidence of life.

Co-author Professor Davide Pisani said: "Using this approach we were able to show that the Last Universal Common Ancestor of all cellular life forms existed very early in Earth's history, almost 4.5 billion years ago – not long after Earth was impacted by the planet Theia, the event which sterilised Earth and led to the formation of the Moon."

This research was funded by the BBSRC and the Natural Environment Research Council.

## £15 million joint investment between UK and India takes aim at global challenges

Scientists and businesses from the UK and India are joining forces to combat global challenges through two new collaborative research and development programmes. The two programmes, worth over £15 million, aim to tackle the reduction and repurposing of industrial waste, and improve and increase pulse and oilseed crop productivity.

The first programme will focus on using cutting-edge bioscience, chemistry and engineering solutions to reduce industrial waste and pollution in India. The conversion of industrial waste into multiple useful products will improve the value recovery from waste, reducing the amounts requiring disposal or being released into water courses. The programme is being delivered through the Newton-Bhabha Fund.

The second programme will increase the sustainable production of pulses and oilseeds in India. Production of both crops currently falls short of demand in India and the outcomes of these joint projects will help enhance food security, reduce the need for imports and meet the demands of a growing population in India. The programme is supported by a joint BBSRC and DBT India investment of £5.3 million.

## £90 million to help feed the nine billion

A £90 million fund that aims to revolutionise how food is produced and dramatically reduce its environmental impact has been launched.

The Transforming Food Production Challenge, part of the government's modern Industrial Strategy, brings together the UK's world-leading agri-food sector with robotics, satellite, data and digital technologies and artificial intelligence to make the UK a world leader in the precision farming techniques needed to make sure the planet is able to feed a population of nine billion people by 2050.

The Challenge, funded through the government's Industrial Strategy Challenge Fund (ISCF), will help to fuel rural growth, create high-skilled jobs and open up new export opportunities while reducing pollution and minimising waste and soil erosion.

The first funding, with an investment up to £20 million, will see projects focussed on the development of enhanced decision support, precision agriculture technology solutions and systems.

## A novel switch to control genome editing

A biological switch that reliably turns protein expression on at will has been invented by University of Bath and Cardiff University scientists. The switch enables control of genome editing tools that might one day regulate cascades of desired genetic changes through entire populations.

This new switching method should work for any protein in any species and uses a cheap, non-toxic amino acid as the control switch – the 'on' mode requires the presence of an amino acid called BOC.

In contrast to other reported switches, this method does not use antibiotics, removing risks of selecting for bacterial antibiotic resistance.

The switch offers the potential to control a host of biological processes; these may include research and practical applications, in the laboratory test-tube, whole animals or both.

Professor Tony Perry, who led the Bath team from the Department of Biology & Biochemistry, said: "What sets our work apart is the potential for this as an environmentally friendly switch across large distances, which no previous method really enables. Gene editing has enormous potential across biological science, from biomedicine to food security, in insects, plants and animals."

The study was funded by the Medical Research Council, BBSRC and the Wellcome Trust.

Transgenic mice carrying a gene that makes their skin glow green. University of Bath

## Burns' works authenticated by new, minimally destructive scientific technique

A cross-disciplinary team of researchers from the University of Glasgow have found a novel way to accurately authenticate ancient documents in a minimally destructive way.

The team analysed the ink and paper of both authenticated and forged Robert Burns' manuscripts to produce a 'Support Vector Machine classifier' that could accurately distinguish true Burns handwriting from the fakes.

The scientists were also able to distinguish which inks Burns used to write each of his poems, whether it be ivory black, iron gall or a mixture of the two.

The scientists were able to lift ink from the copies using a simple pipetting process that could be performed outside the laboratory, and that crucially did not visibly damage the original material.

Dr Karl Burgess from the University of Glasgow said: "Through this technique we now know some things about Burns that we never knew before. However, we're particularly excited about that fact that we have a new way of providing more evidence for a fake or a real manuscript if one turns up, and we have a technique that we can apply to any manuscript to gain more information about it.

The work was funded and supported by the Scottish Funding Council, the Wellcome Trust, the Engineering and Physical Sciences Research Council and BBSRC.

## Scientists decode opium poppy genome

Scientists have determined the DNA code of the opium poppy genome, uncovering key steps in how the plant evolved to produce the pharmaceutical compounds used to make vital medicines.

The discovery may pave the way for scientists to improve yields and the disease resistance of the medicinal plant, securing a reliable and cheap supply of the most effective drugs for pain relief and palliative care.

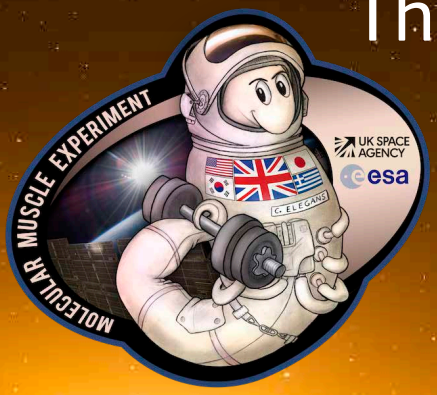
The breakthrough, by researchers at the University of York in partnership with the Wellcome Sanger Institute, UK, and international colleagues, reveals the origins of the genetic pathway leading to the production of the cough suppressant noscapine and painkiller drugs morphine and codeine.

Professor Ian Graham, from the Department of Biology at the University of York, said: "Biochemists have been curious for decades about how plants have evolved to become one of the richest sources of chemical diversity on earth. Using high-quality genome assembly, our study has deciphered how this has happened in the opium poppy.

Synthetic biology-based approaches to manufacturing compounds such as noscapine, codeine and morphine are now being developed whereby genes from the plant are engineered into microbial systems such as yeast to enable production in industrial fermenters. However, opium poppy remains by some distance the cheapest and the only commercial source of these pharmaceutical compounds by some distance.

# WORMS IN SPACE:

## The Molecular Muscle Experiment




**A team of scientists have successfully sent worms into space as part of an exciting project to discover more about muscle loss during space flight.**

The project was the first UK-led experiment to the International Space Station and involved a team of scientists from Exeter, Nottingham and Lancaster Universities. The project hopes to discover more about muscle loss in space, which in turn could lead to developing effective therapies and new treatments for muscular dystrophies.

The new understanding generated from the experiment could, in the future, be used to develop new treatments for muscular dystrophies. The research could also help boost our understanding of muscle loss during ageing and even help improve treatments for diabetes.

Spaceflight is an extreme environment that causes many negative health changes to the body, and astronauts can lose up to 40 per cent of their muscle after six months in space, the equivalent of ageing between 20 and 40 years.

The worms used in the Molecular Muscle Experiment are *Caenorhabditis elegans* (c.elegans). Despite being only 1mm long in adulthood, they share many the essential biological characteristics with humans, and previous experiments have shown they are affected by biological changes in space, including alterations to muscle and the ability to use energy.

The launch took place at the start of December from the Kennedy Space Center in Florida, USA.

The University of Nottingham's Professor of Space Biology, Nate Szewczyk, who travelled to Cape Canaveral for the launch, said: "We were hugely excited to be coordinating the first UK-led experiment on the International Space Station.

"The Molecular Muscle Experiment is the first experiment to try to establish the precise molecular causes of neuromuscular decline in space. We will be using a combination of gene manipulations and drugs to pinpoint these causes."

"The Molecular Muscle Experiment aims to understand the causes of neuromuscular decline in space. This research will help us establish the precise molecules that cause muscle problems during spaceflight and enable us to test the effectiveness of novel therapies for preventing the muscle decline associated with spaceflight."

Dr Tim Etheridge, Senior Lecturer at the University of Exeter, is also part of the team and highlights there are other benefits to this mission: "Worms are, perhaps

Dr Chris Gaffney, Professor Nate Szewczyk, Dr Tim Etheridge, Dr Amelia Pollard, Mike Cooke, Dr Colleen Deane.

The worms travelled to the International Space Station aboard a Dragon spacecraft, launched by a SpaceX Falcon 9 rocket from NASA's Cape Canaveral Air Force Station, Florida.

The worms take-off from the Kennedy Space Centre.


NASA

The SpaceX Dragon spacecraft used to take the worms to the International Space Station.

surprisingly, a very good model for human muscle maintenance. At the molecular level, both structurally and metabolically they are highly similar to that of humans and from a spaceflight specific perspective – they provide a lot of practical advantages. They are very small, quick to grow, cheap and easy to maintain. It makes them good to work with."

As well as benefitting spaceflight and scientific exploration of the solar system, the worms in space experiment could also help in the treatment of ageing and conditions such as type 2 diabetes.

Dr Chris Gaffney, lecturer in Sports Science at Lancaster Medical School, is a member of the scientific team who has been centrally involved in the project: "If we ever want to go to Mars, if we ever want to conduct long-term exploratory spaceflight, then this is a problem that we have got to overcome simply because it isn't ethical to send someone to Mars, as by the time they get back here it would have a massive negative effect on their health."

Understanding the causes of muscle loss in space and using this knowledge to find effective therapies could also help develop new treatments for muscular dystrophies, help understand ageing muscle loss and even help improve treatments for diabetes.

Dr Tim Etheridge added: "Spaceflight represents the accelerated human model of the ageing condition and so, hopefully, by understanding the molecular changes it may provide the opportunity to understand human ageing on earth."

Dr Chris Gaffney adds: "A lot of the work we are doing is also very relevant to type 2 diabetes and preventing ageing. We have got an ageing population and this is more important than ever."

The worms were carried in liquid bacterial feed and sealed in a special gas-permeable plastic bag. The plastic bags were then housed in a special incubator. Whilst in space the worms were able to reproduce and, after growing to adults, in around 6.5 days, were frozen until returning to Earth for further study.

UK scientists are able to carry out this research thanks to the UK Space Agency's subscriptions to the European Space Agency's exploration programme, which contributes to the costs of the International Space Station.

The project attracted interest from former Science Minister, Sam Gyimah: "It's not every day that you hear of the potential health benefits of sending worms into space, but this crucial project which is also the first of its kind, could lead to better treatment for muscular conditions for people on Earth as well as improving the wellbeing of our astronauts.

"Along with our commitment through the modern Industrial Strategy to support our space sector to go from strength to strength, our world-leading research sector is consistently pushing the boundaries of existing knowledge for the benefit of all."

Dr Gaffney, whose previous research into skeletal muscle has involved working with elite athletes, was particularly excited to be part of the team; "I've loved space since I was very young, so to be involved with sending something to the International Space Station was very exciting."

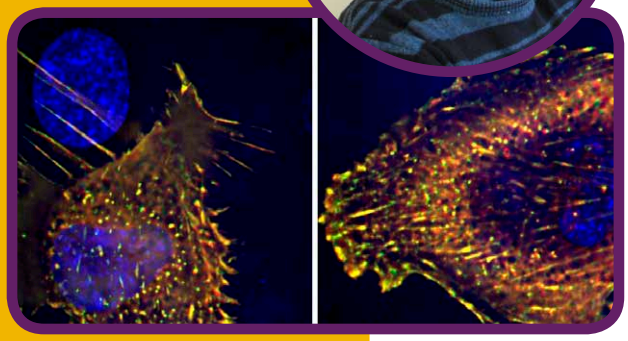
*The project is supported by The European Space Agency, UK Space Agency, BBSRC, MRC, and Arthritis Research UK.*

# Frontier BIOSCIENCE

**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'.**

## Probing the role of actin arginylation through synthetic biology

### Professor Mohan Balasubramanian, University of Warwick



At the University of Warwick, Professor Mohan Balasubramanian, Professor Karuna Sampath, and Dr Masanori Mishima are leading a team of researchers using a combination of synthetic biology and biochemistry to understand how modification of the cytoskeletal protein actin influences its biochemical properties, cellular localization, and functions.

Actin is an abundant cytoskeletal protein that is present in all cells. It plays important roles in cell shape establishment, maintenance, cell division, cell movement, muscle contraction, wound healing, and heart beating. In many animals, actin in non-muscle cells undergoes a modification called arginylation. Through this modification, the amino acid arginine is attached to the front end of the actin protein. However, it is not currently understood why only certain actins get arginylated and what function is accomplished by actin arginylation.

The Balasubramanian laboratory has developed a novel method to overcome a major stumbling block in the study of actin isoforms and their modifications. Using a synthetic biology approach, the team can produce large amounts of pure unmodified and arginylated actins, enabling for the first time the elucidation of the function of actin arginylation.

As mis-regulation of actin cytoskeleton function is linked to several human diseases, understanding actin arginylation and its function may provide insights into actin-linked diseases.

Top: Professor Mohan Balasubramanian.

Above: Fluorescent actin isoforms visualised in human cells.

Bottom: Professor Paul Jarvis.

Below: Arabidopsis protoplasts. Newcastle University

## Stress, chloroplasts, and plant development

### Professor Paul Jarvis, University of Oxford

At the University of Oxford, Professor Paul Jarvis is leading state-of-the-art research to develop understanding of how two newly identified genes regulate the development of chloroplasts and influence plant responses to stresses such as drought and salinity.

Recent work undertaken by the team discovered that a gene called SP1 controls important aspects of plant growth, including plant responses to adverse environmental conditions such as water stress and high salinity.

More recently, they have identified two new genes that function in the same regulatory pathway as SP1 – a pathway which they now term CHLORAD (for "Chloroplast-Associated Degradation"), which plays a role in regulating the development of structures inside plant cells called chloroplasts.

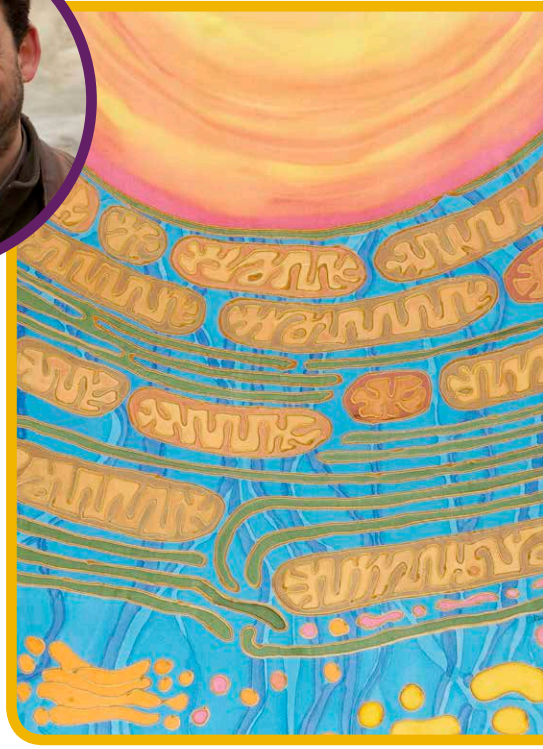
Chloroplasts are organelles that contain the green pigment chlorophyll and are responsible for photosynthesis, capturing sunlight energy and using it to power the activities of the cell. As photosynthesis is the only significant mechanism of energy input into the living world, chloroplasts are of huge importance, not just to plants but to all life on Earth. Chloroplasts also have critical roles in plant responses to abiotic stress, and so are ideal targets for engineering stress tolerance in crops.

In this project, Professor Jarvis and his team will study these genes and the role of CHLORAD in environmental stress tolerance and hope that the findings will have broad application that could be utilised to alleviate reduction in crop yields in response to climate change.

## The cellular flux capacitor

### Professor Nick Lane, University College London

Left: Professor Nick Lane.
Below: Artwork 'Mitonuclear Dawn' by Odra Noel.



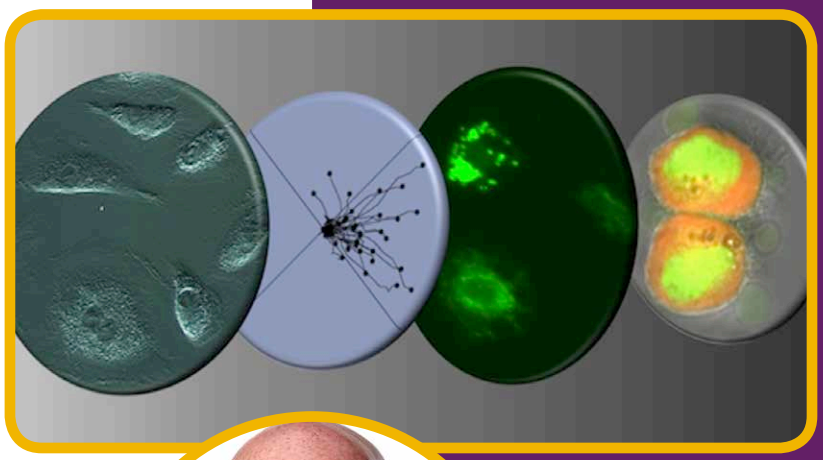
Professor Nick Lane at University College London is spearheading research to understand how fundamental cell processes involving mitochondria affect fertility, health, response to drugs and diet, and lifespan.

Mitochondria are often called the powerhouses of the cell, as they produce nearly all the energy needed for living. Recent research shows that mitochondria do much more than generate energy: they integrate virtually all metabolic inputs and outputs of cells, acting as 'flux-capacitors'. However, mitochondria are uniquely vulnerable to dysfunction, as proteins vital for their performance are encoded by two genomes (nuclear and mitochondrial). Subtle mismatches between nuclear and mitochondrial encoded genes can disrupt normal health, e.g. causing infertility and altered lifespan in animal models. Even when the health effects are too subtle to notice, these mismatches can alter the activity of thousands of genes. Because these mismatches are produced every generation, they most likely have substantial health impacts. Until recently, though, this has been nearly impossible to verify.

Using cutting-edge experimental methods in a fruit fly model, Professor Lane's team aims to measure mitochondrial performance in real time, uncovering how these mismatches alter the function of different tissues over the life course of males and females, and how mitochondrial performance is altered by dietary and pharmacological treatments. This work will generate fundamental biological knowledge with important implications for lifelong health.

## Active extracellular vesicles and the control of inflammation

### Professor Andrew Devitt, Aston University



Top: Panels with the 'orange' image showing vesicles coming off cells.
Above: Professor Andrew Devitt.

Professor Devitt's team at Aston University is investigating how extracellular vesicles, small membrane bags released from dying immune cells and mesenchymal stem cells, play a critical and active role in the resolution of the inflammatory process.

Inflammation is a key response of the innate immune system to challenge, but its success is dependent on its ability to 'switch off'. Complex 'waves' of molecular and cellular events coordinate the return to normal tissue function. In order for this to be effective, inflammatory cells that are no longer required die by apoptosis and are removed (phagocytosed) rapidly by cells called macrophages.

Recent work from Prof Devitt's team has detailed the molecular composition and associated activities of extracellular vesicles that are released during apoptosis. These extracellular vesicles recruit macrophages to sites of cell death to promote resolution of inflammation and produce signals that drive tissue repair. However, currently, little is known about how these extracellular vesicles function. Building on preliminary work, the team aims to shed light on the molecular processes by which these vesicles transmit inflammation-controlling signals to surrounding cells, defining a novel mechanism to the control of inflammation and its resolution.

By understanding the fundamental mechanisms of communication between cells promoting inflammation, and those cells promoting resolution and repair, Professor Devitt's team will deliver insight to possible therapeutic approaches for diseases that are driven by inflammation.

INNOVATOR
OF THE YEAR

Rob Honey and Sabrina Cohen-Hatton.

# The Innovators saving lives:

## Rob Honey and Sabrina Cohen-Hatton

**The winners of BBSRC's Innovator of the Year competition for 2018 couldn't have come from more different backgrounds. Together they have worked on a ground-breaking project that has changed the way emergency services deal with some of their most trying and testing times and ultimately save lives.**

In May 2018 they were awarded BBSRC's Innovator of the Year for their work underpinned by behavioural neuroscience. The research has helped shape guidance for decision making for the fire services Incident Commanders, when dealing with emergencies.

Professor Rob Honey is based at the School of Psychology, Cardiff University, and Sabrina Cohen-Hatton is Deputy Assistant Commissioner at the London Fire Brigade. They have formed an unlikely but powerful partnership that has led to groundbreaking and life-saving research.

Rob and Sabrina's research involves examining the process of decision making in the Fire and Rescue Service. Rob Honey explains:

"We looked at how and why decisions are made by Incident Commanders. They are the people who are in charge of the scene when there's an accident, for example on the motorway or a fire in a building."

"We used small cameras attached to their helmets and were able to watch the footage back afterwards. We could see what sort of decision-making processes they were using to direct the members of their crews, in order to save lives and deal with the major incidents they came up against."

When they analysed the video footage they were able to see how important decisions were being made, the verbal instructions that were being given and how Incident Commanders directed the members of their crews in order to save lives and deal with important incidents.

The recordings showed that for the majority of occasions decisions were based on past experience and automatic and intuitive rather than reflective and deliberative.

Rob explains further:

"Making decisions based on past experiences makes perfect sense - there's nothing wrong with that, but under some circumstances past experience won't help you because the situation you're facing might be rather complex or you might not have come across it before."

They [illegible] develop cognitive tools for the Incident Commanders

that would enable them to use the intuitive processes, which were good under some circumstances, and to use deliberative processes, which would allow them to better cope with complex or novel incidents that they might not have encountered before.

Sabrina became a firefighter when she was 18 years old, joining the brigade with a handful of GCSE qualifications and no further formal education, she is clear why her work is important:

"The big driver for us was looking at ways that we can make firefighters safer and make the public safer. Because of the research our firefighters are able to go out and deal with incidents that much better and resolve problems more effectively. For me the driver was always about firefighter safety."

As she explains, her interest in decision making came from an incident that ended in tragedy:

"One day I was called to an incident where a firefighter had been severely burned. My husband, also a fire fighter, was one of those on the fire engine involved and I knew there was a one-in-four chance that it could be him. I can tell you now that was the longest few minutes of my life. I didn't know whether it was him or somebody else that had been injured and I was absolutely torn between the role of a responder and the role of a loved one. I had a reprieve that day as he wasn't the one that was hurt but someone else was. So, someone else's family had that phone call, they had to rush to the hospital and had to deal with the recovery. For all of the relief that I felt I also had waves of guilt, knowing another person had been so badly injured. That was the turning point for all of this."

During her research, Sabrina has had to balance being a firefighter, wife and mother, but she almost dismisses the challenge that presents:

"Both Rob and Cardiff University made it all possible. I would go into the lab at about five o'clock in the morning, I would run some experiments. I would then pull a full shift in the fire service. I'd then go home and put my new-born baby to bed and then I'd go back in the lab for the night shift and I sometimes wasn't finished until one or two in the morning. I've been working with Rob for nearly a decade now and we've got a fantastic partnership, I've got so much respect for him. He's taught me so much and I'm so pleased that we've been able to build on that work that we did in the very early days looking at the black box neuroscience and build it into something practical that we can use to make my colleagues safer."

For Rob Honey there is satisfaction in knowing that the work they did together has been adopted by fire and rescue services across the country:

"The National Fire Chiefs Council have been fully behind the research, they commissioned part of it, and they're now rolling it out through their own policies which they recommend to all the independent fire and rescue services around the UK. So, it really is quite a big deal actually. Sabrina travels across the UK and around the world telling people about the research and about the changes to policy that's happening in the UK and she's had a lot of interest from all corners of the world, so it really is having an impact."

**Together their work has helped shape new guidance for emergency services which has been rolled out across the country and further afield.**

Their work was recognised in London earlier in the year when they were awarded the title of BBSRC Innovator of the Year 2018.

It's something Rob remembers well:

"We were very shocked, we were delighted of course, and I think it was nice to be recognised for all our hard work."

Roy Wilsher is Chair of the National Fire Chiefs Council, the professional voice of the UK fire and rescue service. They supported part of the research and have been instrumental in helping to roll out the new guidance.

Roy is clearly supportive of the work of both Sabrina and Rob:

"This research really is ground breaking. It is central to what we do. If you criticise the command decision making then you are criticising everything about them. If we can train Incident Commanders to understand how they will make decisions, how they will understand the situation in front of them and how they will make that risk analysis, it's a huge benefit, both on our staff and the communities we serve."

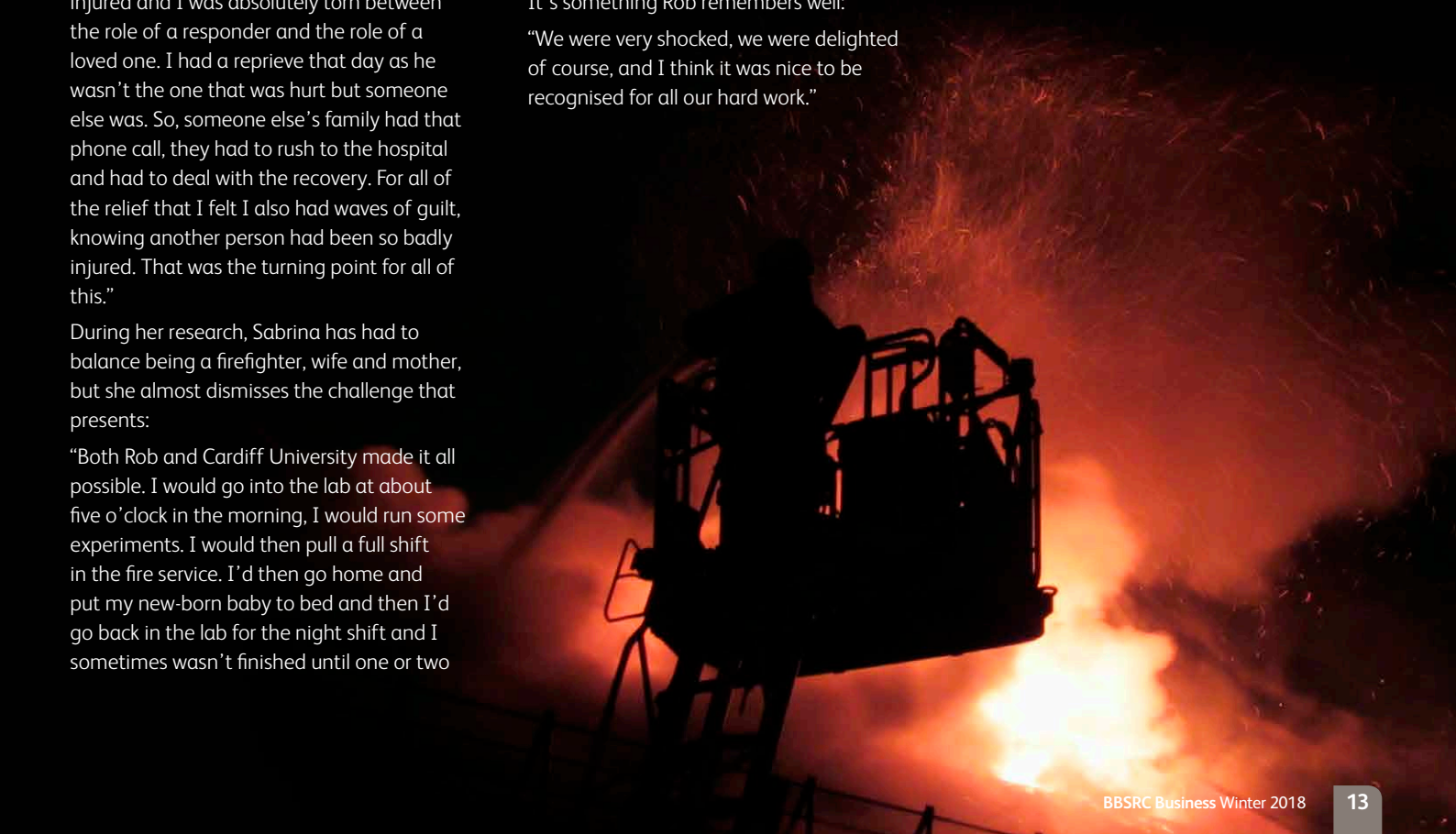
The advice drawn up from the research is now part of national operational guidance for all 50 fire services across the UK and has helped to save lives.

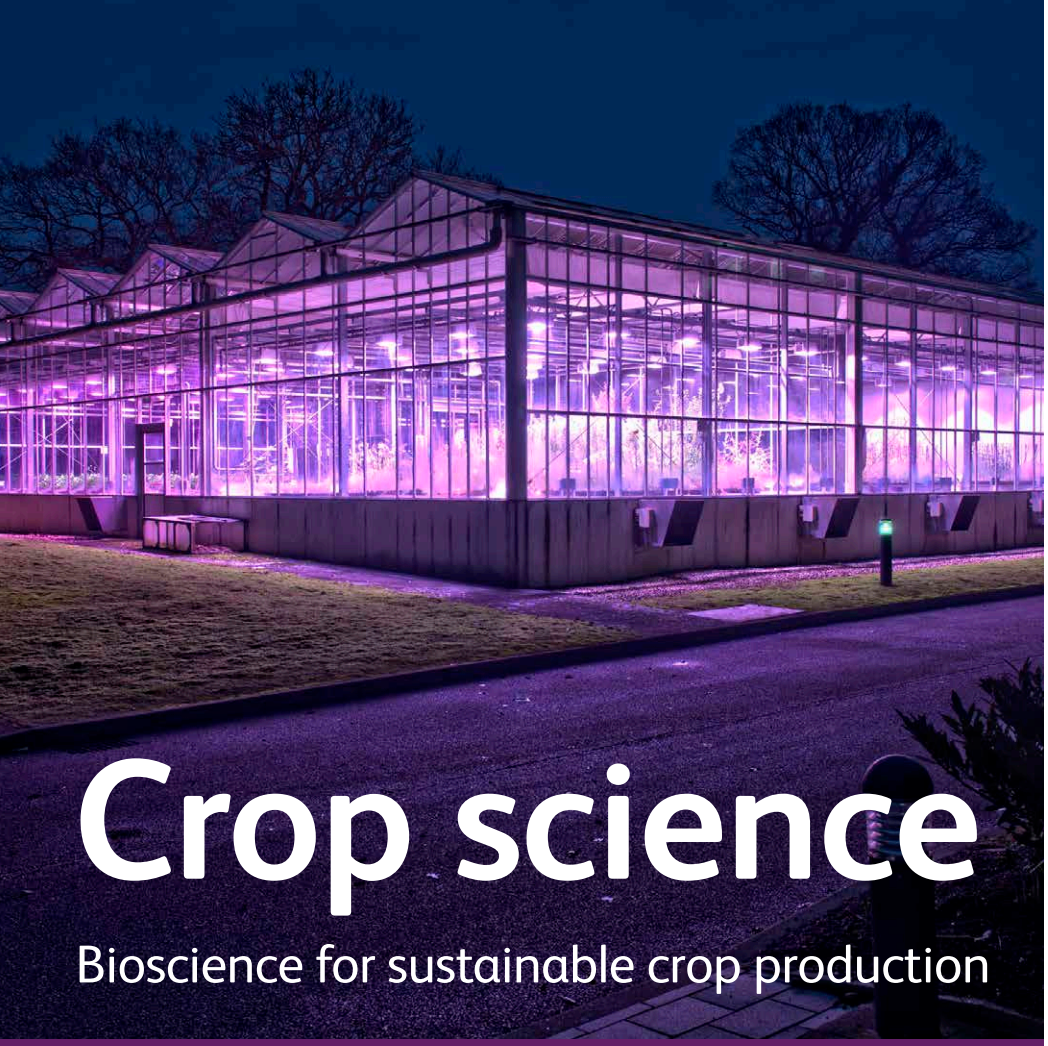
Roy Wilsher adds:

"This is such well-founded research that other people are now learning from this, Australia, Colombia and Belgium, all learning from the research we have supported and adopted here in the UK."

For Sabrina there is the added advantage that the legacy of the research continues to benefit colleagues:

"It's been a wonderful experience, and particularly selfishly from my point of view, because I've been able to mix my two loves - neuroscience and firefighting."





# Crop science

## Bioscience for sustainable crop production

BBSRC continues to fund research and innovation in crop science covering a range of topics. Crop breeding, the study of crop diseases and pests, pollinators and soil-plant interactions and improving our understanding of crops are all important aspects of research.

---

Using bioscience to create sustainable agriculture and food remains a strategic priority for BBSRC. Encouraging an approach that looks at all aspects of the food system, from the farm right through to extending the shelf-life of the produce – using bioscience to achieve these improvements in agriculture, food security research and innovation by focussing on the following areas:

- Sustainable agricultural systems – enabling food and farming systems to be more sustainable and resilient
- Crop and farmed animal health – supporting the improvement of crop and animal health and animal welfare
- Food safety and nutrition – increasing the nutritional quality and safety of food
- Reducing waste – using bioscience to reduce waste on the farm and in the food system
- Understanding and exploiting genomics – enabling better exploitation of genetic diversity and more predictive approaches to determining crop and farmed animal phenotype from genotype
- Precision agriculture – enabling and supporting smart technology and precision approaches to agriculture.

Here are some of the many crop science projects underway.

## Developing oats for human health and nutrition

InnovOat is a five-year project that aims to use modern breeding technologies to capture and enhance the proven health benefits of oats in new varieties.

The primary focus is on the understanding and manipulation of key traits that will enhance the value of oats in human health improvement. It will develop new varieties which will enhance health benefits whilst capitalising on the value of oats as a low-input cereal, and increase the environmental and economic sustainability of cereal-based rotations.

This programme draws upon the expertise of oat breeders and end-users and will address long-term breeding goals using the latest genetic tools and resources, including genomic selection, to develop experimental populations to improve key traits that will increase the production and utilisation of oats, and enhance grain yield, quality and composition.

The project is led by Aberystwyth University with partners NIAB, Heriot Watt University, Senova and the BOBMA research group.

## Speed breeding – seed to seed in just eight weeks

A new speed breeding technique is enabling wheat generation from seed to seed in just eight weeks.

Using a glasshouse with enhanced lighting to create intense day-long patterns is helping to speed up the search for better performing crops. It has been developed by teams at the John Innes Centre, University of Queensland and University of Sydney.

This means that it is now possible to grow as many as six generations of wheat every year – a threefold increase on techniques currently used. Speed breeding uses fully controlled growth environments and can also be scaled up to work in a standard glasshouse. It uses LED lights optimised to aid photosynthesis in intensive sessions of up to 22 hours per day.

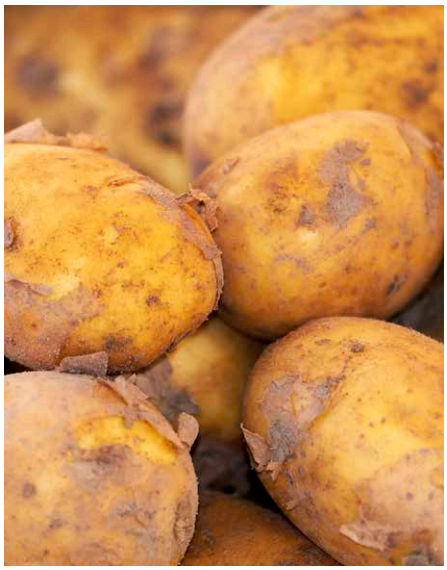
The international team have proved that the speed breeding technique can be used for a range of important crops. They have achieved up to six generations per year for bread wheat, durum wheat, barley, pea, chickpea, and four generations for canola (a form of rapeseed).

Speed breeding can be an important tool to enable advances in understanding the crop genetics. The study shows that traits such as plant-pathogen interactions, plant shape and structure, and flowering time can be studied in detail and repeated using the technology.

## Improved potato varieties

Potatoes are one of the most important UK crops. Many potatoes suffer the effects of pests and diseases such as late blight disease and potato cyst nematodes and are wasted even before harvest. Other challenges faced by the potato industry are tuber bruising and accumulation of reducing sugars and asparagine, which can lead to dark-coloured products. Additionally, potato spoilage due to bruising and blackening generates important wastage both in the supply chain and in the home.

Using the UK's favourite potato, Maris Piper, as a starting point, this project has generated transgenic potatoes with multiple modified traits. The GM approach used has introduced genes which tackle resistance to late potato blight and prevent accumulation of reducing sugars and polyphenol oxidase. Field trials have already started in the UK, to assess whether all these traits remain robust under real-world conditions. The best lines will be carried forwards in further field trials.



## Damaged salad leaves stimulate *Salmonella* in bagged salads

Investigations by University of Leicester microbiologists have revealed that just a small amount of damage to salad leaves could massively stimulate the presence of the food poisoning bug *Salmonella* in ready-prepared salad leaves.

The scientists have discovered that juices released from damaged leaves also had the effect of enhancing the virulence of the pathogen, potentially increasing its ability to cause infection in the consumer. Researchers are investigating how best to prevent food poisoning pathogens from attaching to the surface of salad leaves.

This latest study found that juices from damaged leaves in bagged spinach and mixed salad increased *Salmonella* pathogen growth 2,400-fold and also enhanced their adherence to surfaces.

Leafy green and other salad vegetables are an important part of a healthy diet, providing vitamins, minerals, and dietary fibre. Ready-to-eat prepared salads are particularly popular. Over recent years there have been a number of outbreaks associated with fresh salad produce contaminated with *Salmonella* and *E. coli* both in the USA and Europe.

This has triggered considerable interest in control and intervention measures both in the UK industry, the EU and key research funding bodies.

Despite a number of published reports on improving the microbiological safety of salad leaf production, very few studies have investigated the behaviour of *Salmonella* once the leaves have been bagged.

### MORE INFORMATION

This project is led by Professor Jonathan Jones and Dr Marina Pais at The Sainsbury Laboratory, Norwich in partnership with the University of Leeds and industrial partners J R Simplot Company and BioPotatoes Ltd.

UK-based BioPotatoes plan to take these engineered potatoes forward to commercialisation and to invest in the process of regulatory approval that is required to take the GM potato to market in Europe.

# Bioscience research tackling global challenges

## Sustainable agriculture for sub-Saharan Africa

The Global Challenges Research Fund (GCRF) is a £1.5 billion fund from the UK Government which seeks to deploy UK research capacity to address the challenges faced by developing countries. BBSRC has used its allocation of the GCRF to support a range of programmes, from agriculture and food security to industrial biotechnology. The programmes span fundamental research to translation and impact acceleration and also training and capacity building for developing countries.

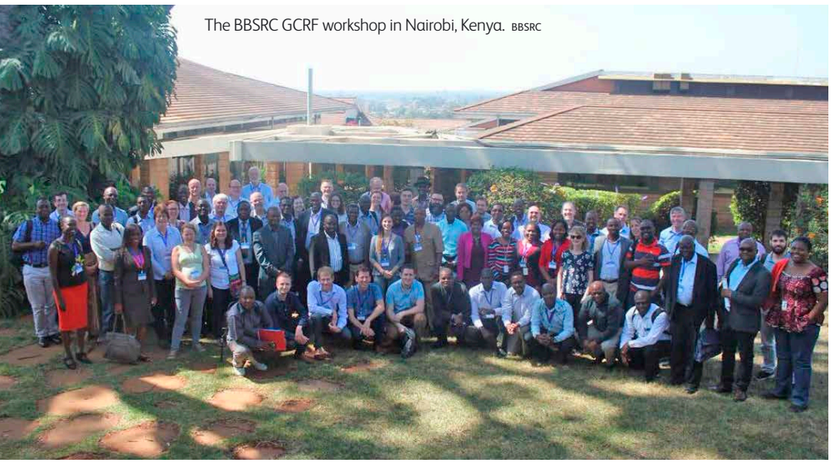
In March 2017 BBSRC held a GCRF workshop in Nairobi, Kenya. The workshop brought together scientists from the UK with their counterparts from across sub-Saharan Africa to identify key research challenges to the sustainable intensification of agriculture in the region. This collaborative approach directly informed the development of the £10 million BBSRC GCRF Sustainable agriculture for sub-Saharan Africa programme.

This innovative call was the first BBSRC programme to allow direct funding of overseas Co-Investigators, recognising the importance of equitable partnerships and co-design in international development research.

Professor Sir Mark Walport, Chief Executive of UK Research and Innovation, agrees this is an important programme of work:

"Stresses such as drought and the restriction of vital resources including nutrients and water are among the challenges affecting the development of sustainable agriculture in Sub-Saharan Africa. By bringing together UK researchers with partners in the region, these projects will play an important role in addressing these challenges and unlocking the potential of sustainable agriculture to transform food production and improve lives."

The scheme funded nine exciting projects and here are just a few.



The BBSRC GCRF workshop in Nairobi, Kenya. BBSRC

Gerard Bishop

*Solanum aethiopicum.*

### Improving the resilience of African eggplant

African eggplant is a relative of the familiar common eggplant or aubergine, and also of tomatoes and potatoes. It produces a range of differently shaped fruits and leaves. Depending on the variety, the fruits may red, white or green; squashed looking or egg-shaped; edible or inedible, and with edible nutritious leaves, or unpalatable spike-covered ones. As well as being hugely varied, African eggplant is a valuable crop, with demand for certain varieties increasing both locally and globally.

This project led by Professor Gerard Bishop at the National Institute of Agricultural Botany is a collaboration with scientists in Kenya, Tanzania and Uganda. The project seeks to improve the resilience of African eggplant to climate change, particularly tolerance of drought, as well as improving soil health for successful eggplant cultivation.

To address the challenge of drought resilience, the project will investigate optimal approaches to irrigation of eggplant, as well as methods to 'precondition' young plants to be more drought tolerant. In order to address the challenge around soil health, the project will investigate the prevalence of disease-causing bacteria and fungi in the soil and investigate biological methods to control these. Finally, genetic resources will be developed to facilitate the breeding of improved varieties of African eggplant.

Knowledge sharing and training of local farmers is integrated into the study, to facilitate uptake of the research and thus to increase production of this valuable crop.

ICIPE

Farmer in Oyugis.

### Biological controls for fall armyworm

Fall armyworm is the target of this project led by Professor Toby Bruce of Keele University, in collaboration with scientists from icipe, the International Centre of Insect Physiology and Ecology in Kenya.

Fall armyworm is an insect pest that has recently invaded Africa and is rapidly spreading across the continent, causing billions of dollars' worth of damage to crops and severely compromising the food security of smallholder subsistence farming communities. This project will work together with local farmers to design and test a system of biological control for fall armyworm.

It will use a technique known as 'Push-Pull' companion cropping. This method involves growing repellent plants in amongst the main crop to drive away the fall armyworm (Push), as well as 'attractive' plants grown at a distance from the crop as bait to tempt the insects away (Pull).

The project will also identify local crop varieties that are resistant to the insects, as well as natural enemies of the fall armyworm which can kill the insect larvae. This multi-pronged biological approach to pest control is particularly relevant for smallholder farmers in sub-Saharan Africa, as these communities are especially vulnerable to crop losses and are often unable to afford pesticides to treat infestations.

Endalkachew Woldemeskel/ILRI

Farmers inspect the faba bean trial.

### Legumes to transform livelihoods

This multinational team led by Professor Liz Baggs at the University of Edinburgh includes scientists from the UK, Nigeria, Kenya, Ethiopia and DR Congo. The project will develop a tool to allow smallholders in sub-Saharan Africa to select the most appropriate legume species for their needs.

Legumes are hugely diverse and have the potential to provide a range of benefits for farmers: a protein-rich food source, fodder for livestock, high-value crops for sale, wood for fuel and an increase in soil nutrient availability. In order for legumes to be successfully adopted by farmers, the most appropriate species for the specific farm must be chosen.

This project will combine new and existing data on the biological traits of different legumes, as well as agricultural conditions such as climate and soil quality, and socioeconomic factors such as market opportunities, to produce a decision-making tool for farmers in sub-Saharan Africa. Using this tool farmers will be able to select the most appropriate legume species for their farm, for example selecting a drought-tolerant species for a farm where rainfall levels are low.

It is hoped that this informed decision making will facilitate greater uptake of legumes by farmers, increasing their food security and contributing to economic development of rural communities.

John Innes Centre

Grass pea.

### Unlocking the potential of grass pea

Grass pea is a tremendously stress-resistant crop, able to tolerate extremes of drought and flood. It also has a high protein content, making it a valuable food source, and, as a legume, it has the capacity to enrich soils for other crops such as cereals. These qualities make grass pea a particularly suitable candidate for regions affected by extreme climates, and cultivation is increasing in countries such as Ethiopia.

However, grass pea has one major downside: overconsumption can lead to severe neurological problems, including paralysis, due to the presence of a toxin in the grass pea. Fear of disease has created a stigma around grass pea, and led to a lack of research and investment in this crop.

Professor Cathie Martin of the John Innes Centre, alongside partners in Kenya and Ethiopia, seeks to establish grass pea as a valuable crop. This project builds on previous research to use genetic techniques to breed safer varieties of grass pea adapted to East Africa, with reduced levels of toxin, high yield and stress tolerance.

The project will undertake field trials in Africa, and will work with local farmers to establish these new varieties as well as developing breeding programmes to ensure the continued development of new and improved grass pea varieties. Rehabilitation of grass pea will contribute to food security in the region, providing a safe and climate-tolerant source of protein.

Dr Claudio Avignone Rossa.

**Polluting waste generated during coffee production could be turned into electricity, thanks to research at the University of Surrey.**

# Transforming coffee waste into electricity

Dr Claudio Avignone Rossa and his team discovered that the community of microbes found in a wastewater treatment plant could hold the key to degrading coffee waste, which is highly damaging to the environment. The microbes eat the waste, producing energy which can be captured as a small electric current, enough to light a bulb. This type of device, called a microbial fuel cell, has not been used to treat coffee waste before.

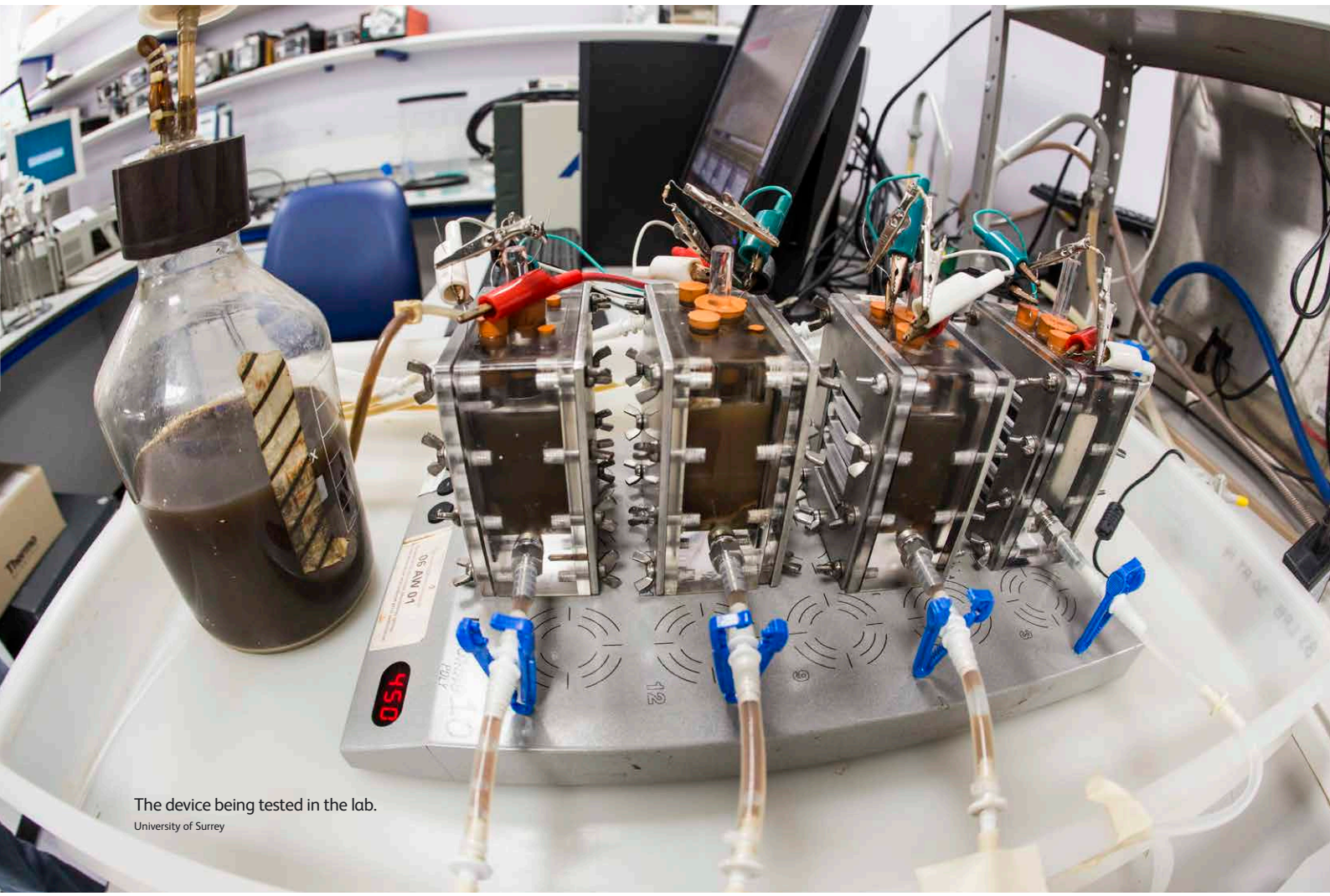
"We showed for the first time that it is possible to treat coffee waste using a microbial fuel cell," says Avignone Rossa. "We feed the fuel cells with coffee waste, and most of the compounds that cannot be degraded naturally are degraded by the microbes inside."

Waste from coffee production is a huge global problem. Each year 9.5bn kg of coffee is produced worldwide, and every kilogram of instant coffee produced generates roughly two kilograms of liquid waste. This is a particular issue in developing countries where the infrastructure does not always exist to process this waste and so it ends up in water courses, which become contaminated.

The new device could solve the problem by breaking down the polluting compounds in coffee waste so that it is no longer harmful to the environment. It is also simple and cheap enough that it can be built and installed on small, family-owned coffee farms in developing countries such as Colombia, the world's third largest coffee producer. A cooperative of Colombian coffee farmers have already expressed an interest in using the devices.

"You can build one of these microbial fuel cells for only a few pounds, or even pennies, using materials that are just lying around, including ceramic tiles, terracotta slabs, kitchen foil and cardboard," says Avignone Rossa, "and because they are very low cost and easy to construct, you can put several on every farm."

As well as preventing environmental contamination, the microbial fuel cells could also help to relieve a huge strain on water supplies. Coffee production requires vast quantities of water. Around 140 litres are needed to produce just one cup of coffee, and a large proportion of this is released as wastewater. In Colombia, many coffee farms are far from the main water sources, making it difficult to obtain the quantities of water required. The fuel cells could allow coffee farmers to clean up their wastewater and reuse it, reducing the amount of fresh water needed.



The device being tested in the lab.
University of Surrey

The researchers hope that, if their devices are used successfully in Colombia, they may be able to interest large coffee companies in Europe, where roughly one third of the world's coffee is consumed, in adopting the same approach to treating their waste.

Energy and Clean Growth Minister Claire Perry has added her support for the project; she commented: "Your morning latte could start its life on a remote Colombian coffee farm and now, thanks to UK Government-funded research, those farms now have grounds to double up as producers of both coffee beans and electricity."

"Local growers getting extra buzz from their beans is a great example of seizing the industrial opportunities of moving to a greener and cleaner economy. At home our modern industrial strategy is helping the UK's innovative clean growth sector brew up innovative technology like these fuel cells to deliver clean growth and build new markets across the globe."

Colin Miles, BBSRC's Head of Strategy, Industrial Biotechnology & Bioenergy, says: "The researchers have created a robust and inexpensive waste treatment solution from readily available household materials, which is capable of processing the quantities of waste produced by small, family-owned coffee farms, making it well suited to use where it is most needed. This research is a good example of how the power of biology can help solve significant problems which affect both the developing world and the UK." ■

Funding for this research was provided primarily by BBSRC and EPSRC.

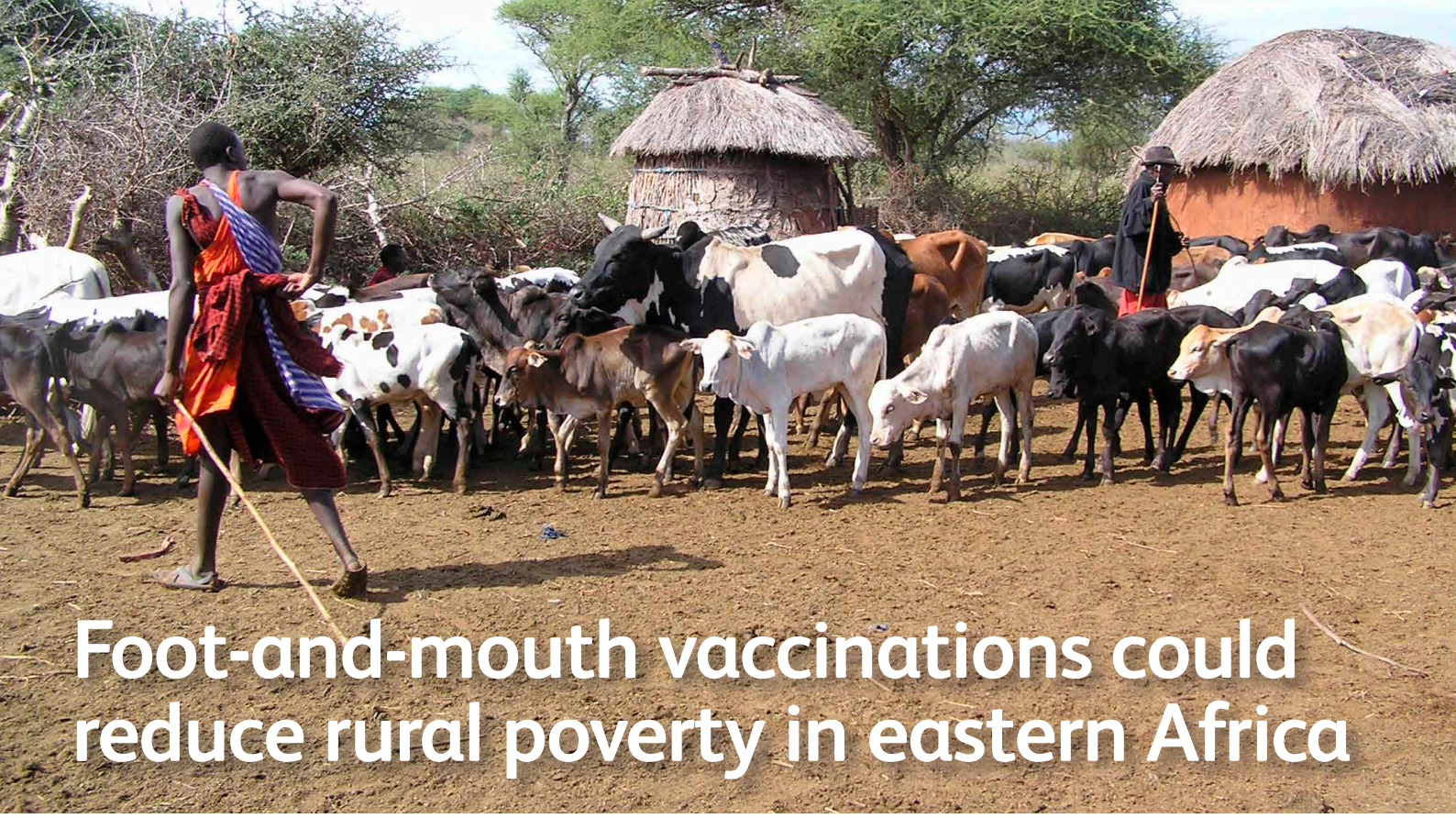
## DATA BREAKOUT

**9.5bn kg**
Coffee produced annually worldwide

**840m kg**
Coffee produced in Colombia in 2017

**2 kg**
Liquid waste generated in producing 1kg of instant coffee

**140 litres**
Water needed to produce a cup of coffee



# Foot-and-mouth vaccinations could reduce rural poverty in eastern Africa

**Research generated by scientists at University of Glasgow and The Pirbright Institute has shown that a targeted vaccination programme against foot-and-mouth disease (FMD) could alleviate poverty in eastern Africa.**

Both photos: Tiziana Lembo/University of Glasgow

In their study the team surveyed farming households in Tanzania and examined how the disease passed to livestock, enabling them to understand the economic burden FMD places on local people, and establish the best methods for controlling its spread.

There are several types of FMD virus, called serotypes, that circulate in Africa, but until now the way in which they spread across eastern Africa was poorly understood. Using the virus archives and facilities provided by the World Reference Laboratory for Foot-and-Mouth Disease, Pirbright experts were able to test Tanzanian livestock and wild buffalo to determine which serotypes they had been infected by over the years.

Dr Tiziana Lembo, lead author from the University of Glasgow, added: "In East Africa, foot-and-mouth disease control policies targeting the most affected communities have been constrained by a limited understanding of the role of wildlife in transmission to livestock, particularly in areas where both populations live in close proximity."

"Our research demonstrates that disease risks are driven by livestock- rather than wildlife-related factors. This suggests that strategies focusing on separation of susceptible livestock and buffalo, such as veterinary fences widely used in southern Africa, would have little effect in terms of reducing livestock infection in eastern Africa and could severely impact the preservation of Tanzanian unique ecosystems."

Professor Satya Parida, group leader of the Vaccine Differentiation group at Pirbright, said: "We found that FMDV serotypes pass through livestock in slow waves, but that it was rare for livestock to become infected by viruses circulating in wild buffalo. This is different to the situation in southern Africa, where there is spill over from buffalo to livestock and control methods therefore focus on their separation. Our results suggest that these strategies would not be effective in eastern Africa."

Livestock production losses due to FMD are estimated to be around $2.3 billion each year in Africa, affecting national economies, food security and the livelihoods of livestock keepers – 85% of whom live in extreme poverty.

The researchers discovered that communities which are reliant on milk as a protein source and for trade saw devastating consequences when FMD outbreaks occurred in their herds due to major reductions in milk production and loss in sales. Households experiencing outbreaks in their livestock typically spent around 25% less on human health, demonstrating the potentially serious effects FMD can have on human health as well as animal health.

FMD eradication campaigns, such as those in South America, have relied on mass vaccination against multiple serotypes to protect against all forms of the disease, but there are currently no commercial vaccines that cover all serotypes in sub-Saharan Africa. Through understanding the pattern of FMD waves, the researchers were able to suggest that, by quickly identifying the serotype causing an outbreak, serotype-specific vaccines could be deployed to prevent its continued spread, thereby providing a cost-effective strategy for reducing the economic and health impacts on livestock owners in these regions.

The primary research underpinning this study was funded by BBSRC, the Department for International Development and the Scottish Government through the Combating Infectious Diseases of Livestock for International Development initiative. ■

# Tackling deadly pig disease
# African swine fever

**With no vaccine to aid the prevention and control of African swine fever, researchers at The Pirbright Institute are joining forces with other research organisations and policy makers to help limit the damage caused by this deadly pig disease.**

The recent outbreak of African swine fever in China represents a significant development in the progression of the disease. China is home to over half the world's population of around 500 million pigs, so any potential spread throughout China and neighbouring countries would be devastating.

Infection with African swine fever virus, which causes the disease, can result in pig fatality rates of up to 100%.

The disease can be spread in a number of ways that make it difficult to control. Wild boar act as a reservoir for the disease, enabling the virus to circulate unchecked and allowing its spread to domestic pig farms, and boar carcasses can remain infectious for long periods given the right conditions.

"African swine fever is a globally emerging disease that is particularly worrying due to the broad spectrum of transmission routes for domestic and wild pig breeds affected," said Jef Grainger, Head of Sector Bioscience for Health, BBSRC. "With no existing means of control beyond strict biosecurity and eradication measures, there are clearly enormous economic, social and animal welfare costs associated with its spread."

Pig keepers can help prevent infection by practicing good biosecurity. Routinely providing dedicated clothing and boots for workers and visitors, limiting visitors to a minimum, and preventing outside vehicles which may be contaminated from coming on to pig premises, are valuable procedures for keeping out African swine fever.

The Animal and Plant Health Agency (APHA) has reiterated that it is illegal to feed domestic food waste or catering waste of any description to farm animals in the UK. This includes all pigs, whether kept commercially, on smallholdings or as pets. Read the APHA announcement on the government website.

To raise awareness amongst veterinarians and farmers, Pirbright scientists have collaborated with APHA to produce a resource which details the clinical signs of pigs infected with African swine fever.

Dr Linda Dixon, African swine fever expert at Pirbright, said: "We hope that by creating resources such as these, we can increase the likelihood of vets and farmers identifying the disease quickly should an outbreak occur in the UK. Thorough surveillance and rapid diagnosis of African swine fever are essential for its control, services which Pirbright provides globally as the World Organisation for Animal Health (OIE) Reference Laboratory for African swine fever. Using our expertise, we can advise Defra and OIE as well as improving tests to detect the virus more accurately and rapidly."

African swine fever virus does not cause disease in humans but it poses a significant threat to food security and has a substantial impact on the economy, especially on trade and farming. Control measures in China have so far been effective, but at a high price – over 8,000 pigs have been slaughtered in a bid to rapidly contain the outbreak. However, this action is necessary; if African swine fever were to circulate in such a substantial pig population, neighbouring countries would be at risk as would other parts of the world through global trade and movement of infected pork products by people travelling internationally.

Understanding this disease is now more critical than ever, and Pirbright researchers are working to find out how the virus evades the host's immune system and how it is transmitted, which will greatly aid the researchers' ability to develop potential vaccines. Development of a safe and effective vaccine has recently made significant progress through the work of the researchers led by Dr Dixon.

The Pirbright Institute receives strategic funding from BBSRC to support the work on global food security and health and improving quality of life for animals and people. ■

# An interview with ...
# Professor John McGeehan

**Professor John McGeehan is Director of the Institute of Biological and Biomedical Sciences at Portsmouth (IBBS). He's been involved in ground-breaking research involving enzymes and their use to degrade plastic waste made from polyethylene terephthalate (PET) and the breaking down of waste products to provide building blocks for sustainable materials, a story that made the headlines in early 2018.**

**John and the team at IBBS have received funding from various UK Research and Innovation councils, including BBSRC. John and his team have shown how successful cross-council research funding can be. Here, we ask him about his important work.**

## Can you explain what your research is about?

I currently lead the Centre for Enzyme Innovation (CEI) at Portsmouth University which targets major global challenges including the development of solutions for plastic pollution, and clean growth for sustainable chemicals, materials and biofuels. We have a focus on the discovery, characterisation and development of natural enzyme systems, and, through understanding the mechanisms of these powerful and selective biological catalysts, we are engineering their activities towards practical applications.

## What drives you in your research and quest for answers?

I am passionate about molecular biology and I am constantly amazed by the diversity and innovation that can be found in nature. Most of the chemistry of life centres on key reactions that are facilitated by enzymes, so for me this is such an exciting space to be working in. My real inspiration always comes from the brilliant researchers that I meet.

## How is the UK placed in the field of enzyme research?

The UK scientific community continues to lead in the publication of fundamental and high-impact research, but we need to be aware that the competition is strong and growing. In order to maintain our lead, we need continued investment in fundamental research and I am hopeful that the creation of UKRI will generate more synergetic routes to the timely commercialisation of these discoveries. I am particularly excited about the commercialisation opportunities after being approached by Ted Chapman and Ben Huckle at GlaxoSmithKline, who invited us to their impressive Biotechnology and Environmental Shared Services facility. Our collaboration with GSK has already reduced the timeline towards enzyme production at scale, but significantly, I believe that working with industry at the earliest stages of development will allow us to target relevant enzymes for relevant processes.

## What about international collaboration?

Our main international collaborators are in the USA, although we also have strong networks in Europe. We have a highly productive collaboration with the National Renewable Energy Laboratory (NREL) in Golden, Colorado. Indeed, US research in general in this area has always been strong. It is therefore reassuring that the UKRI are continuing to support such joint-funded international opportunities.

## Could enzyme science be used to deal with environmental issues?

I believe we are just scratching the surface of what can be achieved with enzymes. In relation to plastics, for example, while we are making progress we need to explore biological chemistries that can tackle the wide variety of plastics that are polluting our environment. This will involve searching in extreme and unusual environments and a great deal of innovation will be required to find, characterise and deploy these 'yet to be found' activities.

In parallel, our most abundant polymers, cellulose, lignin and chitin, have the capacity to provide us with long-term building blocks to generate sustainable materials that can feed a circular economy globally, reducing our carbon footprint, and mitigating the consequences of our impact on climate change.

I see a very promising future for biological enzymes, particularly when coupled and integrated with chemical catalysis to upcycle monomers to materials with enhanced properties. ■

Both photos: University of Portsmouth

**You can read more about the work of Professor John McGeehan on our website: bbsrc.ukri.org/enzymes or visit: www.port.ac.uk/centre-for-enzyme-innovation**

# Global Food Security project advises UK food retailer on food systems resilience

Global Food Security
Sustainable, healthy food for all

**IKnowFood, part of Global Food Security's project 'Resilience of the UK Food System in a Global Context', has helped shape the Co-op's new Future of Food ambition.**

The Co-op is the UK's fifth biggest food retailer, with more than 2,500 local, convenience and medium-sized stores, employing nearly 70,000 people. The *Future of Food* report was launched as part of 2018 Recycle Week and British Food Fortnight and outlines the Co-op's approach to food systems resilience, detailing the group's further recycling and sustainability commitments. The targets include halving food waste and increasing responsible sourcing in the run up to 2030.

For the IKnowFood team, led by Professor Bob Doherty of the University of York, the report launch was the culmination of more than a year's work with the food retailer. Approached by the Co-op's Food Policy team to advise them on the plan, Professor Doherty collaborated with Mark Barthel, sustainability specialist at 3Keel, to lead a series of round-table discussions around production, consumption and the supply chain.

The IKnowFood team worked with stakeholders and suppliers to identify food system challenges such as ethical sourcing, fair trade and high-risk commodities.

"We also led workshops with internal staff working in the system food system," says Professor Doherty. "These examined themes such as food security, with an aim of better understanding the Co-op's role within the food system and how the Group can operate in a more joined-up way."

With the Future of Food committing to specific targets set in the run-up to 2030, such as removing all single-use plastics in Co-op branded packaging by 2023, designing Co-op products with quality, sustainability and health in mind, and ensuring a fair deal and resilient livelihoods for everyone in the Co-op supply chain.

The IKnowFood team is set to continue to work with the Co-op's Food Policy team to create a roadmap for success. Professor Doherty sees the fact that the Co-op has taken a food systems approach as a positive step.


The future of food launch.
Co-operative Group

**IKnowFood is a four-year project led by Professor Bob Doherty with collaborators from across the University of York and the Universities of Liverpool and Manchester. It is one of the ten projects funded through the Global Food Security's Resilience of the UK Food System Programme with support from BBSRC, ESRC, NERC and Scottish Government.**

## Want to know more?

**www.iknowfood.org**
**https://food.coop.co.uk/food-ethics/future-of-food**
**www.foodsecurity.ac.uk**

"The Future of Food plan sees Co-op putting the resilience of the food system at the heart of its strategy," he says. "Furthermore, the fact that that academics have been involved in shaping the Group's strategy is really encouraging."

Cathryn Higgs, Head of Food Policy at the Co-op said: "We're extremely proud of our Future of Food ambition, it truly is our recipe for sustainability. Collaboration is at the heart of the ambition and is fundamental to how we work. We know that no one retailer can know the answer to all the global challenges we face, that's why working with Professor Doherty and Mark Barthel has been an invaluable part of the process and we look forward to continuing our partnership as we start work on our vision for a safe, healthy, sustainable food future." ■

# Rothamsted at 175

## It was 175 years ago that the Rothamsted Experimental Station was founded in Harpenden, Hertfordshire.

And so began what has been an incredible journey of discovery at one of the country's most respected research institutes, on the Rothamsted Manor estate.

The Rothamsted site was initially used to investigate the impact of inorganic and organic fertilizers on crop yield, using turnips. Today it continues to focus on strategic agricultural science to the benefit of farmers and society worldwide and is the oldest continually operating agricultural research station in the world.

Rothamsted marked its 175th birthday this year with a unique celebration and around 8,000 guests, stakeholders, families and friends, visited the institute's campus at Harpenden in Hertfordshire to learn more about the science of feeding the world, sustainably…or just to have some hands-on fun.

The Festival of Ideas presented more than 50 exhibits and experiences over a long weekend at the end of June, with scientists engaging with the public about their work and the regular compromises of supporting a rising global population that faces testing social, economic and climatic conditions.

As the year draws to a close, Rothamsted Research has been reflecting on an extraordinary anniversary and a mission focussed on the future of farming, highlighted in 12 short films from different specialists at the institute, putting evolution, engagement and entrepreneurship at its heart.

The Future Farming films were interspersed with flash talks from PhD students and postdocs at the institute, and short presentations from invited speakers who offered personal perspectives on controversial agri-tech ideas.

Images from the Festival of Ideas 2018.

All images: Rothamsted Research

**"But if our knowledge of the chemistry of soils should progress as rapidly as it has during the last twenty years, the analysis of a soil will ere long become much more significant than it is at present,"** *note the founders of Rothamsted Research presciently in a paper published in 1864.*

In the 12 films, produced under the BBSRC Agri-tech Catalyst Seeding Awards, senior scientists are challenged to explain the work they are doing and why it matters. They are then asked to imagine the future of farming in their specialist area.

From fighting fungi on crops with genetics to exploiting willow's industrial and medicinal secrets, from identifying communications between plants and insects to understanding how nutrients travel from soil into food, the common theme is modern entrepreneurship.

And this is a fitting theme for Rothamsted's anniversary year, which also featured an international conference in May on the future of long-term experiments, their pre-eminent role and increasing value, on the site where the first long-term experiments began 175 years ago and continue to provide prized data.

On 1 June 1843, John Bennet Lawes, Rothamsted's owner, engaged Joseph Henry Gilbert, a chemist, and together they sowed the first plantings in Rothamsted's Barnfield and Broadbalk fields. More followed, and seven of the experiments started between 1843 and 1856 continue to this day.

Across the years the site has played host to myriad important research and projects, and the quest for knowledge continues to this day with a proud history of ground-breaking discoveries, from crop treatment to crop protection, from statistical interpretation to soils management.

Rothamsted's importance is highlighted by being one of the eight BBSRC-funded strategic institutes delivering innovative, world-class bioscience research and training.

In fact, it was Gilbert alone who nurtured those longest of long-term experiments; Lawes was a businessman and fertiliser entrepreneur, interested in the results, less so in the graft of securing them. But they were a great team; together, they established Rothamsted at the forefront of modern agricultural science.

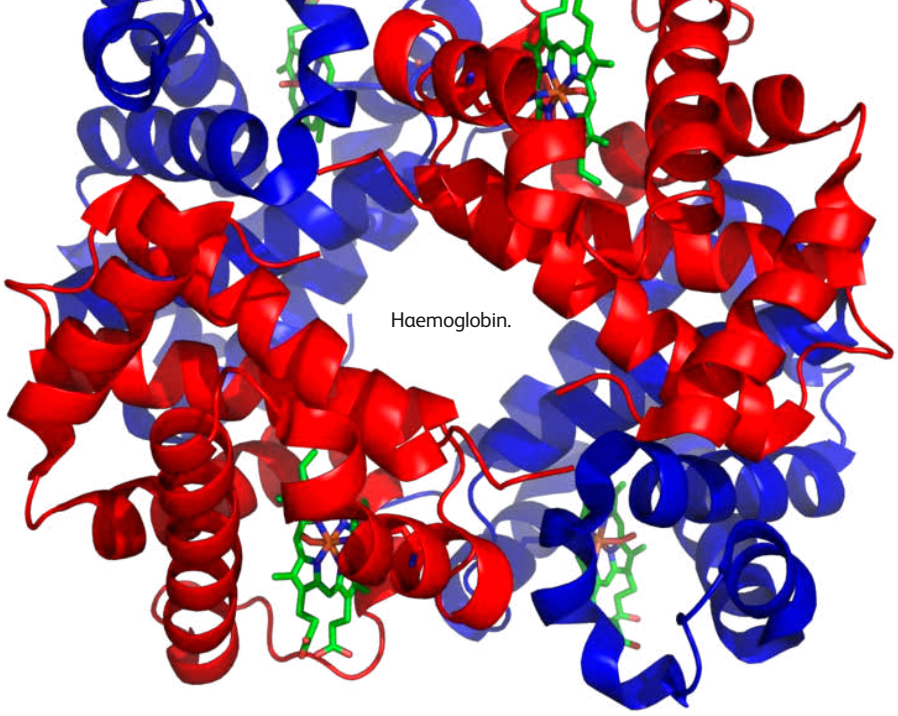
The 175th Anniversary festival celebrated Rothamsted's founding pair and the institute's heritage, but its focus was on a future, a back-to-the-future if you like, in which research programmes deliver tangible results as well as scientific publications.

Institute director Achim Dobermann says, "In short, in the current Annual Review, Rothamsted is engaging and evolving to be more entrepreneurial as it rises to the challenges ahead in the science of feeding the world, sustainably."

It's true that modern farming owes much to Rothamsted's long-standing research that continues to pump out results and provides valuable perspectives to guide the future of agricultural science achievements, and Rothamsted Research is looking forward to the challenges of the next 175 years! ■

**Rothamsted is also home to three unique resources that help provide insight into specific areas. Rothamsted hosts The Long-Term Experiments, the oldest continuous experiments in the world, the Rothamsted Insect Survey, providing the most extensive data on insects, and the North Wyke Farm Platform, an experimental farm research environment in Devon.**

# Making a success of innovative technology



Haemoglobin.

**Fluidic Analytics, a spin-out company established in 2013 at the University of Cambridge, is another successful example of how innovate research can lead to a commercially successful company.**

The Cambridge-based company now employs 25 people and has developed a new device that can characterise protein behaviour at volumes one thousand times smaller than conventional analytical techniques.

The technologies underpinning the company's first device, called Fluidity One, were developed by Professor Tuomas Knowles and his team at University of Cambridge after they were awarded a BBSRC grant in 2012 to examine new methods of analysing protein assembly.

## Understanding basic biological structures

Understanding and measuring the initial steps of protein assembly is a major challenge for researchers. This is partly due to the size of protein molecules – roughly a few nanometres in diameter – and the diversity of individual proteins that interact with one another during the assembly process.

Research that is able to shed light on the initial stages of a protein's life cycle, its size and how it interacts with other molecules would revolutionise the way we understand basic biological structures and certain diseases such as Parkinson's and Alzheimer's.

## Developing the Platform

An investment of £320k from BBSRC allowed Knowles to assemble a team of researchers to examine new ways of obtaining accurate, quantitative protein behaviour data. In particular, Knowles was interested in how to capture the exact moment when individual proteins first bind to one another and assemble into larger structures.

"We really set out to ask whether we could do these measurements in a fundamentally different way. It turns out that actually one very simple way of gaining additional information and overcoming some of the limitations of conventional surface-based biosensing methods is simply to work with much smaller volumes than are used in conventional measurements." says Professor Knowles.

On the back of a number of successes, Knowles and his team were able to attract further investment to continue their research.

## Fluidic Analytics

In 2013 Knowles partnered with serial entrepreneur Dr Andrew Lynn and founded Fluidic Analytics to design, develop, manufacture and sell a microfluidics instrument that offered a unique set of capabilities and a user-friendly experience to the wider bioscience community. The device, named Fluidity One, allows proteins to be studied in their native state.

Fluidic Analytics now aims to add to its product range by developing new tools and technologies that address other questions within the protein science field. The company has already received £5.3M of additional investment to develop these technologies.

"It is very exciting to be involved in projects that further our understanding of fundamental bioscience and to also develop novel technologies that enable researchers to carry out measurements that will greatly improve their own research," says Knowles. ■

The Fluidity One device.


Fluid Analytics

## DATA BREAKOUT

**25**

**People are now employed manufacturing the devices in Cambridge.**

**£320k**

**Awarded by BBSRC to assemble a team of researchers to examine new ways of obtaining accurate, quantitative protein behaviour data.**

**£5.3M**

**Further funding secured to develop tools in clinical diagnostics and consumer healthcare.**

# Our forward look for UK Bioscience


**BBSRC has published its Forward Look for UK Bioscience. The document is a plan for the future – a roadmap setting the direction of travel for UK bioscience and provides an opportunity to address some of the 21st Century's greatest challenges to provide food security, clean growth and healthy ageing.**

BBSRC is now inviting applications for the annual awards that celebrate the best innovations arising from biological science research.

Each year the BBSRC Innovator of the Year awards recognise and reward individuals and small teams who have harnessed the potential of their excellent research.

The awards recognise the full breadth of impacts that investments in research can have, from the creation of spinout companies or social enterprises, to working in collaboration with businesses or policy makers, both in the UK and abroad.

The competition has four award categories:

- Commercial Impact
- Social Impact
- International Impact
- Early Career Impact

Winners in each category will receive a £10,000 award, with a further £10,000 for the overall winner, the BBSRC Innovator of the Year.

Professor Rob Honey from Cardiff University, with his colleague Sabrina Cohen-Hatton, were awarded the social impact and overall winner awards at last year's event for applying their findings in the area of cognitive neuroscience to helping keep firefighters safe.

Professor Honey says he would definitely encourage people to take part: "Winning the Innovator of the Year title was a total surprise for us last year but it has been so worthwhile in helping to recognise the incredibly hard work that goes into projects such as ours. My advice is don't just think about entering, take part and you could be the 2019 Innovator of the Year."

Professor Melanie Welham, BBSRC Executive Chair, says: "The BBSRC Innovator of the Year has become an important date in the calendar that recognises the very significant potential of bioscience research. Every year there are a diverse range of impacts and innovations that catch the judges eye and I invite and encourage everyone to apply to help celebrate their hard work and achievements."

# INNOVATOR OF THE YEAR 2019

The UKRI-BBSRC Innovator of the year competition recognises and rewards inspirational individuals and small teams who have harnessed the potential of excellent BBSRC-funded research to deliver impact.

Do you know of exciting BBSRC-funded research that is making a difference?

If you do, encourage your research colleagues to apply.


More information about the awards and how to apply or recommend an Innovator can be found on our website:

bbsrc.ukri.org/innovator

BBSRC bioscience for the future | UK Research and Innovation