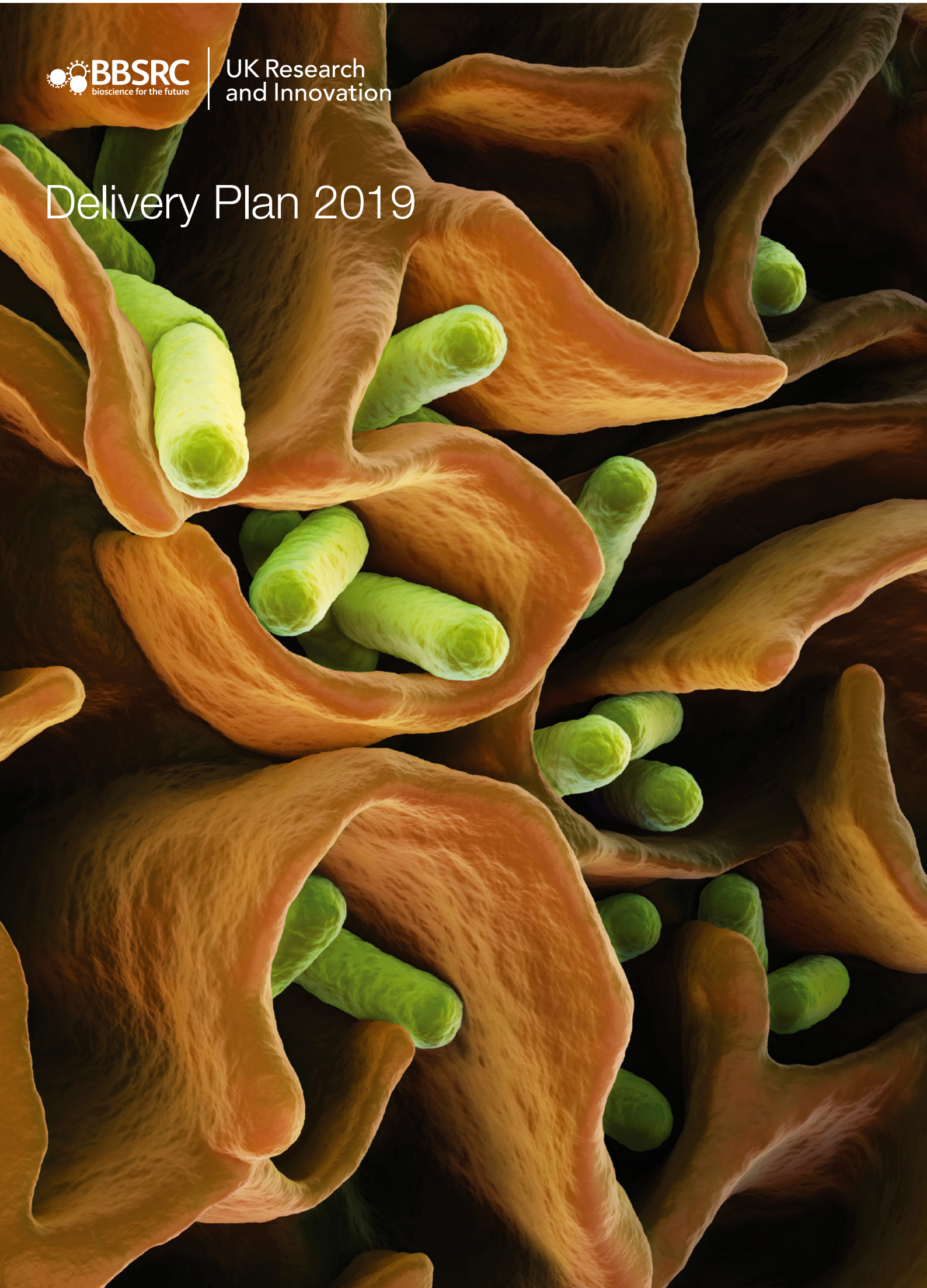
BBSRC bioscience for the future | UK Research and Innovation

Delivery Plan 2019



Front cover: Gut microbes/Professor Parveen Yaqoob.
This page: Bacteria culture/Thinkstock

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1. Foreword

Professor Melanie Welham
Executive Chair, UKRI-BBSRC

In 2018, BBSRC published its *Forward Look for UK Bioscience*. Developed in consultation with our research and stakeholder communities, the *Forward Look* articulates a direction of travel for UK bioscience over the next 5 to 10 years. It identifies high-level priorities to ensure the discipline's continued health, and sets out where bioscience can have most impact in addressing some of the 21st century's greatest challenges, such as food security, clean growth and an ageing society.

Following on from this, our delivery plan (DP) sets out in more detail the actions we will take to support and deliver our aims and objectives, and to contribute to the overarching UK Research and Innovation (UKRI) strategy.

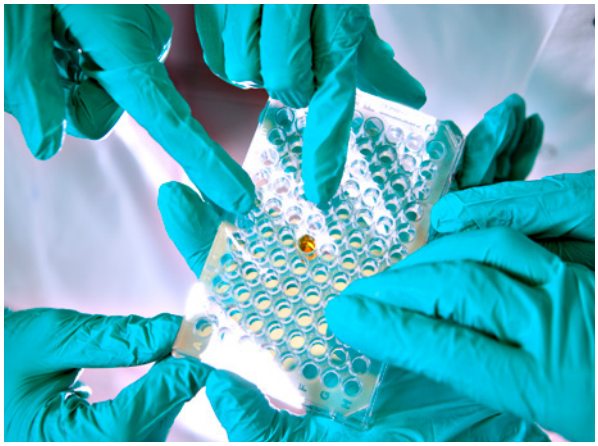
As part of UKRI, we have a key role in providing leadership and support for UK bioscience research, maintaining the health of the discipline and enabling researchers to build on their discoveries through innovation. I am keen that we act as an intelligent investor in research, supporting and enhancing the excellence of UK bioscience and maximising the generation of new knowledge and opportunities to deliver economic and social impact.

I see three key elements as fundamental to achieving this and which will underpin our approach to delivering the ambitious vision set out in this DP:

- Firstly, for BBSRC to be strategic and forward-looking, building on our strong foundations and developing the talent and infrastructure that are key to a vibrant research ecosystem; supporting discovery research and transformative technologies to advance the frontiers of knowledge; building the bioeconomy and ensuring bioscience contributes to addressing strategic 21st-century challenges relating to sustainability of resources, food and agriculture, and health.

- Secondly, to build strong partnerships as an open, collaborative, collegiate council. We already partner in many different ways, within UKRI, nationally and internationally, and will use our catalysing and convening power to seize new opportunities to work across traditional boundaries.
- Thirdly, to invest in people by continuing to support research careers through studentships and fellowships, as well as nurturing the talent within BBSRC (the people who provide the vital links to our research community and stakeholders), whilst embedding equality, diversity and inclusion in everything we do.

This is an incredibly exciting time for UK bioscience, with new tools, technologies and approaches changing the way research is undertaken and allowing researchers to probe unsolved questions as we seek to understand biological complexity and its control. I am confident that, through the ambitions and actions set out in the *Forward Look* and this DP, we will ensure the UK remains at the forefront of this revolution, advancing the frontiers of discovery, creating transdisciplinary partnerships, driving innovation and delivering valuable benefits for society and the economy.



2. Vision and objectives

New technologies, tools and approaches, often spanning several disciplines, are revolutionising biology, providing unprecedented opportunities to advance understanding of the complex, dynamic processes that govern life and to apply that knowledge for the benefit of society and the economy.

At BBSRC, our vision is to push back the frontiers of biology to deliver a healthy, prosperous and sustainable future.

This vision is rooted in an understanding that the power of biology impacts on all of our lives, from the provision of safe and nutritious food, new pharmaceuticals and better health, to 'greener' energy, materials and other everyday products. In the coming decades, bioscience will offer solutions to major challenges facing the world, including sustainable food production, clean growth and healthy ageing. These challenges are also at the heart of the UK government's Industrial Strategy.

Those parts of the UK economy that depend on bioscience, the bioeconomy, contribute around £220 billion per year and support 5.2 million jobs. There are significant opportunities for UK bioscience to drive growth in the bioeconomy, helping to meet the government's Industrial Strategy target of raising investment in R&D to 2.4% of GDP by 2027 and 3% in the longer term, and contributing to the delivery of the UK bioeconomy strategy.[1] The UK's strengths in bioscience will act as a focus for private sector investment, transforming existing industries and inspiring new ones through the emergence of potentially disruptive bio-based technologies and solutions in areas such as agri-tech, biotechnology, data science and synthetic biology.

BBSRC has a long and proud history of supporting the UK's world-leading position in bioscience. The opportunity for us now, as part of UKRI and during a period of rapid change in the research and innovation landscape, is to ensure that the strength of our bioscience research and skills base continues to position the UK as a partner of choice globally, and that the transformative power of biology is realised to help drive a more healthy, prosperous and sustainable future.

Our strategy for UK bioscience is built around the following three long-term, high-level objectives which will keep the UK at the cutting edge of bioscience research and innovation, help deliver the Industrial Strategy and contribute to delivery of UKRI's vision of benefitting everyone through knowledge, talent and ideas:

- **Advancing the frontiers of bioscience discovery** – recognising the revolution unfolding in our understanding of living systems, driven by new tools, technologies and interdisciplinary approaches.

  Our ongoing commitment to excellence in discovery research across the breadth of our remit, from molecules to systems, will enable UK bioscience to push the frontiers of human knowledge and understanding.

- **Tackling strategic challenges** – identifying areas where excellent bioscience can help address major societal challenges, including the Industrial Strategy Grand Challenges, and drive growth in the bioeconomy by transforming existing industries and creating new ones.

  Working with other disciplines, government and industry, we will harness the UK's world-leading bioscience expertise to address significant challenges such as delivering sustainable, resilient food and agriculture, driving clean growth and promoting improved human and animal health.

  Alongside universities, our strategically-supported institutes (see Section 4) play a particular part in addressing these strategic challenges through their long-term, mission-driven research programmes and training. The institutes also provide vital national capabilities, such as the high containment laboratories at The Pirbright Institute and the long-term field experiments at Rothamsted Research, with strong links to industry and the wider community.

- **Building strong foundations** – ensuring that UK bioscience has what it needs to continue to deliver world-leading, ground-breaking research and innovation.

  We recognise that people, infrastructure and collaboration are essential to the success of UK bioscience, and to meeting government targets for increasing R&D investment. We will go on working with other funders nationally and internationally, and with research organisations, government and business, to create the best environment for research and innovation.

Research and innovation priorities

Working with stakeholders, we have identified eight research and innovation priorities, structured around our high level objectives. These are described in more detail in Section 3.

Advancing the frontiers of bioscience discovery

Understanding the rules of life

Transformative technologies

Tackling strategic challenges

Bioscience for sustainable agriculture and food

Bioscience for renewable resources and clean growth

Bioscience for an integrated understanding of health

Building strong foundations

People and talent

Infrastructure

Collaboration, partnerships and knowledge exchange

[1] https://www.gov.uk/government/publications/bioeconomy-strategy-2018-to-2030

3. Research and innovation priorities

3.1 ADVANCING THE FRONTIERS OF BIOSCIENCE DISCOVERY

3.1.1 UNDERSTANDING THE RULES OF LIFE

Promoting creative, curiosity-driven 'frontier bioscience' to address fundamental questions in biology

Understanding living systems and how they function is at the very heart of bioscience research and innovation. From the structure of DNA to the processes by which cells divide and replicate, the UK has a rich history of contributing to ground-breaking discoveries that are revealing the fundamental 'rules of life'. But there is much still to learn and tremendous excitement about the opportunities that future discoveries in bioscience will unlock. For example, understanding how cells communicate with one another, or how the interplay between an organism's genetic make-up and its environment will affect its physical characteristics remain some of the biggest unresolved questions in biology.

Our longstanding commitment to excellence in discovery research, supporting the best ideas wherever they are found, has helped position the UK as a leading nation in bioscience. To maintain this global leadership we will continue to promote creative, curiosity-driven research that advances the boundaries of knowledge and delivers important discoveries with a wide range of potential applications. Recognising that such discoveries often involve cross-disciplinary approaches, we will also work with our UKRI partners to stimulate collaboration across disciplinary interfaces to address key questions in bioscience (see 3.1.2).

Fundamental bioscience discoveries can be transformative for science, society and the economy, and provide the foundation for innovation in business. For researchers working at the frontiers of biology, however, the line of sight to a practical outcome might, at the outset, seem indirect or far off. Our approaches must recognise this and enable the build-up and synthesis of knowledge over longer timespans, as well as providing opportunities for researchers to pursue new avenues and high-risk, high-reward ideas.

Long-term ambitions

- Actively promote creative, discovery-led frontier bioscience research that advances our understanding of the rules of life.
- Ensure our funding decisions create an environment where frontier bioscience thrives, through an emphasis on scientific excellence and the potential to make transformative discoveries.
- Maintain UK strengths in core disciplines underpinning fundamental research into microbes, plants and animals, spanning scales from molecules to populations.
- Enable industry and other users, as well as researchers in other disciplines, to access, collaborate with and benefit from the knowledge and discoveries arising from frontier bioscience research.
- Champion the importance and transformative potential of fundamental discovery research as a key principle for UK bioscience.

Near-term actions

In 2019-20 we will:

- Support internationally-leading research across the breadth of our scientific remit through further investment of £139m in our flagship responsive-mode programme.

Epigenetics: From single cell to complex morphology

Understanding epigenetic mechanisms, which influence how the genome functions under different developmental or environmental conditions, is a key question in biology. Work at the Babraham Institute has developed new methods of studying the influence of epigenetics on gene expression at the single-cell scale, while researchers at the John Innes Centre have revealed how epigenetic memory of temperature in plants influences the switch between vegetative (leaf) and reproductive (flower) development.

Uncovering new mechanisms of photosynthesis

BBSRC-funded researchers are using single-celled organisms called cyanobacteria to reveal new fundamental knowledge about the process of photosynthesis. This has included discovery of a new mechanism of photosynthesis that harnesses near-infrared light, and understanding how the 3D structure and dynamics of the photosynthetic membrane facilitates transformation of electromagnetic energy into chemical energy.

- Invest up to £16m in new strategic Longer and Larger awards in frontier bioscience, addressing significant fundamental questions in bioscience.
- Work with partners across UKRI to progress multidisciplinary themes aimed at advancing our understanding of the rules of life, including:
  - strengthening capacity for microbiome research in the UK by promoting knowledge exchange across the sector and enhancing the skills base
  - supporting the development and application of artificial intelligence (AI) for bioscience, contributing to the AI and Data Grand Challenge, and including delivery of the UKRI AI and Data Science for Engineering, Health and Government programme supported by the Strategic Priorities Fund
  - seeking expert input to develop options for advancing multiscale studies of dynamic biological systems, building on previous investments in systems biology and community networking.
- Identify priority areas for our lead-agency scheme with the US National Science Foundation, which enables collaboration between UK and US researchers to advance the frontiers of biological discovery.
- Work with our research, innovation and broader stakeholder communities through our horizon-scanning programme to identify, develop, and promote emerging areas at the cutting-edge of the biosciences.

3.1.2 TRANSFORMATIVE TECHNOLOGIES

Developing tools, technologies and approaches that enable researchers to push the boundaries of discovery and stimulate innovation

Advances in research often involve development or application of new tools and technologies and, increasingly, data-intensive, predictive and interdisciplinary approaches to biological discovery. To understand biological processes and organisms, researchers need to be able to measure many different parameters across multiple scales from molecules to cells, organs, organisms and populations. Integration of bioscience with engineering and physical sciences offers a huge opportunity to co-develop novel tools that will underpin bioscience discovery. These may include, for example, single cell approaches that enable researchers to move away from 'average' measurements and instead understand the variation and role of individual cells within populations, or the integration of phenotyping technologies to enable a more holistic view of an organism's characteristics.

Dealing with the increasing complexity and scale of biological data arising from technologies such as next-generation sequencing and high-resolution imaging presents both a challenge and an opportunity. AI and machine learning, automation and other innovative data-science approaches are key to unlocking valuable new knowledge and scientific leads from the enormous quantities and huge diversity of bioscience data available, as recognised in the UK's Industrial Strategy AI and Data Grand Challenge.

The emergence, exploitation and integration of disruptive technologies and approaches can also open up transformative new opportunities for research and business, breakthrough innovations and new market opportunities. For example, major developments in genome-editing tools mean it is now possible to make precise, targeted changes to the genomes of cells and organisms. Alongside advances in synthetic biology, this enhances the ability to design and engineer biological systems, fuelling both fundamental bioscience research and its applications in areas such as agriculture, materials, chemicals and human and veterinary medicine.

Long-term ambitions

- Drive convergence and integration across disciplines, particularly between the physical and life sciences, to support development and application of new technologies to advance bioscience discovery.
- Support computational approaches to generate new knowledge from the huge volume and diversity of biological data available, including integration of knowledge and data across multiple scales and the development of predictive models.
- Enable academia, industry and other users to identify, co-develop and benefit from disruptive bioscience technologies, wherever they originate.
- Increase the sensitivity, speed, resolution and non-invasive methods of analytical measuring technologies, opening new avenues for research on living systems and its translation and application.
- Enable development of new models and approaches to reduce the use of animals in research and provide more effective, more representative tools for studying animal and human biology.
- Support the development of industrial biotechnology and synthetic biology as platform technologies that enable a range of applications in a more circular, greener bioeconomy.

(See also section 3.3.2.)

Engineering new biological materials using synthetic DNA

Enabled by BBSRC, EPSRC and Innovate UK funding, PhD students at Imperial College London founded synthetic biology spin-out LabGenius to commercialise their gene synthesis technology. The company uses AI to predict which gene mutations will improve a biological design, enabling scientists to produce new therapeutics and advanced materials such as adhesives, catalysts and sensors. LabGenius has raised US$3.66m in seed funding and secured three contracts with Dstl to create improved body armour and adhesives. In 2017, Imperial's James Field won the Early Career Impact category in BBSRC's Innovator of the Year competition.

Bringing powerful microscopy to the biology lab

Researchers at the University of Oxford have developed and commercialised the world's first desktop-sized super-resolution microscope, which allows the study of individual molecules within living cells. Our responsive-mode programme provided part-funding for the work which led to this breakthrough, while the Joint Synthetic Biology Initiative, supported by BBSRC, EPSRC, MRC and the Defence Science and Technology Laboratory (Dstl), provided funding that helped the researchers create the first prototype. Spin-out ONI (Oxford Nanoimaging) was formed in May 2016 to market the microscopes.

Oxford Nanoimaging

Near-term actions

In 2019-20 we will:

- Pump-prime, through our Tools and Resources Development Fund, the next generation of cutting-edge research technologies that will have a transformative impact on life sciences research.
- Work with academia, business and partners across UKRI to determine the next steps to build on the capabilities, scientific advances and world-leading position of UK synthetic biology established through investments to date.
- Complete a review of our support for data-intensive bioscience to identify opportunities and inform future priorities, in consultation with the research community, and in support of the Industrial Strategy AI and Data Grand Challenge. (See also related activities on AI (3.1.2), skills (3.2.1) and infrastructure (3.3.2))
- Work with EPSRC and MRC to strengthen the interface between life and physical sciences, building on previous joint investments in Technology Touching Life Networks and investing in collaborative, interdisciplinary projects through the £30m Physics of Life programme, with support from the Strategic Priorities Fund.
- Support the £12.5m National Biofilms Innovation Centre with Innovate UK, connecting researchers across the UK and catalysing collaboration with industry in the study of biofilms to achieve breakthrough innovation.
- Develop and support public-dialogue activities on genome editing, working with partners across UKRI as part of UKRI's wider public engagement strategy.
- Develop a position statement on gene drives, an emerging area of biotechnology that carries potential sensitivities in terms of its future applications, drawing on the advice of a specially convened working group.

3.2 TACKLING STRATEGIC CHALLENGES

3.2.1 BIOSCIENCE FOR SUSTAINABLE AGRICULTURE AND FOOD

Delivering more productive, healthy, resilient and sustainable agriculture and food systems

A predicted 60% more food will be needed worldwide by 2050 to feed the growing global population. Reducing food waste is part of the solution but, as recognised in the Industrial Strategy's Clean Growth Grand Challenge, a huge, boost in sustainable agricultural productivity is also needed to meet demand while reducing emissions. It is not simply about using more land for food production, but maximising efficiency of land use and resources. We must increase the resilience of food supply chains in the face of challenges such as climate change, pests, pathogens, extreme weather and soil degradation, whilst protecting the environment.

Advances in 'omics technologies and in crop and livestock breeding, coupled with the convergence of sensor technologies, robotics and autonomous systems, 'big data', machine learning and AI, offer an unprecedented opportunity to revolutionise food supply chains. For example, developing predictive models to select crops or livestock lines that are better adapted to climate change or resistant to disease will help to speed up breeding programmes. Through collaborative research and knowledge exchange our bioscience contributes essential knowledge and evidence for farmers, food producers, processors, manufacturers, retailers, consumers and governments, to enable them to farm sustainably and produce healthy, nutritious, affordable food while reducing impacts on the environment, protecting biodiversity and enhancing natural capital.

We will work with our partners in UKRI, government (e.g. Defra), industry and internationally to ensure the UK's strengths in bioscience have an impact on global food security and drive innovation and clean growth in the agri-food sector. Effective user engagement and knowledge exchange across the food system will be essential, as will integration with other councils and disciplines such as environmental and social sciences and engineering. For example, as part of the Industrial Strategy Challenge Fund, Transforming Food Production, led by Innovate UK and BBSRC, will invest up to £90 million to drive transformation across the agri-food sector so that food is produced in ways which are more effective, resilient and sustainable.

Lameness treatment guidelines save UK farmers £700M

Research at the University of Warwick supported by BBSRC and Defra has enabled UK farmers to cut the number of lame sheep in the UK national flock by half. The research demonstrated that 95% of sheep recovered from lameness within ten days when an antibiotic injection was given within three days. In contrast, traditional methods were successful on less than 25% of sheep. The researchers worked with industry partners such as the Sheep Veterinary Society and Agriculture and Horticulture Development Board to engage farmers and disseminate their results. Over ten years, the research has saved UK farmers £700M and prevented 7.5 million sheep from becoming lame.

Long-term ambitions

- Improve the sustainability and resilience of agriculture by applying interdisciplinary, multi-scale and systems approaches to the understanding and management of agri-ecosystems, soil health and use of resources.
- Work with Defra and others to develop novel strategies to predict, detect and manage disease threats to plant and animal health and to improve the welfare of farmed animals.
- Improve food safety and nutrition through integration of novel crop, farmed animal and nutrition research, including social science dimensions, and by exploiting fundamental knowledge in microbiology to minimise pathogens and toxins in the food system.
- Reduce avoidable waste in the food system by understanding and controlling fundamental biological processes involved in crop physiology and maturation, and food spoilage.
- Understand and use genomics and genetic diversity to develop the next generation of improved crops and farmed animals.
- Support acceleration and uptake of precision agriculture and smart technologies, combining bioscience with novel engineering and technology solutions, including digital and predictive tools, to improve decision-making in agriculture.

Near-term actions

In 2019-20 we will:

- Deliver the Transforming Food Production programme, working with Innovate UK and key stakeholders, including Defra, to define the key priority challenge areas for future funding and scoping bilateral calls with Canada and China.
- Establish a new programme of underpinning and applied research, with NERC and policy partners (Defra and the Scottish Government) and with support from the Strategic Priorities Fund, to improve UK resilience against the increasing threat of bacterial diseases of crops, trees and other plants. A call for multidisciplinary projects will be launched in summer 2019.
- Work with other UKRI councils, government departments, agencies and devolved governments though the UK Science Partnership for Animal and Plant Health to develop coordinated actions to enhance the UK's biosecurity and resilience.

Precision agriculture

A BBSRC and Innovate UK-funded project with Saturn Bioponics Ltd has assisted development of a new inline sensing technology for real-time management of the nutrient composition within intensive hydroponic, aeroponic and aquaponic farming. The multidisciplinary approach has addressed challenges in horticultural production, offering producers a flexible facility to meet changing consumer preferences and sustainability goals.

Saturn Grower System

- Host a workshop to build and strengthen collaborations across the UK's food safety research and innovation community.
- Undertake focused activities to underpin and enhance sustainable agricultural production, working with UKRI, policy, industry and international partners, and including:
  - establishment of a new UK research and innovation network focused on improving quality and reducing food loss in horticultural crops
  - identification of future priorities and interventions to tackle the challenge of boosting farmed animal productivity, with advice from an expert working group
  - building on investments with NERC in research on soils and farming systems through the £8m UK/US Signals in the Soil programme, with support from the Fund for International Collaboration.

(See 3.2.3. for additional actions aimed at integrating food, nutrition and health research.)

3.2.2 BIOSCIENCE FOR RENEWABLE RESOURCES AND CLEAN GROWTH

Transforming industries through bio-based processes and products in a new low-carbon bioeconomy

Harnessing the power of biology through industrial biotechnology has the potential to transform a wide range of industries and supply chains and reduce reliance on chemical processes and fossil fuels. This will help to meet international climate change targets, drive productivity and growth in the bioeconomy and address the Clean Growth Grand Challenge set out in the UK's Industrial Strategy. The move to biologically based processes offers opportunities to generate materials, biopharmaceuticals, chemicals and energy with improved performance, lower operational costs and reduced carbon emissions, leading to more sustainable, cleaner manufacturing and greater use of residues or wastes in a more circular bioeconomy.

The industrial biotechnology sector is growing at a rate of 8-10% per year, which is predicted to continue beyond 2025. Recent investments by BBSRC, with EPSRC and Innovate UK, working closely with key sector groups such as the Industrial Biotechnology Leadership Forum have increased the capacity and capability for industrial biotechnology research and innovation in the UK's academic and business communities, encompassing engineering, physical, chemical and biological sciences. But sustained support is needed if the UK is to realise the full potential of bio-based approaches. So too is access to well-maintained specialist infrastructures, to enable translation of world-leading UK bioscience into innovative bio-based products and processes at industrial scales.

We will work with Innovate UK, EPSRC, other councils, Government and industry to expand the knowledge, skills and key platform technologies, such as synthetic biology and industrial biotechnology, to enable implementation of the government's Bioeconomy Strategy, which aims to double the size of the bioeconomy by 2030.

Long-term ambitions

- Expand UK capacity and capability for research and translation in bio-based manufacturing and foster collaboration between academic researchers and industry.
- Generate new understanding of the molecular and cellular basis of key bio-based processes such as enzyme pathways and their regulation, in a range of industrially relevant organisms.
- Develop and apply whole-cell and enzymatic systems that can be applied across different manufacturing systems to aid production of biopharmaceuticals, antimicrobial compounds, speciality chemicals such as food ingredients, platform chemicals from which materials such as plastics are derived, and fuels.
- Develop and improve the performance of bio-based processes and fermentation at industrial scales, in collaboration with UKRI partners and business.
- Enable the creation of value from unavoidable waste and by-products (agricultural, food, municipal and industrial wastes, and contaminants), reducing pollution and generating economic and environmental benefits through the development and application of biotechnologies.
- Facilitate the emergence of new business models for bio-based manufacture and encourage whole-systems approaches, involving life-cycle analysis, that consider the range, efficiency and cost-effectiveness of bio-based technologies.

Turning coffee waste into electricity

Coffee production requires vast quantities of water. Around 140 litres of water are needed to produce just one cup of coffee, and a large proportion of this is released as wastewater that is extremely damaging to the environment. However, thanks to funding from BBSRC and EPSRC, researchers from the University of Surrey have now created a microbial fuel cell that converts polluting waste from coffee production into electricity, preventing environmentally-damaging coffee waste from entering and contaminating water courses.

Near-term actions
In 2019-20 we will:

- Implement Phase II of our Networks in Industrial Biotechnology and Bioenergy, with support from EPSRC, investing £11m in six networks over five years to build UK capacity and foster collaboration between academic and business communities.
- Work in partnership with EPSRC to deliver research and innovation that will contribute to sustainable growth in the bioeconomy, including:
  - a new £10m Future Biomanufacturing Research Hub to develop new biotechnologies that will speed up bio-based manufacturing in three key sectors: pharmaceuticals, value-added chemicals and engineering materials
  - and £2m Prosperity Partnership between the University of Manchester, Astra Zeneca and Prozomix, to develop new biocatalytic manufacturing technology.
- Develop and implement new mechanisms to enable industry and academic researchers to work together to understand how industrial biotechnology can make the manufacturing of higher-value chemicals more efficient, cost-effective and sustainable.
- Work with NERC and other UKRI and government partners to develop research and innovation activities that will assess sustainable routes for large-scale removal of greenhouse gases from the atmosphere.
- Work with the research and user communities and with other funders to scope emerging opportunities and potential future priorities in areas such as bioelectrical engineering, bio-based carbon capture for manufacturing and storage, algal biotechnology and biotechnological tools for rare-metals recovery.
- Scope and conduct a mid-term review of our joint investment with Brazil's State of São Paulo Research Foundation (FAPESP) in advanced biofuels and biorefineries.
- Support UK participation in the European Research Area Network Cofund on Biotechnologies (ERA CoBioTech), contributing up to £2m to a €15m call for transnational research projects that will help transform the global economy from one dependent on fossil raw materials to a sustainable bio-based economy.

Building capacity for a low-carbon future

The BBSRC Networks in Industrial Biotechnology and Bioenergy foster collaboration between industry, policy-makers, NGOs and academia to harness the potential of biological resources for producing and processing materials, biopharmaceuticals, chemicals and energy. The first phase connected over 800 companies throughout Industrial Biotechnology supply and value chains with more than 3,300 academic researchers, and supported more than 230 Proof of Concept studies worth £11m, leveraging an additional £2.6m from the private sector.

For example, the networks have enabled UK industrial biotechnology company Green Biologics to collaborate with academic researchers to develop a better understanding of the bacteria and fermentation processes the company uses to manufacture chemicals from renewable, non-petrochemical sources. This is helping them to improve the efficiency of their processes and the competitiveness of their products, and to expand the range of chemicals they are able to produce sustainably.

In 2018, BBSRC, with support of EPSRC announced a further £11m to support a second phase of networking activity.

3.2.3 BIOSCIENCE FOR AN INTEGRATED UNDERSTANDING OF HEALTH

Improving human and animal health and wellbeing across the life course

The UK has an ageing population, but as our average lifespan increases, our healthspan is not extending as fast. Changing lifestyles are having significant impacts on health across the life course, with declining health and wellbeing in later life placing increasing pressure on health and social care services. This is recognised in the UK's Industrial Strategy through the Ageing Society Grand Challenge and its first mission; to ensure that people can enjoy at least five extra healthy and independent years of life by 2035, while narrowing the gap between the experience of the richest and poorest.

In addition, globalisation presents specific and urgent animal and human health challenges, including zoonotic infections and antimicrobial resistance (AMR). There is a pressing need for integrated approaches across a range of disciplines, organisms and scales that generate new insights to improve animal and human health and wellbeing, inform strategies for disease prevention and underpin innovation in health-related industrial sectors.

Bioscience has a crucial foundational role in health-related research and innovation, providing a deep, integrated understanding of the 'healthy system' across the life course, and of the factors that maintain health and wellness under stress and biological or environmental challenge. The impact of this knowledge on health challenges depends, however, on effective integration and translation across different areas of bioscience research, as well as with other disciplines such as the medical, social, environmental and physical sciences, and between academia, industry, healthcare providers and policymakers.

Our funding for research to understand healthy human systems, alongside animal health and disease, makes an important contribution to the UK's wider health research landscape. We work closely with other UKRI councils, particularly MRC and ESRC, to develop shared or complementary strategies in areas of common interest, such as healthy ageing, diet and health, infectious disease, vaccines, AMR, and regenerative medicine. We also work with other public and third-sector partners to address shared research priorities in health through, for example, the UK Nutrition and Health Partnership and the UK Age Research Forum, of which we are a co-convener.

Long-term ambitions

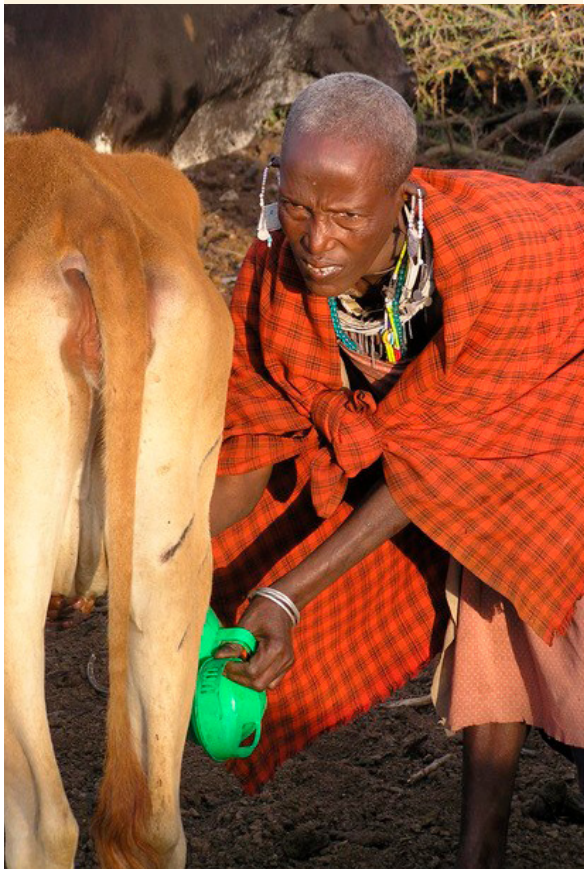
- Improve the health and wellbeing of people and animals through 'one health' approaches that combine biological, medical and veterinary research.
- Keep people healthier for longer by understanding the mechanisms underlying normal physiology and homeostatic control during early development and across the lifespan into old age.
- Reveal the relationships between diet and health, through integration of nutrition, agriculture and food processing research, and by understanding gut function and the role of the gut microbiome.
- Combine knowledge within and across disciplines to understand the biological basis of mental and physical health.

The Quadram Institute: A new national institute for food and health research

Located on the Norwich Research Park, the Quadram Institute is a new £75m state-of-the-art food and health research and endoscopy centre housing 300 scientists and 100 clinicians. It will work with industry to become a leading international hub at the interface between food science, gut biology and health, developing solutions to worldwide challenges and combining scientific excellence and clinical expertise to deliver better patient care whilst accelerating innovation.

Combatting zoonotic disease

Zoonoses are diseases capable of passing from animals to humans and are estimated to have cost more than $20bn in direct costs globally between 2000-2010, with a further $200bn in indirect costs. As well as threatening human and animal health, zoonoses affect livestock production, causing economic and social harm to communities in developed and developing countries. The Zoonoses and Emerging Livestock Systems programme, funded by BBSRC, the Department for International Development (DFID), Dstl, ESRC, MRC and NERC, is investing £20.5m in research and training to combat these damaging diseases and, ultimately, enhance the lives of millions of people. For example, research led by the University of Glasgow has pinpointed goats and sheep as the source of human brucellosis in Tanzania, where the disease is a significant public health challenge. The findings, together with the research team's work with community hospitals in Tanzania, is helping to improve diagnostic processes and inform national strategies for control of the disease.



Sarah Cleveland

- Tackle zoonotic and vector-borne diseases of humans and animals, and resistance to antimicrobial compounds, through the development of new tools and interventions.
- Support the application of biological knowledge, models and tools in existing industries and expanding market sectors such as personalised health, regenerative medicine, biomarkers for health and new therapeutic, food and health-promoting products.

Near-term actions

In 2019-20 we will:

- Work with partners in the Global Food Security programme, across UKRI and government, to develop a coordinated approach to research aimed at transforming the food system so that it delivers for health whilst protecting the environment.
- Identify future activities to build on the collaborations between the nutrition and health research communities and the food sector established through our previous investments in the Diet and Health Research Industry Club and the Priming Food Partnerships initiative.
- Support the integration of nutrition and agri-food research for beneficial health outcomes in developing countries, through £7m Global Challenges Research Fund investment in interdisciplinary, collaborative research projects focused on the nutritional content and bioavailability of nutrients in relevant foods.
- Work with MRC and other partners to support research aimed at understanding the complexity of pain.
- Lead and expand UK participation in the international, multi-agency Ecology and Evolution of Infectious Disease programme, which brings medical, veterinary, social and environmental sciences together to understand disease emergence and transmission, with support from the Fund for International Collaboration.
- Deliver, with NERC and on behalf of the Department of Health and Social Care (DHSC), a call for collaborative research with Argentina focusing on AMR in the environment. In addition to up to £5m UK funding, Argentina's National Scientific and Technical Research Council (CONICET) will provide support.

3.3 BUILDING STRONG FOUNDATIONS

3.3.1 PEOPLE AND TALENT

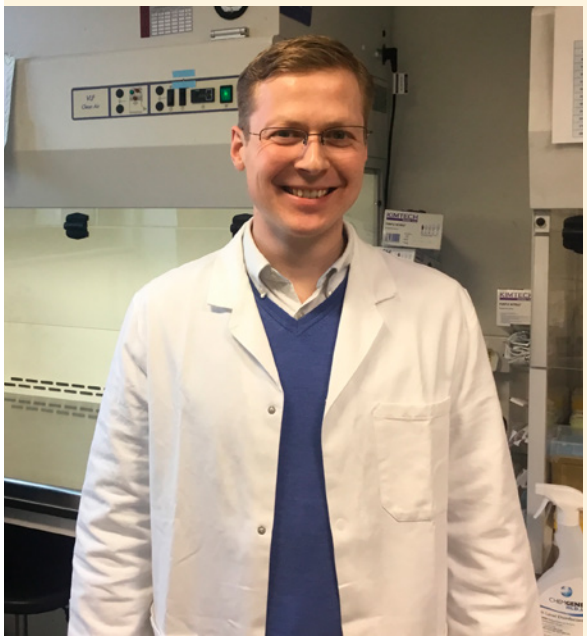
Attracting and developing a flexible, diverse workforce for modern bioscience

A highly skilled and productive workforce is fundamental to the UK's global leadership in biotechnology and biological sciences, and a driving force for growth and inward investment in the bioeconomy. But bioscience is a rapidly evolving discipline. Game-changing advances in technology and data-driven approaches continue to revolutionise bioscience research, requiring researchers to continually develop new skills and ways of working. In addition, as advances in bioscience increasingly drive innovation in key industrial sectors, demand for bioscience skills and expertise is expected to increase, supporting the ambition of improving growth and productivity by investing 2.4% of GDP in R&D by 2027.

More than ever, modern bioscience involves coordination of large, interdisciplinary research teams and interactions with a variety of project partners and stakeholders, requiring a range of teamwork, leadership and management skills in addition to scientific and technical expertise. There is a vital need for the brokerage skills to identify and bring together the best teams, and to lead and manage programmes effectively. A more holistic, inclusive approach to developing and maintaining skills is required that reaches across the research and innovation system and includes support for postdoctoral researchers, technicians, data scientists and knowledge-exchange professionals, for instance. Attracting people into UK bioscience through non-traditional routes, increasing the porosity of the academia/business interface and encouraging researcher mobility across disciplines, institutions, sectors and countries are also key to securing the diversity of talent needed.

Long-term ambitions

- Expand bioscience research and innovation capacity and capability for academia and business, to enable the UK to meet its target of investing 2.4% of GDP in R&D, and enable the growth of the UK bioeconomy.
- Take a system-wide approach to talent that recognises and values the entire workforce needed to deliver high-quality bioscience research and innovation.
- Continue to train for depth of expertise as well as equipping researchers with a breadth of professional, enterprise and transferable skills, including leadership and team-working.
- Develop talent at all career stages, fostering a culture of lifelong learning and development.



Sebastian Eves-van den Akker

Supporting the next generation of research leaders

BBSRC's investments in training are nurturing the development of the next generation of research leaders, who will play a key role in addressing the challenges of the 21st century. For example, Dr Sebastian Eves-van den Akker is an early-career researcher investigating the fundamental biology of plant-pathogen interactions in order to deliver strategies for improved plant resilience and ultimately contribute to global food security. BBSRC support has enabled Sebastian's career at all stages: a PhD studentship to build the basics; an Anniversary Future Leader Fellowship to establish a niche; a David Phillips Fellowship to start an independent research group; and responsive-mode grant funding to build this new research programme.

- Champion a culture of inclusion within the biosciences, supporting diversity in all its forms.
- Enable flexible career structures and researcher mobility, facilitating the flow of talent between different parts of the research and innovation system, across disciplines and sectors, and internationally.
- Actively monitor, horizon-scan and make strategic interventions to address emerging skills needs and/or vulnerabilities in bioscience.
- Attract and grow all multidisciplinary expertise required to advance UK bioscience, in particular to boost capacity and capability for quantitative, integrative and data-intensive bioscience.

Near-term actions
In 2019-20 we will:

- Invest £170m in a third phase of our Doctoral Training Partnership programme, supporting up to 1,700 new studentships over five years to build and maintain the capacity of core bioscience disciplines and deliver skills for impact across the UK economy.
- Consult businesses on the future scope, aims and objectives of our Collaborative Training Partnerships programme, which supports industrially-led doctoral research training.
- Develop future research leaders, investing £7m in early-career Discovery Fellowships and David Phillips Fellowships, and supporting the pipeline of new researchers through mentoring and support for learning and development.
- Develop a plan for embedding enterprise and entrepreneurship in UK bioscience, enabling researchers at any stage of their career to deliver impact from their bioscience research, aligning with wider UKRI activities where appropriate.
- Develop plans to support research teams in the biosciences, including embedding continuous professional development and improving recognition for postdoctoral and other research staff, as part of UKRI's talent strategy.
- Analyse the demographics of the UK bioscience community and how this relates to our investments. Identify and implement interventions to support a diverse community of researchers, working with partners across the bioscience sector.

Professional internships to develop researcher skills

BBSRC Doctoral Training Partnership courses offer 4-year PhD studentships during which each student also undertakes a 3-month professional internship placement, in areas such as industrial R&D, education, publishing, journalism, research administration and policy. These placements allow students to gain broader work experience and develop a range of valuable professional skills, including management, communication and finance.

3.3.2 INFRASTRUCTURE

Ensuring the bioscience community can access the facilities, resources and services it needs

Cutting-edge bioscience depends on modern and sustainable research infrastructure. This ranges from essential bioinformatics and biological resources such as databases and biological collections, to state-of-the-art instrumentation and facilities such as high-throughput 'omics platforms and advanced bioimaging technologies. Infrastructure that supports innovation and research translation by linking researchers and users is also crucial to the competitiveness of UK bioscience.

Looking ahead, bioscience is evolving more and more into big and connected science. This requires networks of small-scale shared facilities to come together to form integrated and distributed infrastructures. In addition, changes in the way bioscience research is undertaken, for example increased automation and use of machine learning, will prompt further changes in infrastructure needs. Creation and maintenance of 'well-found laboratories' that keep pace with rapid developments in research technologies are also integral to the UK's continued leadership in bioscience.

The development and implementation of the UK Research and Innovation Infrastructure Roadmap is an opportunity for funders, research organisations, private sector providers and government to work together to develop a more coordinated, integrated approach to the sustainable provision and use of research and innovation infrastructures. This will need to encompass different types of infrastructure at local, regional, national and international scales, and recognise the requirement for specialist technical staff to support their operation. Development and maintenance of reliable, interoperable, sustained data infrastructures is a high priority, as bioscience becomes an increasingly data-intensive discipline.

Long-term ambitions

- Ensure the UK bioscience research base has access to the essential research and innovation infrastructures identified in the UK Research and Innovation Infrastructure Roadmap.
- Work with UKRI and international partners to establish data infrastructures that meet the needs of UK bioscience as well as facilitating data sharing between disciplines.

- Develop approaches to support the sustainable operation of equipment, facilities and resources, including associated specialist technical support.
- Support the concept of the 'well found laboratory' in UK bioscience through provision of mid-range equipment.
- Lead for the UK in the coordination, development and delivery of relevant transnational research infrastructures for bioscience, working with partners in Europe and beyond.
- Increase the connectivity of research and innovation infrastructures across disciplines, nationally and internationally, and between academia and industry.
- Foster environments to accelerate impact from UK bioscience, including through continued development of our national research and innovation campuses, as part of the wider network of UKRI campuses.

Open imaging data advances bioscience

BBSRC funding has enabled researchers from the University of Dundee, EMBL-EBI, the University of Cambridge and the University of Bristol, working with collaborators in Italy and France, to establish the Image Data Resource (IDR). The IDR makes publicly available a range of image data sets that have never previously been accessible, allowing the research community to search, view, mine and even process and analyse large, complex, multidimensional life sciences image data.

Near-term actions
In 2019-20 we will:

- Lead, with MRC, for the bioscience, health and food sector in the development of the UK research and innovation infrastructure roadmap.
- Deliver major infrastructure investments to establish and maintain bioscience research facilties of national and international importance including:
  - expansion of the technical infrastructure at the European Molecular Biology Laboratory's European Bioinformatics Institute (EMBL-EBI) to provide essential resources and services for data-driven bioscience research, with £44.5m investment from the Strategic Priorities Fund
  - ongoing development of vaccinology laboratories and containment facilities at The Pirbright Institute, the UK's world-leading centre of excellence in research and surveillance of virus diseases of farm animals and viruses that spread from animals to humans. Construction of a new poultry experimental facility is underway for completion in 2020.
- Support acquisition, development and maintenance of equipment, technologies, software and resources essential for cutting-edge bioscience research through our mid-range equipment scheme and Bioinformatics and Biological Resources Fund, investing up to £10m and £6m respectively.
- Lead UK participation in the preparatory phase of the European Infrastructure for Multi-scale Plant Phenomics and Simulation (EMPHASIS) project, which aims to establish a pan-European distributed infrastructure for crop phenotyping.

Andrew Davis

Creating environments to accelerate innovation

Since 2011 we have invested over £100m in the development of five research and innovation campuses, which form a vital component of the UK innovation ecosystem, and are part of a wider network of UKRI campuses. Each one is centred on a critical mass of world-leading bioscience, strategically funded by BBSRC. This provides a unique environment where companies can access specialist facilities and exchange ideas with leading researchers, fostering early-stage innovation and accelerating translation of excellent research into tangible social and economic benefits for the UK and beyond.

For example, the Babraham Research Campus is a hub of bioscience and biomedical research and innovation near Cambridge. More than 60 early-stage bioscience companies are located on the site alongside the world-renowned Babraham Institute.

- Work with partners to develop a business case for the Next Generation Infrastructure (NGI) programme. This encompasses redevelopment of the John Innes Centre and co-location with The Sainsbury Laboratory to provide modern facilities in support of the UK's world-leading plant and microbial science.
- Work with STFC and MRC to complete planning for the sustainability of funding for the Electron Bio-imaging Centre (eBIC) at Diamond Light Source beyond 2020.
- Foster environments to accelerate impact from UK bioscience through further development of UK research and innovation campuses, including:
  - delivery of our £12m investment in the £40.5m Aberystwyth Innovation and Enterprise Campus development, which will support enterprise and innovation in the food and drink, bioprocessing and biotechnology sectors
  - working with partners in the Babraham Research Campus to deliver a project that demonstrates the benefits and impact of public and private investment in the campus, for society and the economy.

3.3.3 COLLABORATION, PARTNERSHIPS AND KNOWLEDGE EXCHANGE

Enabling collaborations across disciplines, organisations and national boundaries

Science is increasingly a connected global endeavour, where collaboration and partnership is essential.

Integration across disciplines and sectors

While ensuring the continued health and vibrancy of our own discipline, we will, in delivering our ambitious strategy for UK bioscience, continue to promote and enable multidisciplinary and interdisciplinary ways of working. Tackling complex economic and societal challenges requires convergence and integration of research across multiple disciplines. Moreover, exciting breakthroughs often occur at the interfaces between disciplines and sectors, where the integration of diverse knowledge, tools and expertise can help stimulate innovation from discovery through to translation. The creation of UKRI is an exciting opportunity to further strengthen coordination, collaboration and translation across the research and innovation landscape.

Knowledge exchange and translation

Bioscience supports a diverse range of established and emerging industry sectors that collectively contribute to the bioeconomy, as well as to national and international policies. Collaboration, partnership and the exchange of knowledge with the users and recipients of research, such as industry, policymakers, charities and civil society, are essential in shaping research agendas through better understanding of users' needs, concerns and aspirations.

Realising economic and societal benefit from the ideas, knowledge, technologies, skills and capabilities derived from bioscience research is complex and multidimensional. Fulfilling this great potential requires a deep, often sector-specific understanding of market needs, regulation and the diverse routes to application. Working with Innovate UK and other partners across UKRI, and more broadly, we will continue to drive innovation in the biosciences by supporting effective knowledge exchange and facilitating development of sustainable partnerships between researchers and research users.

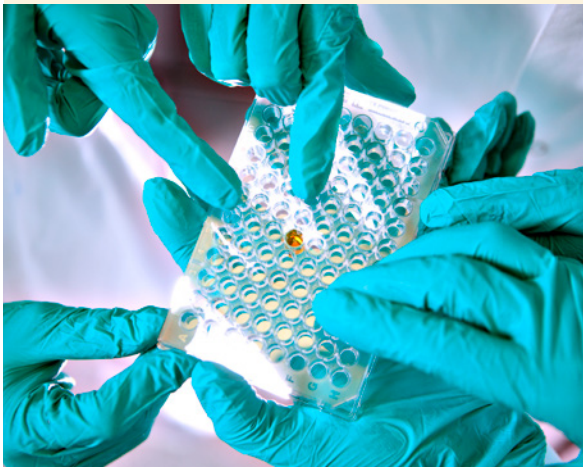
International collaboration

International partnerships help sustain the vibrancy of UK bioscience. They promote the free flow of ideas and researchers, delivering 'best with best' scientific collaboration that advances the frontiers of knowledge by capitalising on complementary research and technology capabilities and contributing to the development and delivery of international research priorities. As a global partner of choice, the UK builds on its strengths in bioscience to influence global science governance and standards, where other countries often look to the UK for leadership, and to support wider international policy and relationships.

Over the last decade, we have established strong, sustained partnerships with funders across the world in areas of mutual strategic priority such as agriculture and food security, animal health, bioenergy, industrial biotechnology and AMR. We are continuing to develop new links with a range of countries in support of our strategic ambitions for UK bioscience. We also enable the UK bioscience community to build international partnerships through pump-priming and collaborative schemes and UK support to international programmes.

From discovery to commercialisation

University of Aberdeen researchers established award-winning spin-out company Elasmogen to develop new medicines based on antibody-like molecules isolated from sharks, called VNARs. BBSRC invested in the initial research that led to the discovery and patenting of the shark VNARs, and have supported commercialisation of the technology through follow-on funding and a BBSRC/Royal Society of Edinburgh Enterprise Fellowship.



Elasmogen Ltd

International coordination of life science data

ELIXIR unites Europe's leading life science organisations to manage and safeguard data. It coordinates, integrates and sustains bioinformatics resources across its member states and enables users in academia and industry to access services vital for their research. ELIXIR comprises a hub, located at EMBL-EBI in Cambridge, and national nodes. The UK nodes are sited within the EBI and at the Earlham Institute, and reflect the UK's strengths in bioinformatics and computational biology.

Building on our strong track record of international engagement, we will contribute to UKRI's international strategy and the implementation of the UK's International Research and Innovation Strategy. We will work with partners in UKRI and overseas to develop new partnering opportunities through the Fund for International Collaboration, and to deliver programmes where UK bioscience can help address international development challenges through the Newton Fund and Global Challenges Research Fund (GCRF). We will also continue to engage in transnational infrastructure projects.

Long-term ambitions

- Foster approaches that facilitate collaboration and the exchange of people and ideas, between disciplines, between academia and industry, and between countries.
- Develop and sustain a range of models to support industry/academic partnership, knowledge exchange and translation which meet the needs of the diverse sectors that bioscience underpins.
- Ensure the UK remains a partner of choice for bioscience research and innovation, recognising too that our global partnerships are changing in terms of a greater emphasis on official development assistance (ODA) and the UK's changing relationship with the EU.
- Identify and build mutually beneficial partnerships for UK bioscience and opportunities for it to help address international research priorities.

Near-term actions

In 2019-20 we will:

Knowledge exchange and translation

- Support translation of bioscience research into applications that deliver benefit and impact, including provision of up to £4.5m follow-on funding, with additional GCRF funding available for activities aimed at delivering impact in developing countries.
- Undertake a review of our responsive industrial partnering schemes to inform our future approaches to supporting business collaboration in the biological sciences.
- Contribute to UKRI's developing strategies and plans for supporting the commercialisation of research.

Tackling global challenges through international collaboration

Wheat is one of the most important global crops. It provides 20% of total calories consumed by humans daily worldwide, and is grown on more land than any other commercial crop. By 2050, global wheat demand is expected to increase by 60%. Through the International Wheat Yield Partnership, BBSRC is working with other public and private research organisations around the world to invest in innovative research, and to enable the best scientific teams from across the globe to work together to address the challenge of raising the genetic yield potential of wheat, with the aim of substantially boosting wheat productivity to help meet this rising demand.

Additional activities are included under other research and innovation priorities, including activities supported through the Industrial Strategy Challenge Fund.

International collaboration

- Support BBSRC-funded researchers to establish and develop international collaborations, investing in up to 30 International Partnering Awards and workshops and up to 10 International Travel Awards.
- With MRC, fund the UK subscriptions to the Human Frontier Science Program and the European Molecular Biology Organisation, to ensure UK researchers can access the opportunities provided by these international initiatives.
- Through the Global Challenges Research Fund support multidirectional interchanges between the UK academic base and users within Development Assistance Committee (DAC)-listed countries, enabling exchange of knowledge, skills and capabilities.
- Play a leading role in major international consortia to tackle 'grand challenges' through coordinated international collaboration, such as the European Joint Programme Initiative on Agriculture Food Security and Climate Change, and the International Wheat Yield Consortium.
- Conclude a review of Bioscience for International Development, to inform future ODA opportunities.
- Contribute to the management and coordination of relevant projects funded under the GCRF Growing Research Capability and Interdisciplinary Research Hubs.

Additional international activities are included under other research and innovation priorities, including activities supported through the GCRF, Newton Fund and Fund for International Collaboration.

4. Delivering and being accountable as an outstanding organisation

Efficient and effective operations

As an investor of public money, we are committed to utilising resources effectively and responsibly, and we have a strong track record of delivery in this respect. We operate a range of flexible and efficient investment mechanisms from small pump-priming and proof-of-concept studies through to strategic longer, larger programmes of research, with grants awarded on the basis of robust peer-reviewed competition.

We have adopted a culture of continuous improvement and regularly seek opportunities to improve the efficiency and effectiveness of our key business processes. Following the successful transition to UKRI in 2018, we will continue to play an active role in the UKRI transformation programme, including contributing to the development of key business systems.

In developing our strategies and funding priorities, we will continue to draw on a wide range of inputs and advice from our research and user communities through our Council, strategy advisory structure, expert working groups, strategic partnerships with higher education institutions (HEIs), research users and other funders, and wider community and stakeholders.This ongoing process of horizon-scanning and strategy development enables us to be flexible and agile in responding to new challenges and proactive in our support for emerging opportunities. Furthermore, we recognise that research informed by a wide range of perspectives is better able to articulate and respond to the challenges it seeks to address. In line with UKRI's public engagement strategy, we will seek to open up discussions about the direction of bioscience research and innovation to diverse perspectives, particularly with regard to new and potentially disruptive areas.

As a responsible investor, we seek to promote high standards of research integrity in UK bioscience and champion UK leadership in standards of research and technology governance, including the open science agenda. We will play an active role in developing and implementing UKRI policies relating to open research, research integrity and research reproducibility.

Investing in excellence across the UK

We invest in excellent bioscience research, infrastructure and training at around 80 UK universities and other UK research organisations. Around a third of our funding goes to eight specialist institutes that provide national capability and expertise in strategically important areas:

- The Babraham Institute
- The Earlham Institute
- The Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University
- The John Innes Centre
- The Pirbright Institute
- The Quadram Institute
- The Roslin Institute at the University of Edinburgh
- Rothamsted Research.

These institutes play a vital role in delivery of our research and innovation priorities, generating new knowledge with impacts on food, agriculture, energy, materials and health that will drive growth in the bioeconomy and benefit society across the UK and beyond. The institutes are also central to our research and innovation campus strategy.

We are also committed to realising UKRI's ambition of embedding equality, diversity and inclusion at all levels and in everything we do, fully reflecting the communities we work in, to ensure we are accessing the best input, talent and perspectives. As part of UKRI and working with partners throughout the sector, we will continue to value and promote an inclusive research community where diverse talent advances discovery, develops skills and knowledge, and drives innovation in UK bioscience.

As a part of UKRI, we have a central role in the UK research and innovation landscape, providing leadership for UK bioscience through our strategy and investments. But we recognise that, if UK bioscience is to achieve its full potential and contribute to the delivery of UKRI's vision, the UK's Industrial Strategy and the government target of 2.4% of GDP spent on R&D by 2027, we will need to work closely with our many partners and stakeholders. We will use our convening power to catalyse joined-up approaches and seize opportunities for coordinated and collaborative actions and investments with our partners across UKRI, government, industry and internationally, to address shared, multidisciplinary research and innovation priorities.

Measuring progress against the UKRI success framework and our plan

We will monitor and evaluate our activities, in alignment with UKRI's overarching monitoring and evaluation framework, in order to develop a robust evidence base of performance and achievement. This will provide accountability, inform future strategy and investment decisions, and help improve policy and practice.

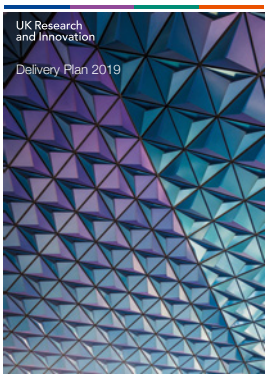
We will work with our Council to track progress in implementing the near-term actions identified in this DP in the context of our longer-term ambitions. We will also explore ways to deepen our understanding of the relationship between our investments and interventions and their outcomes and impacts, building on our existing approaches to capture and evaluate outcomes and impacts.

In the short term, measures of progress will include funding inputs, progress against actions, and, where appropriate, annual monitoring and mid-term reviews of major investments. In the medium term we will track progress against relevant outcomes, for example publications, measures of research quality, training, patents, new business spin-outs and start-ups, and the development of new tools and technologies. We will work with partners to develop benefits realisation plans that help drive and capture the intended outcomes and impacts of specific investments, and will conduct and commission evaluation to understand the relevance, performance, efficiency and impact of investments in bioscience. In addition we will draw on a range of internal and external data to understand and demonstrate the longer-term impacts of our activities and investments on knowledge, the economy and society.

5. Financial allocation

BBSRC, £m		2019-20
Research and Innovation Budgets		**327.0**
Science Infrastructure Capital		**64.1**
ODA		**46.9**
o/w	GCRF	33.2
	Newton Fund	13.7
NPIF		**13.9**
o/w	ISCF	2.4
	Skills	6.3
	Funds For International Collaboration	2.0
	Strategic Priorities Fund	3.1
BBSRC Programme		**451.9**

UK Research and Innovation Delivery Plans



UKRI

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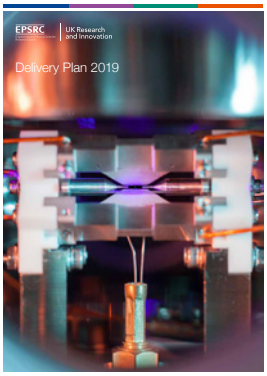
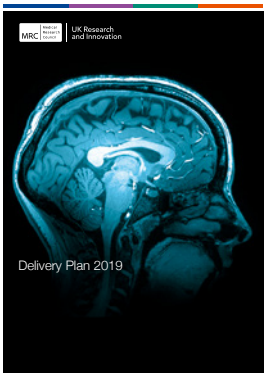


EPSRC

ESRC

Innovate UK



MRC

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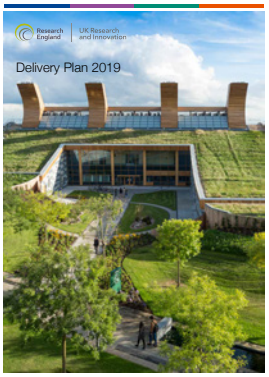

Research England

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