Impact Report 2017

Harnessing the power of biology

BBSRC
bioscience for the future

Chief Executive's Foreword

Bioscience has positive benefits on our society and economy, often in surprising and unexpected ways. This report, highlighting some recent outcomes and impacts of BBSRC investments, shows how bioscience is increasingly making a difference in our lives. From supporting the creation and growth of companies, to changing UK and international policy, to boosting wellbeing.

This is all built on a solid foundation of excellent bioscience research. A report from Elsevier, published in October 2017, shows that UK biological sciences research is world-leading. It also demonstrates that the UK leads in key technologies such as genomics and synthetic biology, which underpin future innovation and in turn provide the tools to further push back the frontiers of our knowledge.

The UK government's Industrial Strategy, published in November 2017, also recognises the UK's strengths in areas such as biotechnology, genetics, and precision agriculture, which are driving innovation in key industrial sectors. In 2017 we continued to play a major role in delivering the Industrial Strategy Challenge Fund, which is helping to support research that addresses the needs of business to boost UK productivity.

During 2017, we have been consulting widely with our community and stakeholders to define what needs to be done to ensure that the UK's world-leading bioscience research base continues to deliver exciting, ground-breaking new discoveries and to realise the opportunities for economic and social good that bioscience offers. This work will be valuable in shaping BBSRC approaches, as part of UK Research and Innovation.

Much of our understanding of the impact of BBSRC investments comes from the information you provide through researchfish®. That information, which is used to create many of the indictors and case studies in this report, is vital to help us see how the power of biology is benefitting society.

Professor Melanie Welham
BBSRC Chief Executive
January 2018

World-class research enables impact

Our research investments support excellent frontier bioscience to creatively address challenges and advance our knowledge.

Innovation and impact arise from world-leading bioscience. Every year BBSRC invests more than £450M in research, training and capabilities to sustain the excellence of, and maximise impact from, the UK bioscience community.

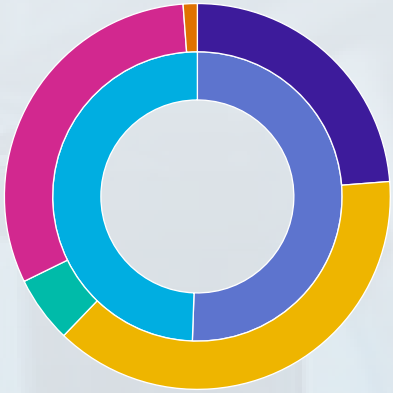
Our research investments support frontier bioscience to creatively address challenges and advance our knowledge, often in unexpected ways. We also support three challenge-led strategic priorities, in agriculture and food security, industrial biotechnology and bioenergy, and bioscience for health (see box on page three), and three enabling themes in enabling innovation, exploiting new ways of working, and partnerships. It can take many years for bioscience to produce tangible impacts for society, underlining the need to maintain investment in UK bioscience.

The UK's world-leading bioscience research base is one of the main reasons why major life science companies invest here and why the best researchers from around the world choose to work in the UK. The quality of UK research is further demonstrated by the continuing high performance of UK bioscience in international citation rankings.

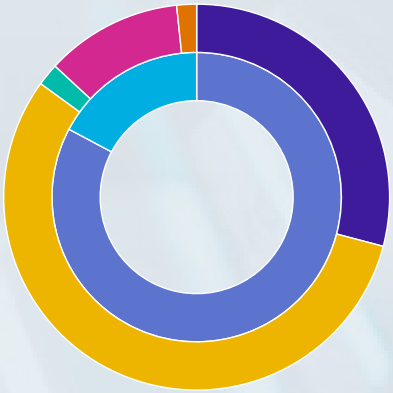
A 2017 report from publisher Elsevier, commissioned by the UK's Department of Business, Energy & Industrial Strategy (BEIS) shows that the UK leads the world in fields such as genomics and synthetic biology, and regenerative medicine, and is highly ranked in agri-science[1].

Common indicators		
2.1	Research Expenditure (2016/17)	£324.1m
6.1.1	Instances of journal articles (2016)	4,934

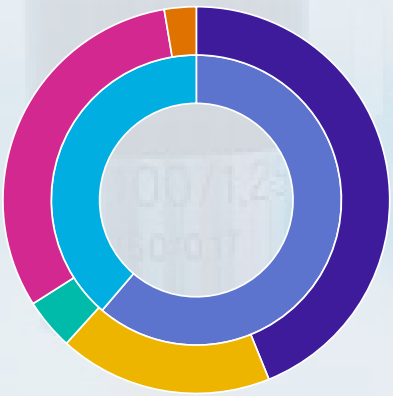
BBSRC research spend 2016-17 by strategic priority



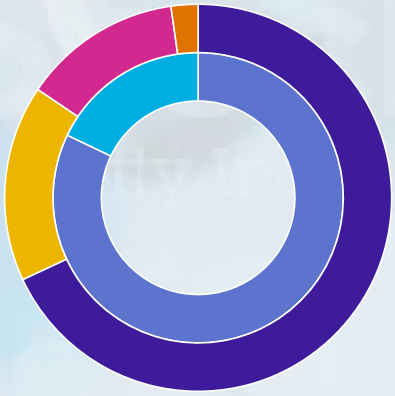
Agriculture and Food Security
£131.3m



Industrial Biotechnology and Bioenergy
£46.6m



Bioscience for Health
£55.3m



World-Class Underpinning Bioscience
£120.6m

Total research spend:
£324.1m

Overall:
62% of BBSRC's portfolio addresses a strategic priority.

38% supports world-class underpinning bioscience.

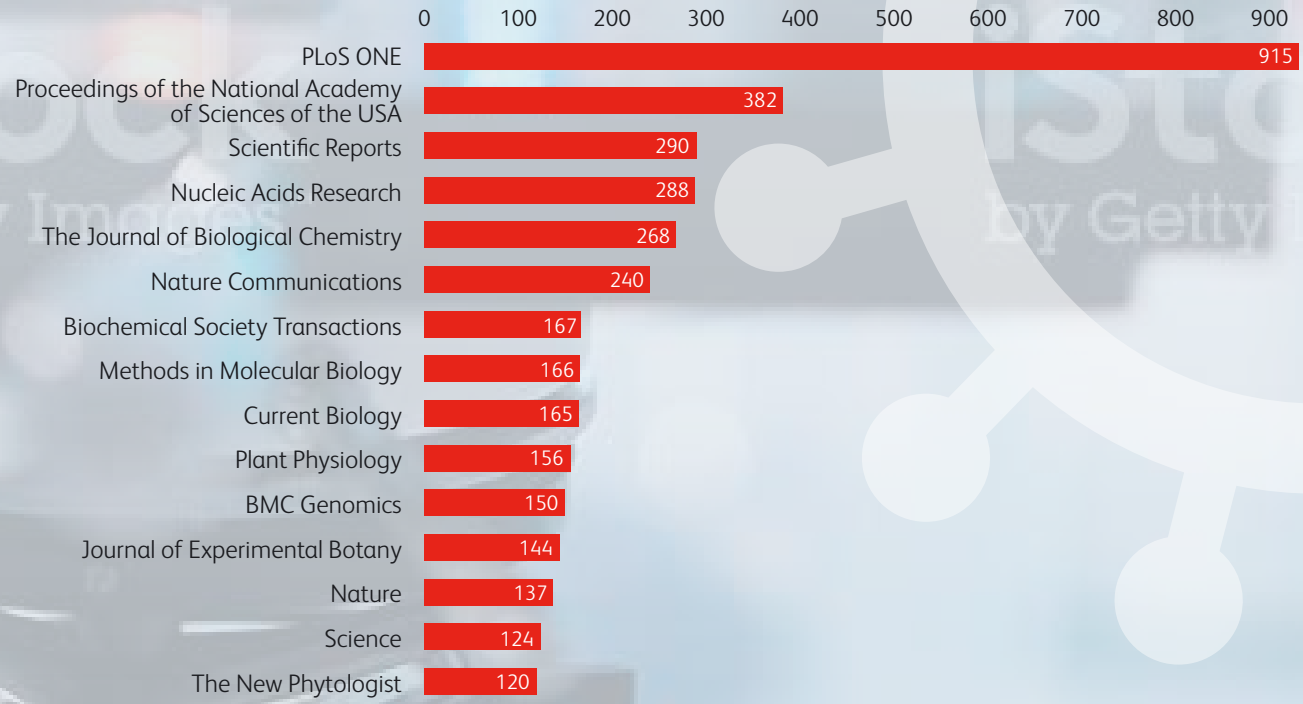
Key:

Outer ring
- Responsive Mode
- Managed Mode
- Research Industry Clubs
- Strategic Institute
- Fellowships

Inner ring
- HEIs
- Strategically-funded Institutes

Top journals for BBSRC research

The outputs of BBSRC research are published in top-ranked academic journals. The chart below shows the top 15 journals in which BBSRC-funded research was most commonly published, based on publications data from researchfish®. It includes journal articles attributed to research grants published between the years 2012 to 2016, inclusive.



Research outcomes data

The collection of outputs, outcomes and impact data from our research is an important component of BBSRC's commitment to openness and transparency around our investments. The graphic below shows the total instances of each outcome type reported in researchfish®, the Research Councils' outcomes collection system, since BBSRC adopted the system in 2014. The examples below and the case studies throughout this report highlight some of the outcomes and impacts reported through researchfish®.

PUBLICATIONS

BBSRC-funded researchers at Royal Holloway, University of London have shown how to boost production of commercially-valuable chemicals called carotenoids in potatoes[2]. Carotenoids are used by the food, cosmetics and pharmaceuticals industries. Journal: Plant Biotechnology[3].

ENGAGEMENT ACTIVITIES

Researchers from Goldsmiths, University of London and Imperial College London have developed computer game BioBlox3D and mobile game BioBlox2D to explore how biological molecules dock together. The Tetris-like 2D game is designed as a fun educational tool. The 3D version simulates protein docking in more detail, allowing the researchers to crowd-source solutions to the problem of how biological molecules dock[6].

POLICY

Researchers at the Roslin Institute are providing expert advice to the Scottish Government and industry stakeholders on the spread of exotic diseases in the UK. This includes risk assessments on the introduction of mosquito-borne West Nile virus into the South of England and the spread of Schmallenberg virus, which infects livestock, into Scotland.

AWARDS AND RECOGNITION

BBSRC-funded CASE student Dr Laura Hall from the University of Stirling was recognised by the NC3Rs for her research into the welfare of laboratory dogs, in collaboration with AstraZeneca. The researchers are now using a BBSRC Flexible Interchange Programme (FLIP) award to collaborate with all of the laboratory dog units in the UK to implement their refined protocols[7].

PUBLICATIONS

Land use changes affect carbon sequestered in both topsoil and subsoil layers, according to scientists from Rothamsted Research[4]. The findings suggest the whole soil system needs to be monitored if soils are to be managed sustainably. Journal: European Journal of Soil Science[5].

SOFTWARE AND TECHNICAL PRODUCTS

Follow-on funding for researchers at University College London has allowed them to develop antibody discovery system software abYsis[9]. It is used by more than 70 pharmaceuticals companies to support their antibody drug development programmes, including ten who have purchased annual licences.

SPIN-OUT

Leaf Expression Systems was founded in 2016 by researchers at the John Innes Centre to commercialise a unique system for rapidly producing proteins, metabolites and complex natural products for research and bio-medical applications in the tissues of plants[8].

Behavioural neuroscience improves firefighter decision-making

Manchester FireFlickr. CC BY-NC 2.0

BBSRC-funded behavioural neuroscience research at Cardiff University underpinned changes to the national guidance provided to Incident Commanders in the UK Fire and Rescue Services. The guidance provides a rapid mental checklist that aims to ensure Incident Commanders are making the best decisions to protect firefighters and meet incident objectives.

The new decision control process has also been incorporated into the doctrine of the Joint Emergency Services Interoperability Procedures used when UK emergency services come together to tackle large complex incidents. It has also attracted significant interest from fire and rescue services in other countries.

Fire and Rescue Services have also incorporated the research methods into their own evaluation and training processes by equipping Incident Commanders with small digital cameras, as used in the research, to record their actions and review performance.

2016: Year the updated national guidance was published

80%: Proportion of firefighter injuries caused by human error

£402K: Funding from BBSRC to support the underpinning research

Open source bone software benefits industry and academia

Open source image analysis software BoneJ, developed during BBSRC-funded biomechanics research at the Royal Veterinary College, is being used in fields as diverse as volcanology, marine biology, soil science, battery design, and food science. The software has been downloaded more than 28,000 times by users in 57 countries.

The research from which the software arose, which looked at differences in bone structure between animal species, also led to a collaboration between the researchers and London-based architecture firm Foster + Partners. The architecture firm is interested in using knowledge about bone structure and its ability to self-repair to develop biologically-inspired building materials.

Scan data from the research has also been used by digital film-makers and animators, including Weta Digital, in the design of CGI characters.

John Hutchinson, RVC

450,000: Number of times users ran a BoneJ module in 2016

£0: Cost of using BoneJ, allowing anyone to use and modify the software

2010: Year BoneJ was first published

£336K: Value of funding from BBSRC to support the research

Supporting impact through innovation

BBSRC is committed to supporting researchers to take their ideas from the lab to where they can deliver economic and social impact.

London Event Company

In 2017 our support for innovation included:

- Follow-on fund and follow-on fund pathfinder, which support the translation of bioscience research supported by BBSRC into practical application. In 2017 BBSRC ran two follow-on fund calls with a total investment of £4.5M.
- Royal Society of Edinburgh Enterprise Fellowships, supported by BBSRC, STFC and Quantic. These provide Fellows with one year's salary, business training and funding, and access to mentors to help develop business ideas[10].
- Biotechnology YES. Now in its 22nd year, the scheme raises awareness of research commercialisation with early career researchers. Teams enter business plans for hypothetical start-up companies, competing for a £5,000 prize fund (see below). It is organised jointly by the Haydn Green Institute at the University of Nottingham and BBSRC.
- GCRF Impact Acceleration Accounts. In September 2016 BBSRC invested a total of £3.8M at 23 institutions to support knowledge exchange and innovation in the context of international development.
- BBSRC Innovator of the Year competition (see facing page).

Biotechnology YES Success

In 2016 Biotechnology YES was won by BeEco Ltd from the Babraham Institute. They presented a business plan for their hypothetical product, Varroanin, which could safely and effectively treat devastating varroa mite infestations in honey bee hives.

Common indicators		
6.3	Instances of IP reported (2016)	37
4.3.3	Destination of leavers (from higher education) – private sector (2015/16)	34 %

London Event Company

Innovator of the Year 2017

BBSRC's Innovator of the Year competition recognises and rewards researchers who have harnessed the potential of their research to benefit the economy and society. The competition is now in its ninth year.

This year the categories were revised to include international and early career impacts, alongside the existing commercial and social impact categories[11]. Category winners and the overall winner were announced at an event in Canary Wharf in May 2017.

2017 winners

Overall winner and Commercial Impact winner:

Research into the ability of tropical fish to see polarised light enabled Dr Shelby Temple to develop a new device to assess one of the major risk factors for age-related macular degeneration (AMD). Temple has founded spin-out company Azul Optics Ltd to commercialise the discovery. AMD is the leading cause of blindness in the developed world[12].

London Event Company

Innovator of the Year Dr Shelby Temple (centre) receiving his award.

Social Impact winner:

Professor Juliet Osborne created a computer model of bee colony health and survival under different conditions, which is being used as the basis for a regulatory model by the European Food Safety Authority (EFSA). See case study on page 13.

International Impact winner:

Professor Sarah Cleaveland's interdisciplinary research informed the development of new strategies to control livestock diseases in Tanzania, including foot-and-mouth disease (FMD) and malignant catarrhal fever (MCF). FMD research shows cattle vaccinations are likely to offer an effective and sustainable approach in comparison with fence-based separation of livestock and wildlife. Research demonstrates the potential of new MCF vaccination strategies to improve pastoral livelihoods and reduce land-use conflicts.

Early Career Impact winner:

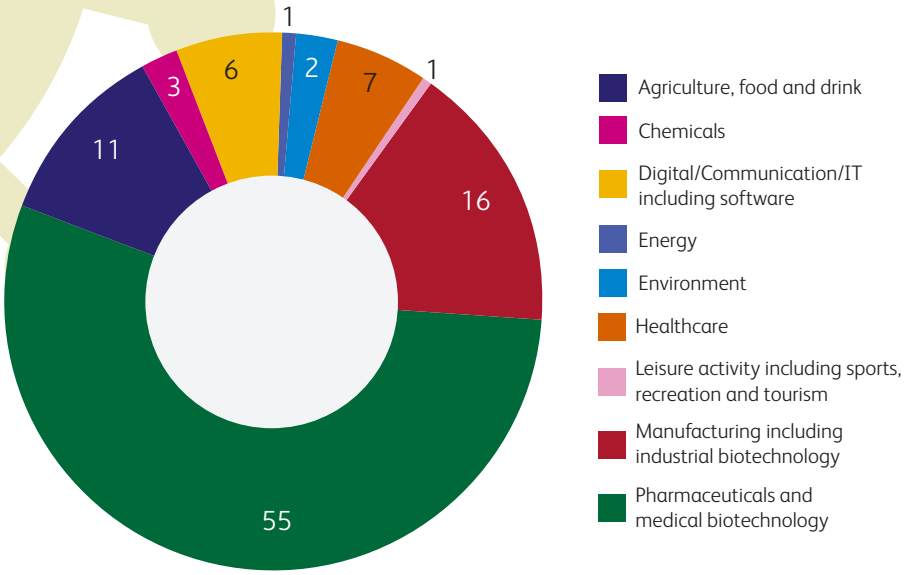
Spin-out company LabGenius, established by Dr James Field at Imperial College London, harnesses artificial intelligence to design DNA sequences that are most likely to be useful and then rapidly produces a suite of variants for testing. See case study on page 19.

New businesses from bioscience

New businesses created from BBSRC research often depend on many different funding mechanisms, progressing from ideas developed during fundamental bioscience research and training, to translational funding, as well as training and support for researchers seeking to commercialise their ideas and establish a company.

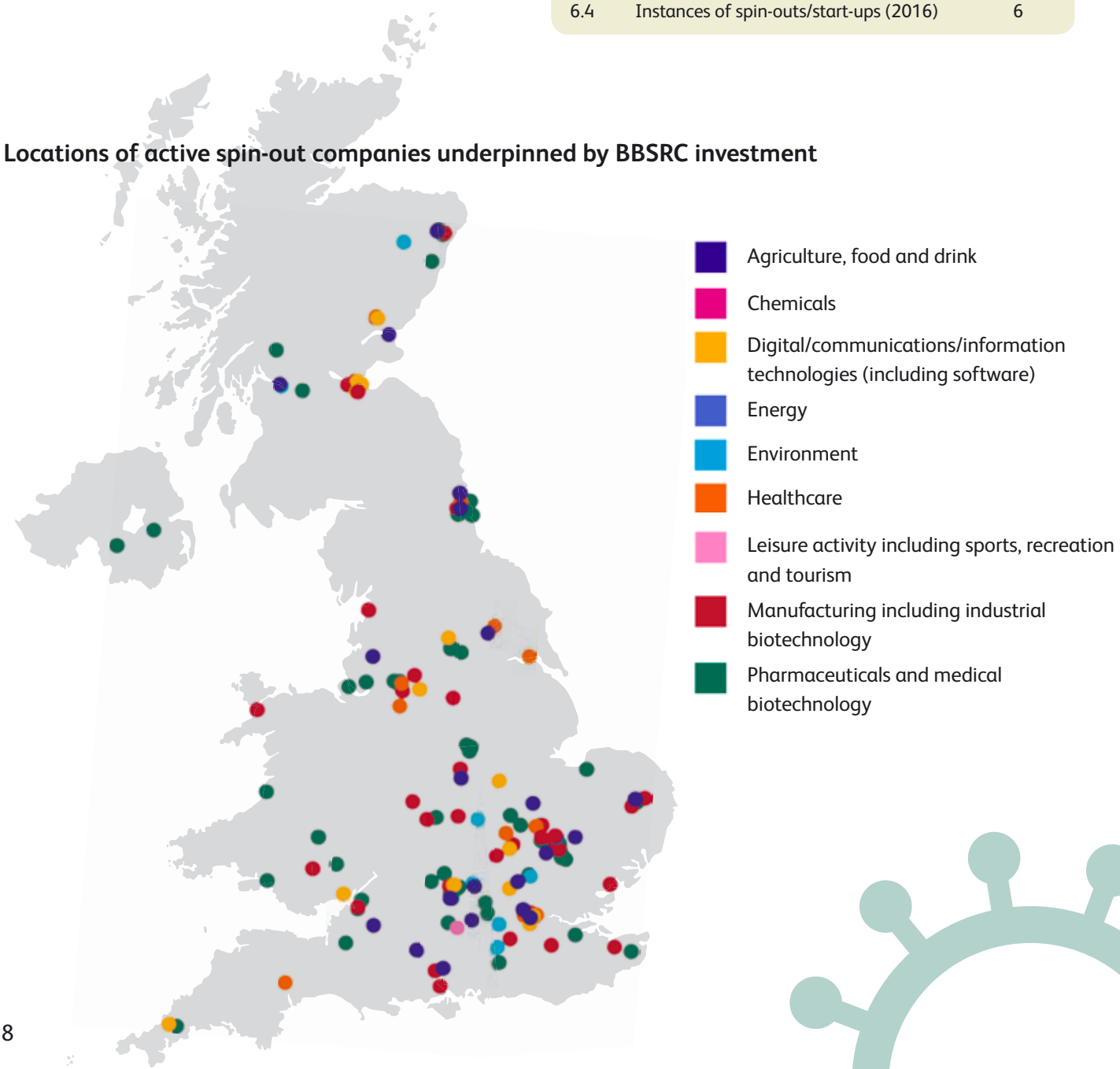
Overall, BBSRC has identified 388 spin-out companies with links to BBSRC investments. Of those, two-thirds (251) were still active in 2017, employing 2,718 people.

Active spin-out companies by sector (%)



Common indicators		
6.4	Instances of spin-outs/start-ups (2016)	6

Locations of active spin-out companies underpinned by BBSRC investment



Elasmogen Ltd – shark proteins for drug discovery

University of Aberdeen researchers Dr Caroline Barelle and Professor Andrew Porter established award-winning spin-out company Elasmogen to develop new medicines based on antibody-like molecules isolated from sharks, called VNARs.

Elasmogen is currently collaborating with Almac Discovery Ltd to develop anti-cancer drugs targeting solid tumours and with Merck Group in the area of bioprocessing.

Since it was founded in early 2016 the company has received £1.1M private investment. It employs six people and has won several awards for new start-up companies.

BBSRC funding supported both the initial research that led to the discovery and patenting of the shark VNARs, as well as commercialisation activities.

Elasmogen Ltd

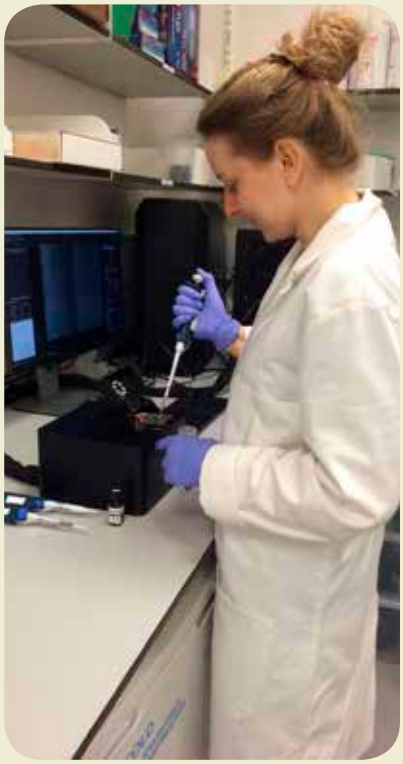
£1.1M: Investment received by Elasmogen Ltd since founding

1st: Place taken by Elasmogen at BioTrinity 'Perfect Pitch' competition in 2016

1/10: Size of VNARs compared to typical human antibodies

£435K: Value of BBSRC follow-on funding to support technology development

ONI Ltd – bringing powerful microscopy to the biology lab



ONI Ltd

Oxford University researchers have developed and commercialised the world's first desktop-sized super-resolution microscope, which allows researchers to study individual molecules within living cells. It can be operated on a desk by a life scientist, unlike other super-resolution microscopes which require dedicated rooms, specialist infrastructure, and operation by imaging experts.

Spin-out company ONI (Oxford Nanoimaging), formed in May 2016 to market the microscopes, received £1.2M in seed funding. It currently employs 14 people.

A Joint Synthetic Biology Initiative grant, part-funded by BBSRC, helped the researchers create the first prototype of their microscope. The life science research which led them to develop the microscope was also funded in part through BBSRC responsive mode grants.

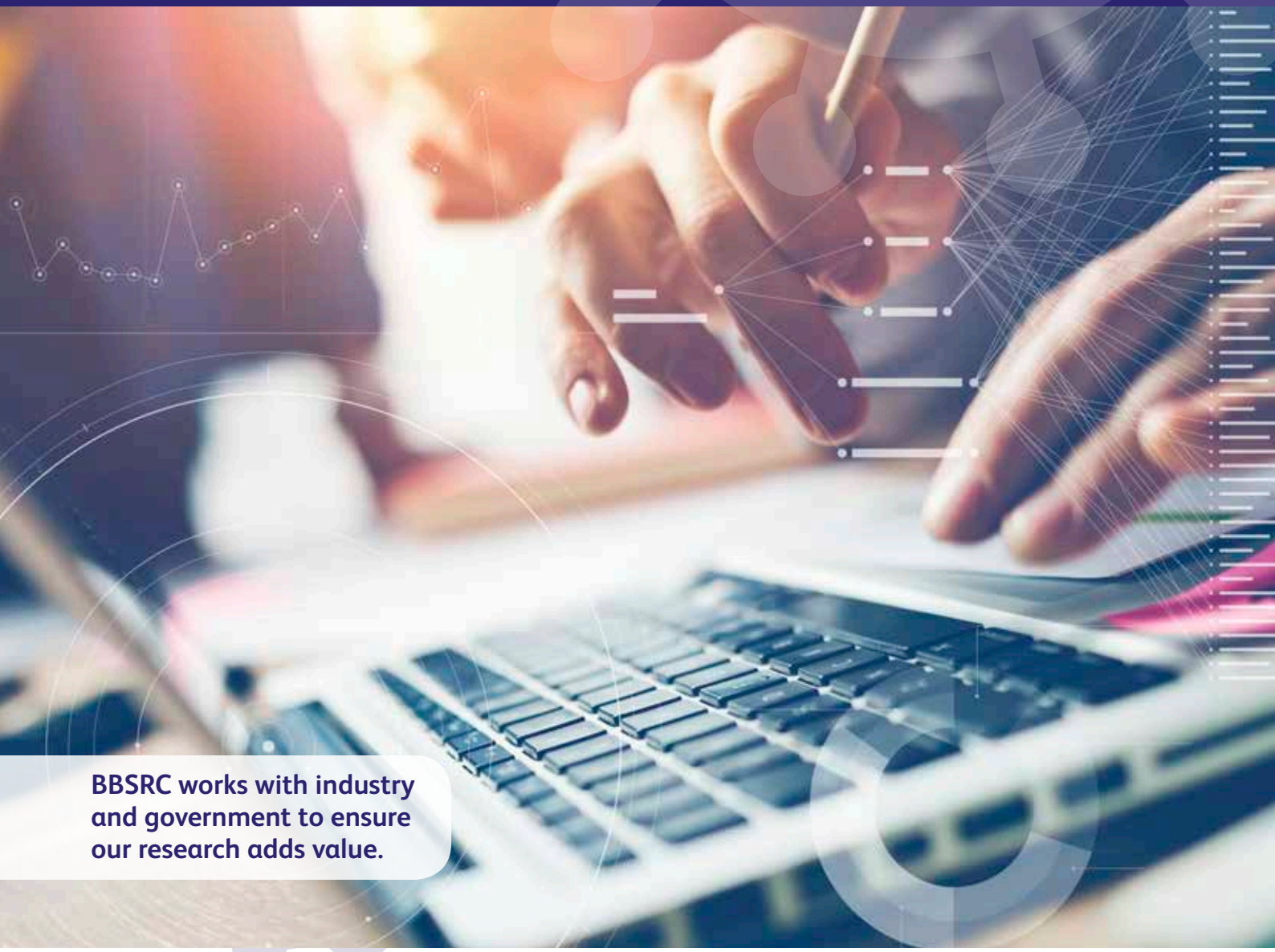
2016: Year ONI founded

£1.2M: Seed funding investing in ONI

14: Jobs created in Oxford by the company

£120K: Award from Joint Synthetic Biology Initiative to develop prototype microscope

UK industry and policymaking benefit from bioscience



BBSRC works with industry and government to ensure our research adds value.

We have a sustained and productive record of maximising the impact of our investments by bringing companies and policymakers together with researchers, enabling them to access the outputs and outcomes of high quality bioscience research. This includes:

- In August 2017 BBSRC received an additional £16.6M from the Government's Industrial Strategy Challenge Fund to develop new agricultural technologies and industrial bioprocesses to underpin a more successful bioeconomy[13].
- Thirteen Networks in Industrial Biotechnology and Bioenergy (NIBB), established in 2014. Overall, more than 2,600 researchers and more than 750 companies are involved in the NIBB[14].
- The UK Biofilms Programme. The second phase of the programme, to establish a UK Biofilms Innovation Centre, launched in November 2016 with £12.5M investment from BBSRC and Innovate UK[15].

Common indicators

1.3	Additional funding leveraged by research projects (2016/17)	£12,179
9.1.1	Number of awards with at least one instance of policy engagement within five years of the start date (for awards starting in 2012)	75 (10%)

Industrial partnership leads to new cancer therapy

"Data from the BBSRC grant really reinforced the role of FKBPL in angiogenesis and reassured us we were all on the right track in terms of developing this anti-angiogenic peptide. The two research strands worked hand-in-hand with one supporting the other."

Professor Tracy Robson

Research funded by BBSRC and pharmaceuticals company Almac Ltd into the mechanisms controlling the growth of new blood vessels has led to the development of a potential new anti-cancer drug. The drug, ALM201, is now in clinical trials to treat solid tumour cancers.

The research, led by Professor Tracy Robson at Queen's University Belfast in collaboration with Almac Ltd, showed that a protein produced by human gene FKBPL plays an important role in controlling the growth of blood vessels. The researchers were then able to develop potential new drugs from the active portions of the FKBPL protein, which could be used to limit blood vessel growth.

The drug has recently passed phase Ia clinical trials in late-stage cancer patients. The researchers also believe ALM201 may have potential in treating a range of other diseases associated with excessive blood vessel growth such as age-related macular degeneration or diabetic retinopathies.

2015: Year the new drug entered Phase I/II clinical trials

£457K: Initial investment from BBSRC into the research

Bacterial biofilters keep swimming pools clean

Research at the University of the West of England is enabling a Bristol-based company, Clear Water Revival, to develop and install innovative new biofilters in swimming pools, eliminating the need for chemical filters.

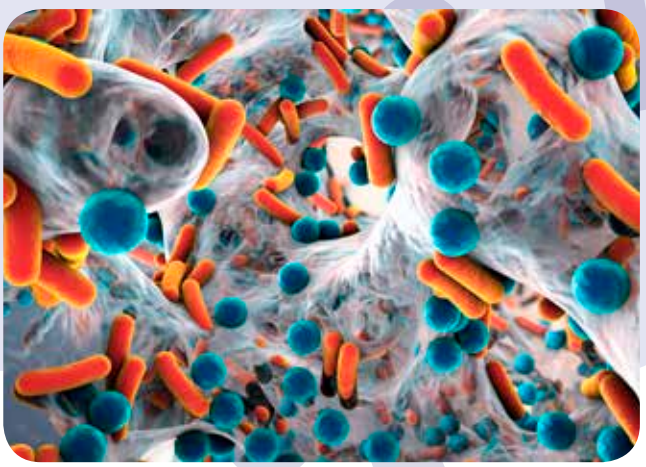
The filters use biofilms – slimy aggregations of microbes better known for causing infections, plaque on teeth and damage to machinery – to control water nutrient levels and suppress pathogens. Biofilters are cheaper and more energy-efficient to run and do not rely on harsh chemicals to keep pools clean.

The research, led by Professor Darren Reynolds, was funded by BBSRC and Innovate UK through the UK Biofilms Programme.

90%: Energy saving using biofilters compared to conventional chemical filters

£3Bn: Value of global swimming pool market

£35K: BBSRC funding for the research



Innovative multidisciplinary solutions

Industry and policy challenges often require solutions that cut across traditional discipline boundaries.

BBSRC works with the other research councils, Innovate UK and government departments and agencies to support innovative multidisciplinary research and address major societal challenges.

- The UK Regenerative Medicine Platform, supported by BBSRC, EPSRC and MRC, received an additional £17M over five years. The Partnership has brought together researchers from 20 institutions spanning biology, medicine and engineering, and has worked with 25 companies, via the Cell and Gene Therapy Catapult, to support translation of research to the clinic[16].
- The Priming Food Partnerships initiative funded three new multidisciplinary projects to stimulate innovative research and technological advances in the food industry. Each of the three projects included academic and industry partners. The initiative is supported by BBSRC, EPSRC, ESRC and MRC[17].
- A new Food Innovation Network was launched in October 2016, with support from BBSRC, Defra and the York, North Yorkshire and East Riding Enterprise Partnership, and coordinated by The Knowledge Transfer Network. The new network will enable UK agri-food businesses to access the research expertise required to address key challenges in food, nutrition and health, leading to innovative new commercial products for the UK's food industry[18].

Common indicators		
5.1.2	Instances of new collaborations reported in Researchfish (2016)	601
5.2	Instances of new secondments reported in Researchfish (2016)	370

Natural grapefruit flavouring from industrial biotechnology

University of Oxford researchers, supported by BBSRC and EPSRC, have found a way to produce grapefruit flavouring from orange oil, using an enzyme. The first product containing their flavouring is expected to be on the market in 2018.

Nootkatone – the flavour and fragrance of grapefruit – is in high demand, but is very difficult to extract, and supply of grapefruits is limited. It can be produced synthetically from more plentiful orange oil, but this process requires a high energy input and toxic metal catalysts. The new process is more environmentally sustainable and produces nootkatone that can be labelled 'natural' under EU regulations, making it preferable to consumers.

Spin-out company Oxford Biotrans is now able to produce natural nootkatone in commercial quantities and buyers have expressed interest in using it in their products.

In addition to long-term funding for their study of enzymes from EPSRC, the researchers received follow-on funding from BBSRC and a £5K Business Interaction Voucher from the BBSRC Metals in Biology Network in Industrial Biotechnology and Bioenergy. These awards allowed them to investigate ways of producing new products using the enzymes developed through Wong's research.

400,000kg: Amount of grapefruit needed to produce 1kg of nootkatone

20 tonnes/year: Worldwide market for nootkatone

$7,000/kg: Market price of natural nootkatone

£5.2M: Investment received by Oxford Biotrans

12: Jobs created in Oxford

Oxford Biotrans Ltd

Bee survival model adopted by industry

"…BEEHAVE should be adopted as the basis for modelling the impact on honeybee colonies of pesticides and other stressors…" EFSA Journal 2015;13(6):4125

£690M: Value of pollination to the UK economy each year

Researchers at the University of Exeter have used BBSRC funding to create a computer model of bee colony health and survival under different conditions. The model is freely available, user-friendly, and predicts how well bee colonies fare in different landscapes and when exposed to threats such as disease and pesticides, based on the latest science.

The European Food Safety Authority (EFSA) plan to use this model as the basis for creating a regulatory model, which they will recommend industry and other users employ when assessing threats to bees, for example from pesticides. Syngenta and Bayer are already using it to evaluate how their pesticides affect bee colonies, and promoting it to the worldwide agrochemical industry.

Professor Juliet Osborne and her colleague Dr Matthias Becher developed the computer model using a BBSRC Industrial Partnership Award part-funded by Syngenta, and a further BBSRC grant in collaboration with Professor David Goulson at the University of Stirling.

The legacy of **Dolly the sheep**

In July 1996 Dolly the sheep was born at the Roslin Institute. Dolly, the first mammal cloned from an adult cell, arose from the long-running Pharming project. That project aimed to commercialise the production of human proteins in the milk of farm animals. In that respect, it did not succeed.

Yet the excellent frontier bioscience that led to Dolly has had far-reaching consequences and continues to underpin major impacts in human health and in food security. From the pharming project emerged techniques that led directly to modern human stem cell research and underpinned the development of farm animal genomics.

In 2015 BBSRC and the University of Edinburgh funded a team of science historians to explore the long-term impacts of Dolly and to place her in her historical context. Through archival research and in discussion with the original researchers and others associated with the pharming project they have developed a new perspective on the legacy of Dolly the sheep.

The Edinburgh researchers have published a policy report that summarises their findings:

The invisible history of the visible sheep: How a look at the past may broaden our view of the legacy of Dolly. Miguel García-Sancho, Dmitriy Myelnikov and James Lowe, Science, Technology and Innovation Studies, University of Edinburgh[19].

An edited transcript of the Collective Memory Event, which gathered together many of the key players from Roslin and the company PPL Therapeutics to explore Dolly's legacy, is available:

Dolly at Roslin: A Collective Memory Event. Edited by Miguel García-Sancho and Dmitriy Myelnikov. Science, Technology and Innovation Studies, University of Edinburgh[20].

1970s: Policy changes mean that research is expected to deliver demonstrable returns. Agriculture is one of the areas targeted for improvement

1980s: ABRO (now the Roslin Institute) budget cuts and staff changes lead to creation of molecular biology programme

AFRC (BBSRC predecessor) and MAFF (now Defra) funding

1990s: ABRO Pharming project established which aims to commercialise the production of human proteins, such as certain medicines, in farm animal milk.

- 1991: Tracy – first transgenic sheep. Produces human Alpha 1-antitrypsin in her milk.
- 1995: Megan and Morag – first sheep cloned from embryo cells
- **1996: Dolly – first mammal cloned from adult cell**
- 1997: Polly and siblings – transgenic and cloned sheep. Produce some human Factor IX in milk.

The Historicising Dolly Project

In 2017, the Historicising Dolly project produced its final report. Among the conclusions from the project was the recognition that impact is often long-term, crosses disciplinary boundaries and can take many decades.

The team of science historians who conducted the research made extensive use of Roslin Institute and BBSRC archives, including collections of material relating to animal genetics in Edinburgh catalogued and preserved thanks to Wellcome Trust funding. They also ran a collective memory event attended by scientists and technicians who worked at Roslin at the time Dolly was born.

The historical approach taken by the project provides another tool that can be used to illuminate the breadth of impacts arising from fundamental bioscience research, even where the direct links are not immediately obvious.

Above: Dolly with her first born lamb Bonnie.
Left: Dolly with Professor Sir Ian Wilmut, who led the research which produced her.
The Roslin Institute, The University of Edinburgh

Pharming project does not succeed in producing commercial quantities of human proteins in sheep milk. However, the project has a number of other impacts…

Created new technologies and expertise:
Nuclear transfer (or cloning)technology used for more than a decade to underpin stem cell research/regenerative medicine. The technology also inspired approaches to describe induced pluripotent stem cell technology used throughout modern stem cell research.

Re-purposed and developed existing technologies and skills:
E.G. underpinning farm animal genomics. Now used to produce new varieties of crops and livestock. Contributing to human health studies (pig as model organism).

Stimulated extensive media coverage and a national debate around cloning:
Substantial on-going public engagement with bioscience research and ethics, leading to regulatory and policy changes.

Building partnerships to solve global challenges

BBSRC works with partners in the UK and overseas to address some of the major challenges facing society in the 21st century.

INVESTMENT:
BBSRC announced the RCUK-CIAT Newton-Caldas Fund Sustainable Tropical Agricultural Systems Programme, with ESRC, NERC and the International Centre for Tropical Agriculture (CIAT), which is headquartered in Colombia. The programme will promote economic development, improve social welfare and enhance livelihoods in Colombia to maximise food security.[24]

INVESTMENT:
In 2017, BBSRC invested £16.7M in multidisciplinary research projects under the GCRF Foundation Awards for Global Agriculture and Food Systems, in partnership with MRC, ESRC, AHRC and NERC[21]. The projects address key agricultural issues in the global south, across 30 countries – see red dots on map.

CASE STUDY:
Safeguarding the Ghanaian coconut crop

Professor Matthew Dickinson from the University of Nottingham and Dr Joseph Owusu Nipah from the Oil Palm Research Institute (Ghana) have developed improved diagnostic techniques for detecting a devastating disease of coconut palms in Ghana. The new tests are quick, inexpensive and portable. 4.2 % of Ghana's population is supported by coconut farming.

The researchers were supported by BBSRC and DfID through the Sustainable Agricultural Research for International Development programme.

All of the UK Research Councils are delivery partners for the Newton Fund, which aims to use science and innovation to promote economic development and social welfare of partner companies. We are also key delivery partners for the Global Challenges Research Fund (GCRF). This funding stream is a key part of the UK Aid Strategy, and the Research Councils and others deliver directly-allocated portions of a central fund.

CASE STUDY:
Simple arsenic sensor could save lives

A low-cost, easy-to-use arsenic sensor to test drinking water has been developed by Dr Joanne Santini at University College London (UCL) and Professor Tony Cass at Imperial College London, with BBSRC funding. They expect the tests to be on the market within three years.

The sensor is small, sensitive and accurate, and produces an immediate result, at a cost of less than $1 per test. This makes it suitable for use in rural areas in low and middle income countries, where the problem of arsenic poisoning from contaminated drinking water is greatest.

CASE STUDY:
'The Worm Wagon'

Professor Sheena Cruickshank and colleagues at The University of Manchester, assisted by BBSRC-funded PhD students, developed 'The Worm Wagon': mobile workshops aimed at engaging people with their research on parasitic worm infections. Funding from BBSRC also allowed Cruickshank to develop an infection and immunology course for non-native English speakers, with the aim of addressing misunderstandings about worm infections and encouraging the uptake of anti-worm therapies, which has recently been developed into an online distance learning course.

The researchers have now run over 70 engagement events, engaging with more than 300,000 people. The health resources have also been used to provide six Madagascan schools with toolkits and lessons about infection transmission.

INVESTMENT:

The UK-China-Philippines-Thailand Swine and Poultry Research Initiative was launched by BBSRC via the Newton fund and in collaboration with partner agencies[22] for those nations. The initiative will address research challenges in swine and poultry, building on the combined strengths of research groups from the participating nations.[23]

Developing skills for research and innovation

BBSRC supports high-quality postgraduate and postdoctoral training to ensure the UK has the skills to support a world-leading bioscience research base and to translate the outcomes of that research into benefits for society.

Highlights in 2017 include:

- The launch of the Agri-Food Training Partnership (AFTP) with an additional £1.5M investment. This builds on three previous Advanced Training Partnerships in agri-food, food and pasture. The AFTP combines the complementary skills and knowledge of six university partners offering over 150 courses and workshops in agricultural production, environmental protection, food manufacture, scientific research & development and associated business & transferable skills[25].
- £19M invested in world-leading industry-led collaborative doctoral training through 10 Collaborative Training Partnerships (CTP). This will support research training for 189 PhD students within the context of a mutually beneficial research collaboration between academic and partner organisations[26].
- Two new Daphne Jackson Fellows starting in 2017 at the John Innes Centre and the University of Cambridge. Daphne Jackson Fellowships enable scientists to return to research after a career break of two or more years for family, caring or health reasons[27,28].
- Funding for 556 new PhD students in 2016. This includes all studentships that were at least 50 % funded by BBSRC, full-time or part-time, and on any of our PhD funding schemes.

Common indicators		
3.1	Principal Investigators (2016/17)	1,404
4.2	Doctoral submission rate	90

LabGenius – engineering new biological materials

Graduates from Imperial College London, led by Dr James Field, have founded synthetic biology spin-out company LabGenius to commercialise their gene synthesis technology. This technology allows them to rapidly identify and produce the building blocks for new biological products such as enzymes, pharmaceuticals and high-value materials.

LabGenius has raised $3.66M in seed funding, and secured three contracts with the Defence Science and Technology Laboratory (Dstl) to create improved body armour and adhesives.

The basis of LabGenius' technology is the ability to create large libraries of similar DNA sequences. Each sequence can be evaluated to identify the variant that gives the best results, depending on the biological product required. The most promising can then be used to begin manufacturing the product.

Funding from BBSRC, EPSRC and Innovate UK enabled the researchers to develop the technology and establish LabGenius. This support also helped the company to attract private investment.

In 2017 Field won the Early Career Impact category of BBSRC's Innovator of the Year competition.

£56Bn: Value of the UK bioeconomy, in which synthetic biology plays a core role

2012: Year LabGenius was founded

10^{13}: Number of unique sequences that can be included in a LabGenius DNA library

£102K: BBSRC investment to support the research

New poppy variety benefits pharmaceutical industry

A new poppy variety created by researchers at the University of York in collaboration with GlaxoSmithKline (GSK) has reduced the cost of producing noscapine, a cough suppressant and potential anti-cancer drug, by 25 % in the last three years. These poppies provided an estimated 70 % of global noscapine supply for cough suppressants in 2016-2017.

The value of the discovery to the pharmaceutical industry assisted GSK in selling its Australian Opiates Division to Sun Pharmaceutical Industries Ltd, India's largest pharmaceutical company, in 2015.

25%: Reduction in noscapine production cost over three years

70%: Proportion of global noscapine supply from the new poppy variety

£1.2M: BBSRC Industrial Partnership Award for the research

A BBSRC Industrial Partnership Award and Flexible Interchange Programme (FLIP) award allowed Mr Tim Bowser, presently head of Sun Australia's Opiates Division and formerly head of GSK's Opiate R&D programme, to spend 18 months working with Professor Ian Graham and his colleagues at York. During this time they discovered a gene in the opium poppy which allowed them to breed poppies that produce noscapine without producing opiates. These poppies offer a more reliable supply of noscapine, and the drug is also easier to extract.

National capability for future impact

BBSRC's Research and Innovation Campuses are fostering early stage innovation, enabling excellent tangible economic and social benefits for the UK and beyond from excellent research.

The new BBSRC National Vaccinology Centre: The Jenner Building.

Richard Chivers

In 2017 BBSRC announced £319M of strategic funding for UK research institutes for the next five years. The funding has been invested in 17 institute strategic programmes that will further scientific knowledge, promote economic growth and job creation in important sectors such as food, farming, renewables and pharmaceuticals – delivering an even more productive UK bioeconomy (see facing page for details).

Other developments this year include:

- In March 2017 HRH The Princess Royal officially opened the BBSRC National Vaccinology Centre: The Jenner Building – a world leading vaccine development facility, located at The Pirbright Institute in Surrey. Researchers at the Centre are developing new vaccines for livestock diseases, focussing primarily on poultry species but with some work on diseases such as African horse sickness virus. Construction cost £24M, which was part of a £350M strategic capital investment from government[29].
- Construction of the new Quadram Institute at the Norwich Research Park reached a significant milestone in March 2017, with the final cement pouring. George Freeman MP attended a ceremony to mark the occasion. When completed in mid-2018 the Quadram Institute will house 300 researchers and 100 clinicians to develop solutions to worldwide challenges in human health, food and disease[30].

Institute strategic investments:

BBSRC's strategic research investments at the institutes were made following a robust, independent and international peer review process. The 17 funded institute strategic programmes are:

- **Blueprints for Healthy Animals:** The Roslin Institute
- **Control of Infectious Diseases:** The Roslin Institute
- **Designing Future Wheat:** John Innes Centre, Rothamsted Research, Earlham Institute, University of Bristol, EMBL-EBI, NIAB, The University of Nottingham
- **From Genomes to Food Security Core Strategic Programme:** Earlham Institute
- **Enhanced host responses for disease control:** The Pirbright Institute
- **Epigenetics in development and ageing:** Babraham Institute
- **Resilient Crops Core Strategic Programme:** Institute of Biological, Environmental and Rural Sciences
- **Genes in the Environment:** John Innes Centre
- **Improving Animal Production & Welfare:** The Roslin Institute
- **Keeping you healthier for longer as you age:** Babraham Institute
- **Molecules from Nature:** John Innes Centre
- **Plant Health:** John Innes Centre, The Sainsbury Laboratory
- **Soil to Nutrition (Optimising Nutrient Flow):** Rothamsted Research
- **Tailoring Plant Metabolism for the Bioeconomy:** Rothamsted Research
- **Understanding and preventing viral diseases:** The Pirbright Institute
- **Understanding the immune system to extend health span:** Babraham Institute
- **Achieving Sustainable Agricultural Systems:** Rothamsted Research, Centre for Ecology & Hydrology, British Geological Survey. (Co-funded with the Natural Environment Research Council following their assessment process in 2015.)

Note that the Institute of Food Research was not included in this Institute Assessment Exercise. Following a peer-review process, IFR received a one year extension of current funding levels because it is currently in the middle of restructuring and incorporation within the Quadram Institute (QI). Institute Strategic Programme Grants as part of QI will go through the same process this year to determine its strategic funding from 1 April 2018.

Developing our evidence base

BBSRC continues to work closely with all of the research councils and RCUK through the RCUK Performance Evaluation Network. In common with all of the research councils, BBSRC continues to collect research outcomes data through researchfish®. Over the past year, the research councils have worked in partnership with Researchfish Ltd to address feedback relating to the researchfish® user interface (UI). Prior to the 2017 Submission Period, the UI was updated to enable an improved user experience and increase the accessibility of the site. New functionality was also introduced to assist users, such as providing support for researchers to exchange publication data using their ORCID identifier.

BBSRC runs integrated programmes for gathering and analysing evidence from its investments: one focussing on the evaluation of outcomes, the other on impacts arising from BBSRC bioscience. These, together with analyses of data collected through researchfish® and other internal and external data sources, provide a broad base of evidence of outcomes and impacts. BBSRC is also using researchfish® data to identify and develop impact case studies, many of which are included elsewhere in this report.

Benefits realisation

BBSRC is leading the delivery of a strategy and approach for benefits realisation, to track and capture the outcomes, benefits and wider impact of major investments and interventions.

The benefits realisation methodology used by BBSRC is based on common tools, best practice and learning from work with external partners to develop and embed an approach for significant capital investments in research and innovation campuses. We continue to develop and improve the methodology, extending the approach to other significant investments including capital investments in institute infrastructure and Industrial Strategy Challenge Fund projects.

BBSRC works with a range of internal and external stakeholders to deliver its programme of benefits realisation projects, which helps to develop a shared understanding about the intended benefits of a specific investment or intervention. The evidence base collected by the programme informs learning about what works, and supports future investment bids.

Analysis for insight

Our research investments data are a key asset for BBSRC. In 2017 BBSRC has continued to enhance analytical capability across the organisation and recognise the value that data analytics brings to our work, enabling rapid data driven insights.

BBSRC has continued to develop and adopt innovative analytics tools for the analysis of both structured and unstructured 'text rich' data, and embed these approaches across the organisation. Where possible, we use automated approaches to add value to our data. We adopt an iterative approach and build strong collaborations between data experts, systems experts and subject matter experts across the office to understand the 'evidence' requirements and tailor our data analytics approaches appropriately.

We provide various evidence bases resources across the office, including: corporate 'dashboards'; automated approaches for classification and analysis; user friendly analytics tools to provide top level overviews with drill down detail; and tailored analyses that link multiple datasets to provide deeper analytical insights (e.g. data from other funders or comparing investments vs outputs).

In all of this work BBSRC continues to work collaboratively with our colleagues across the research councils, most recently organising an 'Analysis for Insight' event for colleagues to demo various analytics tools, to discover how these can enable new insights and to share views and influence how we can continue to build a strong and robust evidence base for UKRI.

Common Indicators

The research councils have agreed a revised set of common indicators on performance with the Department of Business, Energy & Industrial Strategy (BEIS). These indicators draw on information from grants databases and the researchfish® system.

researchfish® is an online system supported by Researchfish Ltd. It is used by research councils to collect information on the outputs, outcomes and impacts of RC-funded research. Outcomes can be entered into researchfish® at any time, but once a year there is a formal submission period when researchers are required to confirm that their outcomes information is accurate and up-to-date.

Total Funds Available		Year									
		2012/13		2013/14		2014/15		2015/16		2016/17	
1.1	Budget Allocation (£m)	462.8		463.4		485.9		421.1		418.4	
1.2	Leverage (£m)	18.4		14.0		19.2		23.8		28	
1.2.1	*of which Private (£m)*	7.4	40%	5.8	41%	8.7	45%	12.7	53%	11.8	42.7%
1.2.2	*of which from other Research Councils (£m)*	8.1	44%	5.7	41%	7.7	40%	8.3	35%	14.6	52.7%
1.2.3	*of which from other source (£m)*	3.0	16%	2.5	18%	2.8	15%	2.8	12%	1.3	4.8%
1.3	Additional funding leveraged by research projects (£k)	99,461		33,661		20,985		15,656		12,179	
1.3.1	*of which Private*	6,369	64%	20,768	62%	11,243	54%	10,774	69%	7,492	62%
1.3.2	*of which Public*	254	3%	190	1%	653	3%	1,261	8%	986	8%
1.3.3	*of which Non-profit*	23	0%	170	1%	52	0%	0	0%	225	2%
1.3.4	*of which Academic sector*	3,300	33%	12,534	37%	9,036	43%	3,621	23%	3,476	29%

Research Expenditure		Year									
		2012/13		2013/14		2014/15		2015/16		2016/17	
2.1	Research expenditure (£m)	307.9	64%	312.9	66%	320.4	63%	323.9	73%	324.1	73%
2.2	Training expenditure (£m)	52.3	11%	52.3	11%	50.5	10%	45.7	10%	50.9	11%
2.3	Other (£m)	121.0	25%	112.2	24%	134.5	27%	75.3	17%	71.0	16%

Human Capital		Year									
		2012/13		2013/14		2014/15		2015/16		2016/17	
3.1	Principal Investigators	1062		1193		1317		1391		1404	
3.2	Research Fellowships	58		51		39		45		49	
3.3	Number of PIs and CO-Is on research grants (on 1st April)/ the number of Research Organisations (including Independent Research Organisations)	2,169	183	2,462	200	2,845	189	3,302	203	3,258	200

Human Capital – Postgraduates		Year				
		2012/13	2013/14	2014/15	2015/16	2016/17
4.1	Number of new doctoral students within that financial year	393	418	415	415	415

Human Capital – Postgraduates		Year				
		2011/12	2013/14	2014/15	2015/16	2016/17
4.2	Doctoral submission rate	89	94	94	89	90

Destinations of leavers		Year				
		2011/12	2012/13	2013/14	2014/15	2015/16
4.3	Destination of leavers	446	464	467	455	459
4.3.1	Of which University	48%	41%	42%	42%	40%
4.3.2	Of which Public Sector	5%	4%	6%	5%	6%
4.3.3	Of which Private Sector	25%	32%	31%	31%	34%
4.3.4	Of which Other or Unknown	13%	15%	11%	15%	13%
4.3.5	Of which Unemployed	9%	8%	11%	8%	6%

Collaborations, partnerships and secondments		Year									
		2012/13		2013/14		2014/15		2015/16		2016/17	
5.1.1	Instances of collaborations and partnerships reported at point of application and % of awards reporting at least one partner organisation	147	12%	246	11%	216	11%	166	11%	189	12%

Collaborations, partnerships and secondments		Year the collaborations, partnerships or secondments were first reported				
		2012	2013	2014	2015	2016
5.1	Instances of new collaborations reported in researchfish®	396	482	585	666	601
5.2	Instances of secondments reported in researchfish®	145	175	301	334	370

Publications		Year outcome realised				
		2012	2013	2014	2015	2016
6.1.1	Instances of journal articles	4,102	4,374	4,873	5,114	4934
6.1.2	Instances of books	19	21	13	16	16
6.1.3	Instances of books chapters	105	130	104	66	73

Publications: Number/proportion of awards		Year the award started									
		2008		2009		2010		2011		2012	
6.1.4	Number/proportion of awards that gave rise to at least one example of a publication within five years of award start date	613	78%	462	81%	456	84%	443	85%	666	86%

Other outputs		Year outcome realised				
		2012	2013	2014	2015	2016
6.2.1	Instances of artistic and creative outputs	9	14	29	42	34
6.2.2	Instances of research databases and models reported	100	100	113	121	101
6.2.3	Instances of software and technical products reported	65	81	101	103	133
6.2.4	Instances of research tools and methods reported	91	104	144	125	127
6.2.5	Instances of medical products, interventions and clinical trials	5	3	13	9	7
6.3	Instances of IP reported	26	34	40	42	37
6.4	Instances of spin-outs/start-ups	9	9	14	9	6

Further funding Number/proportion of awards		Year the award started									
		2008		2009		2010		2011		2012	
7.1.1	Number/proportion of with at least one instance of further funding within five years of the start date	122	15%	124	22%	112	21%	183	35%	298	39%

Engagement activities Number/proportion of awards		Year the award started									
		2008		2009		2010		2011		2012	
8.1.1	Number/proportion of with at least one instance of engagement within five years of the start date	194	25%	171	30%	198	37%	230	44%	423	55%

Influence on Policy and Practice Number/proportion of awards		Year the award started									
		2008		2009		2010		2011		2012	
9.1.1	Number/proportion of with at least one instance of policy influence within five years of the start date	21	3%	21	4%	27	5%	43	8%	75	10%

Notes on Common Indicators data

The outcomes data included in the Common Indicators are not static. Researchers can enter data retrospectively, which may result in changes to individual indicators in subsequent Impact Reports.

BBSRC has used the researchfish® system for outcomes collection since 2014. As such, data for earlier years may not be complete.

A particular output, for example a publication or a collaboration, might have arisen from more than one award. In this report, a particular output is always reported against each individual award where the unit of analysis is at the award level (for example the proportion of awards reporting a particular output). Duplicate outputs are removed, where possible, in analyses at the level of the type of output generated. Duplicate outputs are removed using system-generated codes to indicate when a researcher has attributed an output to more than one award. This cannot identify duplicate outputs where researchers have entered similar information independently of one another.

Percentages in this report are rounded up or down to the nearest whole number and so some may appear as zero if this represents less than half of one per cent.

Additional information on individual indicators is provided on pages 26 and 27. The Common Question Set used by researchfish® is available from the Researchfish website (www.researchfish.com).

Notes on individual common indicators

Total funds available
Total additional funds leveraged by projects: This indicator reports the cash and in-kind contributions from partner organisations that were listed on the original research proposal. It does not include any further leverage funding that may have arisen during the course of the award. It does not include additional funding leveraged by Research Council Centres, Institutes, and other intramural investments.

Total expenditure
Total Expenditure: Research expenditure: This indicator reports all research expenditure. Prior to the 2016 Impact Reports, this indicator was referred to as 'responsive mode expenditure'.

Human Capital
Number of PIs: This indicator reports the number of PIs supported on research grants on the 1 April of each reporting year. It excludes PIs supported through intramural investments, unless they are in receipt of a research grant.

Number of Research Fellows: This indicator reports the number of Research Fellows supported on the 1 April of each reporting year.

Number of PIs and Co-Investigators on research grants: This indicator reports the number of PIs and Co-is supported on research grants on the 1 April of each reporting year. It excludes PIs and Co-Is supported through intramural investments, unless they are in receipt of a research grant. This indicator also includes the number of Research Organisations (including Independent Research Organisations) where these PIs and Co-Is are located.

Postgraduates: These figures include only students 100 % funded by BBSRC.

Collaborations, Partnerships and Secondments
Instances of collaborations: This indicator relates to collaborations reported within the research proposal at the point of application. It includes the proportion of awards (expressed as a percentage) reporting at least one partner organisation at the point of application.

Instances of new collaborations: This indicator relates to new collaborations as reported within researchfish®. Collaborations are only included in the indicator for the first year that they were reported, but may continue for several years after this date. Researchers may also report collaborations that were in place at the point of application.

Instances of secondments: This indicator relates to secondments as reported within researchfish®. Secondments are only included in the indicator for the first year that they were reported, but may continue for several years after this date.

Knowledge generation
Instances of publications: A publication may have arisen from more than one award. Duplicate publication outputs are removed, where possible, using system-generated codes to indicate when an individual researcher has attributed an output to more than one award. This cannot identify duplicate outputs where different researchers have entered similar information independently of one another. It is not feasible to calculate the precise number of unique publications as some publications/publication types do not have unique identifiers (e.g. a Digital Object Identifier, a PubMed ID). The indicator is intended to provide information on the trends over time, rather than a precise measure of total publication output.

Instances of research databases and models: Some of the data within researchfish® do not have an associated time stamp. For BBSRC there are 295 instances of research databases and models which do not include a time stamp and which are therefore excluded from the common indicators.

Instances of software and technical products: Some of the data within researchfish® do not have an associated time stamp. For BBSRC, there are 16 instances of software and technical products which do not include a time stamp and which are therefore excluded from the common indicators.

Instances of research tools and methods: Some of the data within researchfish® do not have an associated time stamp. For BBSRC, there are 725 instances of research tools and methods which do not include a time stamp and which are therefore excluded from the common indicators.

Intellectual Property

Instances of Intellectual Property: This indicator includes patents, copyrights and trademarks. Some of the data within researchfish® do not have an associated time stamp. For BBSRC there are 72 instances of intellectual property which do not include a time stamp and which are therefore excluded from the common indicators.

Spin-outs

Instances of spin-outs / start-ups: Within researchfish®, researchers are asked to provide details of links between their research and the establishment, development or growth of new private sector organisations, including for profit and not-for-profit organisations. Supplemental information was used to identify duplicate spin-out companies where available (e.g. Companies House IDs for UK companies).

Further funding

Number / proportion of awards with further funding: This indicator includes further funding to continue or develop the research, or to support the translation of outcomes into practical application.

Engagement activities

Number / proportion of awards with engagement activities: Researchers engage with a wide variety of audiences and stakeholders to communicate research outcomes, disseminate knowledge, stimulate public awareness, and encourage public engagement and dialogue. The engagement activities indicator helps demonstrate the extent to which researchers are engaging with audiences outside academia.

Influence on Policy and Practice:

Number / proportion of awards with policy influence: Research may be used to inform policy and practice, which may subsequently lead to wider societal and economic benefit. The influence on policy and practice indicator helps demonstrate the extent to which researchers are informing decision making within government departments and elsewhere.

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