IMPACT REPORT 2011

BBSRC DELIVERING IMPACT

BBSRC IMPACT REPORT, 2011: BBSRC DELIVERING IMPACT

2010-11 MAJOR HIGHLIGHTS

Beneforté Broccoli

© Institute of Food Research

"This is a fantastic achievement and testament to the quality of research we have in this country and its ability to drive growth." David Willetts

In October 2011 a new variety of broccoli with higher levels of a key nutrient was launched in UK shops thanks to experts working on the biology of plants and on the link between human nutrition and health. The new broccoli, known as Beneforté, was developed from publicly-funded research at two of the UK's world-leading biological research institutes: the Institute of Food Research and the John Innes Centre, which both receive significant levels of strategic funding from BBSRC

The researchers used conventional breeding techniques to develop the new broccoli, which contains two to three times the level of the phytonutrient glucoraphanin than standard broccoli. Glucoraphanin is a beneficial chemical found naturally in broccoli and is thought to help explain the link between eating broccoli and lower rates of heart disease and some forms of cancer. Glucoraphanin also leads to a boost in the body's antioxidant enzyme levels.

British-grown Beneforté broccoli is now available in Marks and Spencer stores around the UK and will become more widely available in other supermarkets during summer 2012

Rinderpest eradication

African cattle
© Stockbyte/Thinkstock, 2010

" The biggest achievement of veterinary history has been the eradication of rinderpest globally" – Dr John Anderson, Institute for Animal Health

Building on vital and sustained effort by the World Reference Laboratory for rinderpest, based at the BBSRC Institute for Animal Health, in late 2010 the United Nations Food and Agriculture Organisation (FAO) declared the end to field operations as part of the Global Rinderpest Eradication Programme. This is only the second time that the world has been able to eliminate a viral disease.

Through a concerted programme of vaccination this devastating disease of cattle and buffalo has been halted, helping to reduce famine and poverty in rural communities worldwide and, over the years, enabling additional livestock production of almost $1.3Bn from India and Africa.

IAH scientists developed novel diagnostic tests, trained local people and scientists in Africa and Asia, and performed thousands of diagnostic tests to advise and monitor the eradication programme.

In June 2011 Dr John Anderson, former Head of the IAH Pirbright Laboratory, was awarded a medal and certificate by the FAO for his personal contributions to the eradication of rinderpest. Medals were also awarded to the IAH for its decades of commitment to the fight against this disease and to several researchers who had worked within the Institute.

Innovator of the Year 2011

Jason Swedlow , Dundee, BBSRC Innovator of 2011
Image: Andrew Davies

Jason Swedlow, University of Dundee, won BBSRC Innovator of the Year 2011, for work on the Open Microscopy Environment (OME), a revolutionary venture into open source software. OME is now the leading provider of software solutions for biological image management. It has remarkably wide benefit due to the flexibility and openness of the approach and uses a very clever business model which allows for open source software development (for example Linux, Java, OS X, Firefox) and commercial opportunities through licensing platforms based on the software, leading to both economic and social impacts

David Willetts commented, " Bioscience is a key growth sector … These awards recognise the impact of bioscience both on the economy and society…"

Maia building at Babraham

"The opening of new research facilities at Babraham for early stage companies is very good news for the development of the antibodies of the future"
Sir Gregory Winter, FRS

The Babraham Research Campus, at the Babraham Institute, recently attracted some of the most exciting new generation antibody companies in Europe. The Campus is expanding: in November 2010 the fourth bioincubator building, Maia, opened. Constructed with financial support from BBSRC, Maia provides seven early-stage biomedical companies with flexible lab and office space, cell culture and high-class level 2 containment facilities as well as access to the Institute's world-class animal facilities, next generation sequencing, mass spectrometry, cell sorting and imaging services. In total the Campus now provides around 70,000 square feet of laboratory space to 28 early-stage biomedical companies.

Wheat genome

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"This is an outstanding world class contribution by the UK to the global effort to completely map the wheat genome" David Willetts

BBSRC-funded scientists took a major step towards fully sequencing the wheat genome, publicly releasing the first draft sequence of a reference bread wheat. The work is a vital contribution to our understanding of wheat genetics, providing direct access for scientists and breeders to nearly all the genes in wheat. This will support global food security efforts by helping to meet challenges from new diseases, climate change, altering trade and sustainably increasing production; it also has the potential to increase the competitiveness of UK farming: the wheat harvest is worth around £1.6Bn a year to the UK economy.

The work was conducted by scientists from the Universities of Liverpool and Bristol and the John Innes Centre, an Institute of BBSRC. The researchers collaborated with The Genome Analysis Centre (TGAC), a national sequencing and bioinformatics facility established by BBSRC.

CONTEXT

Bioscience is high-impact science: it drives advances in health and wellbeing, "green materials", new pharmaceuticals, and safe and nutritious food. It leads to more sustainable agriculture, helps combat infectious diseases and underpins responses to climate change. Bioscience has transformed our understanding of ourselves and of the world around us. As the leading UK public funder of bioscience research underpinning such key economic sectors (see below[1]), BBSRC plays an essential role in developing the UK bioscience research base and in encouraging the uptake and translation of bioscience research and training to address user needs, and to deliver economic and social impact. The Council currently invests c£450M pa in research at universities, sponsored research institutes and other organisations through a variety of funding schemes. Maximising the impact of our science and skilled people on the UK economy, on policy formation and on improving the quality of life is a key enabling theme of the BBSRC Strategic Plan.[2]

Our research underpins agriculture, the food and drinks industry, biotechnology, pharmaceuticals, and the chemical industries and BBSRC strives to engage users from these sectors in the development and translation of the research we fund. Bio-industries in particular rely extensively on our research, and in the broader pharmaceuticals and chemicals sectors BBSRC-funded research in basic biology provides essential understanding of basic concepts that can be exploited directly by industry or indirectly through strategic or translational research funded by others, including other Research Councils and research charities.

Sound bioscience research is crucial to inform public policy decisions and to address many of the UK's and the world's most pressing policy challenges: feeding a growing population; deciding land use priorities when there is increasing competition for its use; coping with climate change; generating the energy we need without relying on fossil fuels; improving the quality of life for an ageing population. The outcomes from BBSRC research are increasingly vital for addressing these major issues.

In partnership with all Research Councils BBSRC is also developing the research community's awareness of the potential impact of their research at all levels from individual projects, through the "Pathways to Impact" initiative to the major, multimillion cross-Council research themes [3].

The impacts from BBSRC-funded research and training are therefore multifaceted and widespread and we are committed to identifying, understanding, enabling and publicising the impact of bioscience research in the UK[4]. This impact report sets out our recent achievements and developing plans to ensure we continue to deliver significant impact.

UK Food and drink:

- Turnover: £182Bn in 2010
- Including alcoholic drinks, total food and drink exports, 2010: £16.1Bn, 12.2% up on 2009
- Employs over 3M people

UK Pharmaceuticals:

- £21Bn exports in 2009
- Trade surplus of £7Bn

European Knowledge-Based Bio-Economy

- Worth €2 trillion in 2010

UK Agriculture:

- Total value UK agricultural production, 2010 £20.7Bn
- UK farming contributed £7.2Bn to the economy, 2010

IMPACT THROUGH KNOWLEDGE EXCHANGE

BBSRC is fully committed to the translation research outcomes into both direct and indirect benefits to individuals and organisations, and encourages and facilitates knowledge exchange in its broadest sense[5]. It can take many years for innovative research ideas in fundamental bioscience to generate tangible impacts, so BBSRC takes a multi-stranded approach to this important challenge. As well as supporting a portfolio of tailored activities to complement our research and training investments, we expect our research and training communities to work with industrialists, policy makers, major charities and other users wherever and whenever this will add value, and to build the kinds of long-standing collaborative relationships most likely to deliver impact.

1) WORKING WITH UK INDUSTRY …

BBSRC has an excellent record of working with industry, through mechanisms developed in collaboration with our partners and therefore designed to maximise mutual benefit. Currently BBSRC:

- Invests c£50M during Spending Review periods in specific schemes for collaborative research and research training with industrial partners (e.g. Industrial Partnership Awards; LINK programmes), which support collaborative projects instigated jointly by academic and industrial researchers, and in jointly funded consortia to support research projects in the science base
- Runs four Research & Technology Clubs, with total investment of over £46M, and involving three Research Councils, the Scottish Government, two Knowledge Transfer Networks (KTNs) and 48 other companies and research organisations (including seven involved in two RTCs), and will develop RTCs in new sectors where these can add value
- Works closely with the Technology Strategy Board in support of two existing KTNs and to develop new ventures and schemes, particularly in the agri-food industry
- Encourages the major research institutes and university research groups in which we invest to work strategically with industrial partners wherever appropriate
- Devotes significant time and effort to fostering productive working relationships with key industrial partners and to ensuring our entire research base has the potential to deliver outputs of interest and relevance to industry: for our major industrial partners maintaining the quality of our basic research portfolio is an essential requirement

AND BUILDING AWARENESS OF THE RESEARCH NEEDS OF INDUSTRY...

In recent years BBSRC has focused increasingly on building academics' understanding of the importance of their research to industry and of the benefits to academics of considering industrial needs when designing their research. Significant achievements include:

- 63% of researchers funded by the Diet & Health RTC experienced a significant or very significant increase in awareness of UK food and drink industry needs [6]
- 45% of responsive mode grant holders working on genomics reported that their BBSRC awards led to new or improved partnerships with industry; 32% established or developed formal collaborations, involving at least 45 different companies (multinationals, SMEs, start-ups, UK and international) operating in the agriculture, animal health, food and drink sectors as well as the more anticipated areas of pharmaceuticals, healthcare and biotechnology [7]
- In recent years industry has contributed 17% (£7.9M direct investment) well above the target of 10-15% (including in-kind contributions) to the costs of over 90 industrial partnership awards through which long- term, successful industry-academic partnerships were forged. [8]

"BBSRC's creation of the systems biology centres was fundamental to our decisions. Seeing the investment that BBSRC was making in the science and the focus the centres provided was very influential in our thinking."

Stuart John Dunbar, Senior Fellow Syngenta

TO DELIVER IMPACT

- The Babraham Research Campus, based at the Babraham Institute, recently attracted some of the most exciting new generation antibody companies in Europe. The Campus is expanding: in November 2010 the fourth bioincubator building, Maia, opened. Constructed with financial support from BBSRC, Maia provides seven early-stage biomedical companies with flexible lab and office space, cell culture and high-class level 2 containment facilities as well as access to the Institute's world-class animal facilities, next generation sequencing, mass spectrometry, cell sorting and imaging services. In total the Campus now provides around 70,000 square feet of laboratory space to 28 early-stage biomedical companies [9]
- Industrial interest in and commitment to major research institutes and centres funded by BBSRC includes over £28M invested in five institutes over the last five years from over 35 different companies, and over £4M invested by 14 industrial associates into the BBSRC Sustainable Bioenergy Centre[10]
- Building on a long-term partnership between Plymouth Marine Laboratory (PML) researchers and Boots UK Ltd that has led to the discovery of a number of bioactive microalgae compounds with beneficial properties, BBSRC-funded researchers at the PML have developed a scalable model for the sustainable production of valuable bioactive compounds from microalgae, which could provide alternatives to petroleum-based materials in healthcare products as well as in the development of biofuels and bioplastics[11]
- In November 2010 The John Innes Centre announced an exclusive commercial license agreement for BBSRC-funded technology that enhances the root systems of plants and with important implications for crop improvement. JIC's technology management company Plant Bioscience Limited (PBL) has licensed the technology to Dow AgroSciences [12]
- With collaborators throughout the value chain from food waste producers to horticultural media producers like Bulrush Horticulture Ltd, commercial composters, Organic Recycling, and growers Lincolnshire Herbs and the Farplants consortium, as well as a number of retailers, Keith Waldron and colleagues at the BBSRC-supported Institute of Food Research have developed and patented a process to control the degradation of plant material during composting, as a viable alternative to peat. As well as its commercial potential the process has important implications for preserving peat and associated environmental benefits [13]

2) *FACILITATING ENTREPRENEURSHIP AND COMMERCIALISATION*

As well as encouraging and brokering collaborative working with industry, BBSRC is increasingly fostering entrepreneurial, impact-aware research environments which encourage our research communities to think about the huge potential value of their research and about how they can best ensure this is realised. Formal schemes include:

- c£3M pa committed through Follow-on Funding to turn research outputs into commercial propositions
- Annual Innovator of the Year competitions to celebrate and reward the delivery of economic and social impact by BBSRC-supported scientists
- Biotechnology Young Entrepreneur Scheme, now in its 16th year, bringing together teams of early career researchers to benefit from entrepreneurial awareness training [14]
- Excellence with Impact, a major one-off scheme funding university departments to promote and foster a culture of economic and social impact

"Dow AgroSciences is excited to be collaborating with one of the most respected organizations in the biotechnology industry. By combining our expertise in biotech crops and PBL's innovative technology from JIC, we have the opportunity to enhance a plant's ability to survive stress, increase nutrient utilization, and provide yield stability"

Dan Kittle, Vice President, Dow AgroSciences

BBSRC also works in partnership with universities, institutes and other funders, particularly HEFCE, to ensure we are all working towards common goals; key activities include:

- Building partnerships with major research universities (Cambridge, Edinburgh, Imperial College, Nottingham, Oxford, Warwick) with which we have common strategic research interests, including the generation of impact
- Further developing the KEC focus within research institutes through networking and, from 2012, specific funding streams
- Collaborating with other Research Councils and UK Funding Councils, particularly in relation to the next REF, to ensure common interests, aims and standards for impact from research

TO DELIVER IMPACT

- In October 2011 a new variety of broccoli with higher levels of a key phytonutrient was launched in UK shops thanks to experts working on the biology of plants and on the link between human nutrition and health. The new broccoli, known as Beneforté, was developed from publicly-funded research at two of the UK's world-leading biological research institutes: the Institute of Food Research and the John Innes Centre, which both receive significant levels of strategic funding from BBSRC [15]
- Jason Swedlow, University of Dundee, won BBSRC Innovator of the Year 2011, for work on the Open Microscopy Environment (OME), a revolutionary venture into open source software. OME is now the leading provider of software solutions for biological image management. It has remarkably wide benefit due to the flexibility and openness of the approach and uses a very clever business model which allows for open source software development (for example Linux, Java, OS X, Firefox) and commercial opportunities through licensing platforms based on the software, leading to both economic and social impacts[16]
- Chris Lowe was named Commercial Innovator of the Year for creating 'smart' holograms by fabricating them in flexible gels that bear specific receptors so they swell or contract in response to specific physical, chemical and biological stimuli and respond with a change in colour, brightness or image. Chris Lowe holds more than 70 patents and has established eight other spin-out companies[17]
- Procarta, a spin-out company previously supported by BBSRC and emerging from John Innes Centre science, has secured up to £1.25M funding to continue the development of its novel DNA-based antibiotic technology to help combat drug-resistant infections[18]
- Exosect, a company previously funded by BBSRC, and a provider of 'Intelligent Pest Management' services, aims to help food producers move away from the use of conventional insecticides. To do this, they have employed novel tactics, derived from research funded by BBSRC in the mid-1990s. Exosect's product range now includes traps to tackle cockroaches, mating disruption products to control codling moths (major pests of apples), as well as devices to tackle clothes moths and the Varroa mite that has been implicated in the decline of honeybee hives. The insecticide-free approach has gained the company a place on The Guardian Global Cleantech 100 list, 2010 – recognition for promising clean technology companies most likely to make significant market impact over the next 5-10 years [19]
- Coda Therapeutics, a spin-out company formed by David Becker, to develop research on cells he discovered had a central function in wound healing has risen $23M to take them through toxicity testing and good manufacture practice (GMP). Phase I and II safety trials produced positive results from the treatment of venous leg ulcers, which heal about five times faster at the highest dose of the company's gel.[20]

"This is a fantastic achievement and testament to the quality of research we have in this country and its ability to drive growth. This excellent work has led to the development of a highly commercial food product that will be both grown and sold in the UK, giving a real boost to agriculture, our personal health and the economy."

David Willetts, UK Science Minister, speaking about Beneforté broccoli

3) WORKING WITH POLICY PARTNERS

Some of the most significant impacts from BBSRC-funded research are on key global policy challenges and related public policy making. Our research sheds essential light on hugely important issues, including global food security, sustainable agriculture, land use, climate change, renewable energy, and healthcare. The impact of BBSRC research on policy continues to be a major focus of BBSRC's activities to identify and assess the impact of our investments and, in particular, to ensure the world-leading basic bioscience research we fund is deployed to best effect in policy-making. Building on our commitments in the *Strategic Plan* BBSRC:

- Led the establishment of the Global Food Security (GFS) Programme, [21] and leads the Research Council contributions to the emerging research programme
- Remains committed to the Rural Economy and Land Use cross-Council multidisciplinary research programme
- Manages, and contributes £3M to the £20M initiative to improve food sustainability in sub-Saharan Africa and South Asia, with the Bill & Melinda Gates Foundation, the Department for International Development and the Indian Department of Biotechnology
- Invests in other high-priority, policy-relevant strategic research programmes, including joint investments of: up to £2M with Defra and the Food Standards Agency for research into *Campylobacter*; £2.9M for the UK-USA collaboration on research on enhancing photosynthesis; the "Nutrition for Life" programme with the Technology Strategy Board (TSB), EPSRC and MRC; as well as the TSB-led innovation platform in sustainable agriculture.
- Through the cross-Council theme Living with Environmental Change, is committing up to £2M to the Environmental and Social Ecology of Human Infectious Diseases initiative and £1M to a new programme on Ecology of Human Infectious Diseases, with the NSF, NIH and ESRC.
- In the Global Uncertainties programme, has funded four joint projects in the Emerging and Major Infectious Diseases of Livestock ERA-Net.

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- Building on vital and sustained effort by the World Reference Laboratory for rinderpest, based at the BBSRC Institute for Animal Health, the Food and Agriculture Organisation (FAO) of the United Nations has declared the end to field operations as part of the Global Rinderpest Eradication Programme. Through a concerted programme of vaccination this devastating disease of cattle and buffalo has been halted, helping to reduce famine and poverty in rural communities worldwide and, over the years enabling additional production of almost $1.3Bn from India and Africa. Dr John Anderson and IAH were awarded medals by the FAO for decades of commitment.[22]
- Jane Hurst, funded by BBSRC at University of Liverpool, has shown that a new way of handling laboratory mice can improve their welfare and the quality of the science they are used for, an important result in BBSRC's -going programme of animal welfare research; it won the 2010 National Centre for the 3Rs' prize for advances in animal welfare [23]
- Joint BBSRC work with the UK Energy Research Centre has identified drivers of and barriers to bioenergy development; among the common drivers are reducing carbon emissions and the dependency on fossil fuels; the main barriers were economic constraints which may be overcome with the right financial support mechanisms. To get buy in therefore bioenergy schemes must be economically attractive to all parts of the supply-chain with proven net energy and carbon balances[24]
- In the last year, the RELU programme has generated 13 Policy and Practice Notes and three in depth Briefing Papers. Among the most recent are, "The governance of livestock disease: putting epidemiology in context", note from the multidisciplinary research team led by bioscientist Graham Medley, University of Warwick, and Briefing Paper, "Growing concerns: animal and plant disease policy for the 21st century", which draws on the research from several projects in the plant and animal diseases research theme.[25]

"Most importantly, the protection of cattle in sub-Saharan Africa, the Near East and Asia has improved both food and income streams for hundreds of thousands, if not millions, of pastoral people and small farmers, and helped avoid famine and the loss of draught power in agricultural communities"

Felix Njeumi, FAO GREP Secretariat

IMPACT THROUGH SKILLED PEOPLE

The most obvious route for transferring bioscience knowledge and skills and for influencing behaviour and the take up of new ideas is through the movement of people, both into the research base and outwards from the research base. BBSRC has long recognised the power of the people it supports to deliver change, and remains committed to:

- Maintaining the strength of the UK bioscience base, and its potential for widespread impact, through funding of high-quality postgraduate and postdoctoral training
- Fostering the pre-eminence of UK bioindustries by continuing to supply high-level bioscience skills and expertise in the UK
- Focusing training on areas with the highest potential impact, often interdisciplinary research
- Working with universities and institutes to attract and retain the best bioscientists
- Working with industry and other users to understand their skills and training needs

1) POSTGRADUATE TRAINING AND SKILLS

- BBSRC supports over 500 PhD students trained in collaboration with industry through CASE, involving over 200 different companies, and requires all PhD students to be provided with wide-ranging skills training to help equip them for a variety of roles after completion of their courses
- All students are given the option to attend training by Vitae and made aware of entrepreneurial opportunities, for example Biotechnology YES
- Studentships are awarded in research priority areas in which BBSRC wishes to develop or maintain critical mass of expertise
- Following expert evaluation, BBSRC's main funding route for PhD studentships will be Doctoral Training Partnerships, encouraging universities to work together and in support of BBSRC's strategic research priorities
- BBSRC's Advanced Training Partnership in agri-food supports research-led, user-focused training for food security research and development, in keeping with the industry-led AgriSkills Strategy, launched by Lantra (the sector skills council for environmental and land-based industries) and the NFU (National Farmers Union), which aims to ensure the UK can equip itself for a profitable, sustainable agricultural industry for the future
- BBSRC also funds policy placements, 3-month placement opportunities for BBSRC-funded PhD students to gain experience of working in science policy

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- BBSRC students move on to work across the economy, in industry, commerce and the public sector as well as in academic careers [See Annex A]
- Erica Bickerton, (PhD student at the Institute for Animal Health)'s work on vaccines for avian infectious bronchitis virus (IBV) poultry led to a patent application and the British Poultry Council (BPC) 2010 Scholarship Award. IBV causes a disease which mainly affects the respiratory tract of chickens and can cost the UK economy nearly £19M per year due to loss of egg production. [26]
- The evaluation in 2010-11 of BBSRC's Doctoral Training Grants concluded that "Quota DTG funding is supporting the training of highly-skilled scientists who are able to pursue careers in academia, industry and the wider economy" It also identified positive examples of innovative ideas being picked up by industry, including:[27]

"Obtaining a PhD in the 21st Century is about more than just producing a good research thesis. Research activity has to sit alongside broader professional skills development and take place in training environments which encourage both innovation and interdisciplinary thinking … The decision to include professional internships in each studentship demonstrates BBSRC's commitment to high-quality and innovation in PhD training."

Malcolm McCrae, Chair of the UK Council for Graduate Education

- CASE studentships (University of Southampton) helped develop commercial assays, including work to describe a model of cerebral function which contributed to the development of a standardised system for the screening of neuropharmacological agents.
- CASE studentships (Cardiff University) are producing novel findings which could result in improvements to food safety, drug development and biosensor development

2) POSTDOCTORAL TRAINING AND SKILLS

While BBSRC-funded training at postgraduate levels is designed to equip the students with skills for several different career options, at postdoctoral levels the provision of training and skills is focused more particularly on the experience and skills required by bioscience researchers working within the academic world and beyond. BBSRC runs and supports a number of tailored mechanisms each designed to provide specific training and skills for bioscientists in different circumstances, including:

- David Phillips Fellowships: formal research fellowships for early career bioscientists in universities and institutes
- Enterprise fellowships, working with the Royal Society of Edinburgh, to foster entrepreneurial initiative
- With the Royal Society, EPSRC, NERC, Rolls-Royce plc and Astra Zeneca, industry fellowships to enhance knowledge transfer in science and technology between those in industry and those in academia and provide opportunities for collaborative projects
- Industrial impact fellowships to support industrial researcher leaders in collaborative research with BBSRC-funded researchers and enhance the impact of BBSRC's research
- Investment in BBSRC fellowships is over £10M pa. [For numbers see **Annex A**]
- Over 2,000 postdoctoral researchers supported on BBSRC research grants in universities and research institutes, working in innovative and cutting edge areas of research; all employers of postdoctoral research staff funded by BBSRC must abide by the *Concordat for the development of researchers* and be supported in skills and careers development
- Programmes to support the movement, in either direction, of researchers between the science base and industry

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- Davidson Ateh, from Queen Mary, University of London, and supported by BBSRC Follow-on funding and then a RSE/BBSRC Enterprise Fellowship created BioMoti, a company that specialises in drug delivery platforms, in particular a new way to deliver existing cancer drugs that will improve efficacy and reduce side effects.[28]
- Chris Gilligan, a BBSRC professorial fellow, has developed an epidemiological toolkit, in response to regulator and policymakers' needs. The toolkit will help develop effective and cost efficient disease control strategies. It is built on a detailed understanding of the fundamental and complex mechanics of disease and plant interactions.[29]
- The recent independent evaluation of the BBSRC's David Phillips Fellowships for early career researchers concluded that the scheme supports excellent early career scientists who conduct very high quality research and have either already delivered or have high potential to deliver important economic and societal impacts, for example:[30]

"I was then awarded a RSE/BBSRC Enterprise Fellowship to develop its potential fully. That was fantastic as it was to concentrate on developing a business plan, to talk to potential customers, and I had access to mentors and attended business training at the Hunter Centre for Entrepreneurship at Strathclyde University in Glasgow."

Davidson Ateh, Bioengineering entrepreneur, and RSE/BBSRC Enterprise Fellow

- A Senior Lecturer, and former David Phillips fellow, at the University of Cambridge has established a research programme examining photosynthesis within 'C4' leaves, and is now part of an international consortium which aims to examine the feasibility of introducing 'C4' photosynthesis into rice in order to increase the yield of this crop. In 2007, the fellow was awarded the Melvin Calvin award. This international prize recognises outstanding investigations into metabolic and cellular aspects of the photosynthetic process by an early-career researcher. He was also named as one of five crop researchers who could change the world in a 2008 article in *Nature*.
- A fellow at the University of Strathclyde conducted research on DNA analysis using Surface-Enhanced Resonance Raman Scattering (SERRS), a vibrational technique that provides molecularly specific information at ultra-low concentration levels. The fellow produced a portfolio of patents from the work and sought to commercialise his findings. In July 2007, over five years after the fellowship ended, he co-founded the spin-out company D3 Technologies Ltd. The company was subsequently acquired by the Renishaw group, who agreed to invest approximately £5M over a five year period. The company is now known as Renishaw Diagnostics and is focused on developing and commercialising in vitro diagnostic and clinical research products to detect human infectious diseases.
- The research of a fellow at the University of Manchester led to the development of a unique technology, which could be used to determine the 3D shape of small drug-like molecules. The fellow pursued a commercialisation strategy, aided by a BBSRC/RSE Enterprise fellowship and two BBSRC Follow-on Fund awards, establishing a spin-out company, Conformetrix Ltd. The company is exploiting its proprietary analytical tools to understand how bioactive ligands work and is using this information to develop new drugs. In 2008, Conformetrix Ltd received the BioNoW Biomedical Start Up Company of the Year award.
- A fellow at the University of Glasgow (initially the University of Edinburgh) developed novel technologies for producing protein-coated microcrystals (PCMCs), recognised the potential applications of the findings in biocatalysis and drug-delivery, and developed a commercialisation plan with the help of a BBSRC / RSE Enterprise Fellowship. The fellowship contributed to the production of five patents and, the co-founding of the spin-out company Xstalbio Ltd. The company is focused on advanced mechanisms of drug delivery, specialising in the formulation of therapeutic proteins, peptides, DNA and vaccines. A key benefit of the PCMC technology is that the crystals are stable at relatively high temperatures and humidity, making them ideal for the supply of drugs and vaccines in countries where it is not possible to maintain a reliable cold-chain.

"The calibre of individual early-career scientists supported by the David Phillips fellowship scheme is very high. The majority of fellows are very accomplished researchers, a notable number are outstanding, and several are exceptionally talented. Fellows' achievements, both during and after the fellowship, are impressive. Fellows are conducting high-quality, creative and innovative research, they are establishing sustainable research programmes, and they are achieving excellent career development outcomes."

Independent Evaluation of BBSRC's David Phillips Fellowship scheme chaired by Professor Steve Yeaman, Institute of Cellular Medicine, Newcastle University

SUSTAINING WORLD CLASS RESEARCH TO ENABLE IMPACT DELIVERY

DELIVERING EXCELLENT RESEARCH AND TRAINING

At the heart of BBSRC's approach to impact is our commitment to funding world leading bioscience research and training, without which impact would not be possible. UK excellence in bioscience research is the reason major life science companies invest here and why the best researchers are attracted to work here. We are committed to ensuring that the UK stays internationally competitive by driving data intensive and multidisciplinary approaches to bioscience to deliver new, deeper understanding of how complex living systems function.

BBSRC's total investment over recent years is set out in **Annex A**. We employ a balanced portfolio of funding mechanisms to prioritise the fundamental bioscience upon which all our strategic priorities depend, and to protect crucial core subjects where BBSRC is the dominant funder.

The quality of the research and training delivered is demonstrated by the UK's prominence in international citation ranking, which has been sustained for several years [31], and in the endorsements of quality outputs and achievements running through all our recent formal evaluations by external experts [32]

IN SUPPORT OF IMPACT

Among the most important research outcomes from the last year, with clear implications for impact are the numerous genomes sequences announced, including plant genomes with clear implications for food security through crop improvement, and specific human and microbial genomes with profound implications for health and well-being:

- BBSRC-funded scientists took a major step towards fully sequencing the wheat genome, publicly releasing the first draft sequence of a reference bread wheat. The work is an important contribution to our understanding of wheat genetics, providing direct access for scientists and breeders to nearly all the genes in wheat. This will support global food security efforts by helping to meet challenges from new diseases, climate change, altering trade and sustainably increasing production; it also has the potential to increase the competitiveness of UK farming: the wheat harvest is worth around £1.6Bn a year to the UK economy. The work was conducted by scientists from the Universities of Liverpool and Bristol and the John Innes Centre, an Institute of BBSRC. The researchers collaborated with The Genome Analysis Centre (TGAC), a national sequencing and bioinformatics facility established by BBSRC. [33]

- Other significant outcomes from genome sequencing include:
  - Identification by BBSRC institute TGAC of several genes which may be key factors in the recent *E.coli* outbreak of strain 0104:H4, implicated in a number of hospitalisations and deaths, particularly in Germany. The outbreak had a high economic impact on the fresh vegetable market across the EU[34]

"This is an outstanding world class contribution by the UK to the global effort to completely map the wheat genome. We now have the capability to improve the crops of the future by simply accelerating the natural breeding process to select varieties that can thrive in challenging conditions."

David Willetts, UK Minister for Universities and Science

"An excellent example of how to achieve technology transfer from research lab through to practical deployment."

Richard Summers, Vice Chairman, British Society of Plant Breeders

- BBSRC-funded scientists led the UK part of the international programme to establish and publish the genome of the wild strawberry (*Fragaria vesca*), results which will help strawberry breeders to develop disease resistance and improve fruit quality to benefit consumers [35]
- Completion at TGAC of the first whole-genome sequence of a Parsi breast cancer patient completed as part of), a systems biology-based study on the Parsi population to determine the genetic basis of longevity and age-related disorders, supported by Avesthagen, one of India's leading healthcare technology groups [36]
- BBSRC-funded researchers sequencing the genome of potato, the first major UK crop plant to be fully sequenced. This can help speed up traditionally time-consuming development of new varieties (currently 10-12 years), that in many cases help ensure future food security due to improved yield, quality, nutritional value, and resistance to pests and diseases [37]

There are many examples of other major scientific breakthroughs detailed in the news pages on the BBSRC website and in BBSRC's most recent Annual Report.[38] Examples of research results with more immediate implications for impact include:

- In research funded by BBSRC Paul Birch, at the University of Dundee and his team at Dundee, the Scottish Crop Research Institute (SCRI), and the University of Aberdeen have developed a new approach to breeding resistance to the mould-like organism *Phytophthora infestans* that causes late blight in potatoes, a discovery that could instigate a paradigm shift in breeding resistance to late blight, a devastating disease of potatoes and tomatoes costing the industry £5-6Bn a year worldwide[39]
- Early results from research underway at the BBSRC Sustainable Bioenergy Centre (BSBEC), are already yielding important information in ensuring impact from the Centre's activities: a unique trial of fast growing bioenergy grasses and trees grown in England and Wales is providing insights into the growth strategies of Miscanthus and willow which could help in the development of new varieties better suited to different climates and more sustainable bioenergy production[40]
- An international team of scientists led by BBSRC Diamond Fellow Professor So Iwata has successfully solved the complex 3D structure of the human Histamine H_1 receptor protein. Published in the journal *Nature*, their discovery improves our understanding of how Histamine and the Histamine H_1 receptor interact in normal immune responses as well as in allergic reactions. This opens the way for the development of 'third generation' anti-histamines, specific drugs effective against various allergies without causing adverse side-effects.[41]
- Scientists funded by BBSRC have tested a predatory bacterium - *Bdellovibrio* - against *Salmonella* in the guts of live chickens and found that it significantly reduced the numbers of *Salmonella* bacteria and, importantly, showed that *Bdellovibrio* are safe when ingested. The research was carried out by Professor Liz Sockett's team at The University of Nottingham, with Dr Robert Atterbury and Professor Paul Barrow at the University of Nottingham Vet School; and published in the journal *Applied and Environmental Microbiology*. *Bdellovibrio* has the potential to be used as a living antibiotic against some major human and animal pathogens, such as *E.coli* and other so-called Gram-negative bacteria [42]
- BBSRC-funded researchers, led by Professor Martin Sheldon from Swansea University's School of Medicine, have established in mice the mechanism that detects and responds to the presence of bacteria in the womb - a discovery that opens up the possibility of new preventative treatments for diseases like pelvic inflammatory disease and Chlamydia. They have established that in mice the womb relies on cells not normally involved in immunity to detect and respond to bacteria. This is crucial information as it has the potential to provide us with new targets for preventing disease.[43]

"[Sequencing the potato genome] is a great achievement by British scientists and is fantastic news for our farmers. If we're to feed the nine billion people projected to be living on the planet by 2050 then potato crops with improved water uptake and resistance to disease and drought will be an important development."

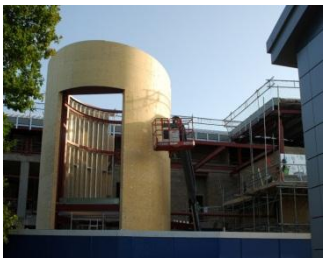
Jim Paice, UK Minister for Agriculture

FUTURE PLANS: INVESTMENT AND FOCUS FOR FUTURE IMPACT

BBSRC will continue to support the highest quality bioscience research and training, investing in programmes designed to meet the aims and objectives set out in the 2010-15 Strategic Plan and elaborated further, following the 2010 Comprehensive Spending Review, in the BBSRC 2011-15 Delivery Plan, *Maximising Economic Growth in the Age of Bioscience* [44] Over the current Spending Review years BBSRC research and training investments will be targeted on our strategic research priorities in food security, bioenergy and industrial biotechnology, and basic bioscience underpinning health, and on three key enabling themes: knowledge exchange, innovation and skills; exploiting new ways of working; and working in partnership. We anticipate generating impact from across the research and training portfolio and will continue to encourage and foster this through the implementation of the plans set out in Part 3 of the Delivery Plan.

DEVELOPING CAMPUSES

A key plank of our impact plans and our major focus over the coming year is the development of research and innovation campuses at research institutes supported by BBSRC. Each of the institutes in which BBSRC invests has specific strengths in relation to the research and training undertaken, the user communities which benefit, and the networks within which they operate. Our long-term goal for campus development is to create an individual vision and strategy for each of the institute research and innovation campuses that identify how they will contribute uniquely to regional and national innovation.



Significant progress has already been made at the Babraham Research Campus and at the Norwich Research Park. The early success of these developments was recognised and given an important boost with the new investment of £44M and £26M at Babraham and Norwich respectively by the Department of Business, Innovation and Skills, and accounting for much of the capital/ infrastructure investment for science announced by Government as part of the 2011 budget,[44] BBSRC is playing a key role in leading the developments at both campuses. Going forward at Babraham, we will build on our current strengths in research and innovation, and initiate further infrastructure and facilities which will help create and support exciting new companies and jobs based on world-leading bioscience. At Norwich the new investment will underpin the transformation of the NRP from 'World-Class Research Centre' to a 'National Research Campus' embracing a world-class commercial science park.

With programmes at Babraham and Norwich underway, the next priority will be the campus at Rothamsted Research, which combines excellent basic and strategic research relevant to food security and bioenergy, major national capabilities for long-term experiments and data collection and curation, and a long-standing reputation for excellence within UK and international agricultural communities. At Roslin, with the bio-campus (20 companies) on its former BBSRC site and the new Roslin laboratories on the Easter Bush Campus, alongside the University of Edinburgh Veterinary School, Scottish Agricultural College, University Animal Hospital and the Moredun Institute, making the UK's largest centre for animal sciences, BBSRC is working with partners, to help build the vision and focus for a new commercial campus at Easter Bush.

PROGRESS IN METHODOLOGY AND FUTURE PLANS TO DEVELOP THE EVIDENCE BASE

Impact portal
For the last year BBSRC has been developing a system to record and manage information on impacts arising from our investments. The system has been thoroughly tested and is now being rolled-out to users in BBSRC. Other Research Councils have expressed an interest in the system and we plan to explore this further over the coming months.

Research Outcomes System ROS
AHRC, BBSRC EPSRC and ESRC have worked together to develop a system to collect and store information on outputs, outcomes and impacts from our research and training investments. This major project has involved developing the existing ESRC system to accommodate the needs of all four Councils and has involved significant input from our research communities. The system has been well tested and is about to be available to researchers and research managers in universities and research institutes across the UK. Over the coming year we will run our first major collection of data, which will be crucial for the development of the impact evidence base.

Case studies
As well systematising the collection of data, BBSRC is developing a programme of key case studies of research and training leading to impact. This will draw on our extensive programme of evaluations and on the developments of ROS and the Impact portal.

Evaluations
Our refreshed evaluation framework and agreed evaluation programme for this year have been published,[46] Evaluations are now designed to provide evidence of performance and achievements relevant to our strategic priorities. They continue to combine data generation and analysis with expert review and take account of emerging methodological ideas. In future the evaluation and case studies programmes will be closely aligned.

Cross-Council developments
BBSRC continues to work constructively with colleagues in all the Research Councils through the RCUK Impact Group and the associated RCUK Performance Evaluation Network. A major focus going forward will be on the identification of impact and the evaluation of outcomes from the cross-Council themes.

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Annex A: Key Indicators

		UNITS	2007/08	2008/09	2009/10	2010/11
INPUTS	Total Funds Available	£mil	£mil	407	430	507
	Budget Allocation	£mil	£mil	394	412	486
	Leverage	£mil	£mil	13	18	21
	of which Private	£mil	£mil	5	7	2
	of which from other Research Councils	£mil	£mil	8	9	18
	of which from other source	£mil	£mil	0	2	1
	of which Private	%	%	1%	2%	0%
	of which Other Research Councils	%	%	2%	2%	4%
	of which Other	%	%	0%	0%	0%
	Total Expenditure	£mil	£mil	407	430	507
	of which Responsive Mode Grant	£mil	£mil	273	291	292
	of which Postgraduate Awards	£mil	£mil	47	51	52
	of which Other components	£mil	£mil	88	89	163
	of which Responsive Mode Grant	%	%	67%	68%	58%
	of which Postgraduate Awards	%	%	11%	12%	10%
	of which Other components	%	%	22%	21%	32%
	"Other" Largest Component[a]					Roslin Institute £35M
	Human Capital			.		
	Principal Investigators[b]	#	#	1642	1618	1524
	Research Leaders in Sponsored Institutes[c]	#	#	202.71	184.63	182
	Research Fellowships[d]	#	#	53	54	58
OUTPUTS	**Knowledge Generation**		.			
	Refereed Publications	#	1059	895	821	755
	Non Refereed Publications	#	0	381	285	228
	Co-authorship of refereed publications - International	%	0%	0%	40%	60%
	Co-authorship of refereed publications - Industry	%	0%	0%	9%	48%
	Human Capital		.			
	Number of PhD Students Supported	#	511	503	539	555
	Number of Masters Students Supported	#	86	85	90	92
	Finishing Rates	%	80%	80%	83%	88%
	Student funding/training schemes		.			
	CASE Studentship Awards (New)[e]	#	268	258	225	226
	Knowledge Transfer and Exchange		.			
	KE Spend[f]	£mil	2.43	3.45	3.85	4.14
	KE Main Programmes		.			
	The Modular Training for Industry	(£M)	0.13	0.09	0.08	0.15
	The Biotechnology Young Entrepreneurs Scheme	(£M)	0.1	0.1	0.13	0.13
	The Royal Society of Edinburgh Enterprise Fellowships	(£M)	0.25	0.25	0.3	0.3
	The Follow-on-Funding Scheme	(£M)	1.5	2.6	2.8	2.9
	The Royal Society Industry Fellowship Scheme	(£M)	0.05	0.05	0.05	0.05
	Knowledge Transfer Partnerships	(£M)	0.16	0.25	0.35	0.33
	The Industry Interchange Programme	(£M)	0.24	0.09	0.12	0.26
	The Innovator of the Year	(£M)	N/A	0.02	0.02	0.02

		UNITS	2007/08	2008/09	2009/10	2010/11
	IP Activity (discretionary)[g]		.			
	Patents granted	#	10	27	15	23
	Spinouts/new businesses created	#	5	0	0	0
	Income from IP activity	£mil	0.7	0.7	1.0	1.2
OUTCOMES	**Human Capital**		.			
	Destinations of leavers[h]		.			
	Of which University	%	39	49	46	
	Of which Wider Public Sector	%	9	8	6	
	Of which Further Training and known to be engaged in study.	%	4	4	4	
	Of which Private Sector	%	18	16	16	
	Of which School teaching/other	%	1	2	2	
	Of which Unemployed	%	7	8	11	
	Other including R&D sector, unknown and self employed	%	22	13	13	
	Placements in user organisations					
	Number of Staff exchanged with industry	#	2	2	1	1
	Number of Industrial staff exchanged with institutes	#	0	2	0	1
	Placements in user organisations		.			
	Public Policy: See page 8		.			
	Instances of influence See page 8		.			
	Value/changes induced See page 8		.			
	Public Engagement		.			
	PE Schemes		.			
	Media Releases	#	47	67	98	54
	Media and Comms courses	#	8	13	7	6
	Local Schools' coordinators N.B. 2010/11 replaced by new scheme "School Regional Champions"	#	20	22	22	13

a. These are out of total capital expenditure of £136M in 09/10 and £113M in 10/11. The balances made up of a large number of different projects.
b. Total number of PIs on all current research awards (ISPGs, fellowships, RM & initiatives) as of 01/04 each year.
c. Total number of research leaders in sponsored institutes where applicable on 01/04 each year
d. Total number of Research Fellowships on 01/04 each year
e. Includes estimate of DTG allocation.
f. On main programmes
g. License income
h. 2010/11 data will not be available until July 2012