Biotechnology and Biological Sciences Research Council

Bioscience for an Integrated Understanding of Health

Strategic Research and Innovation Framework

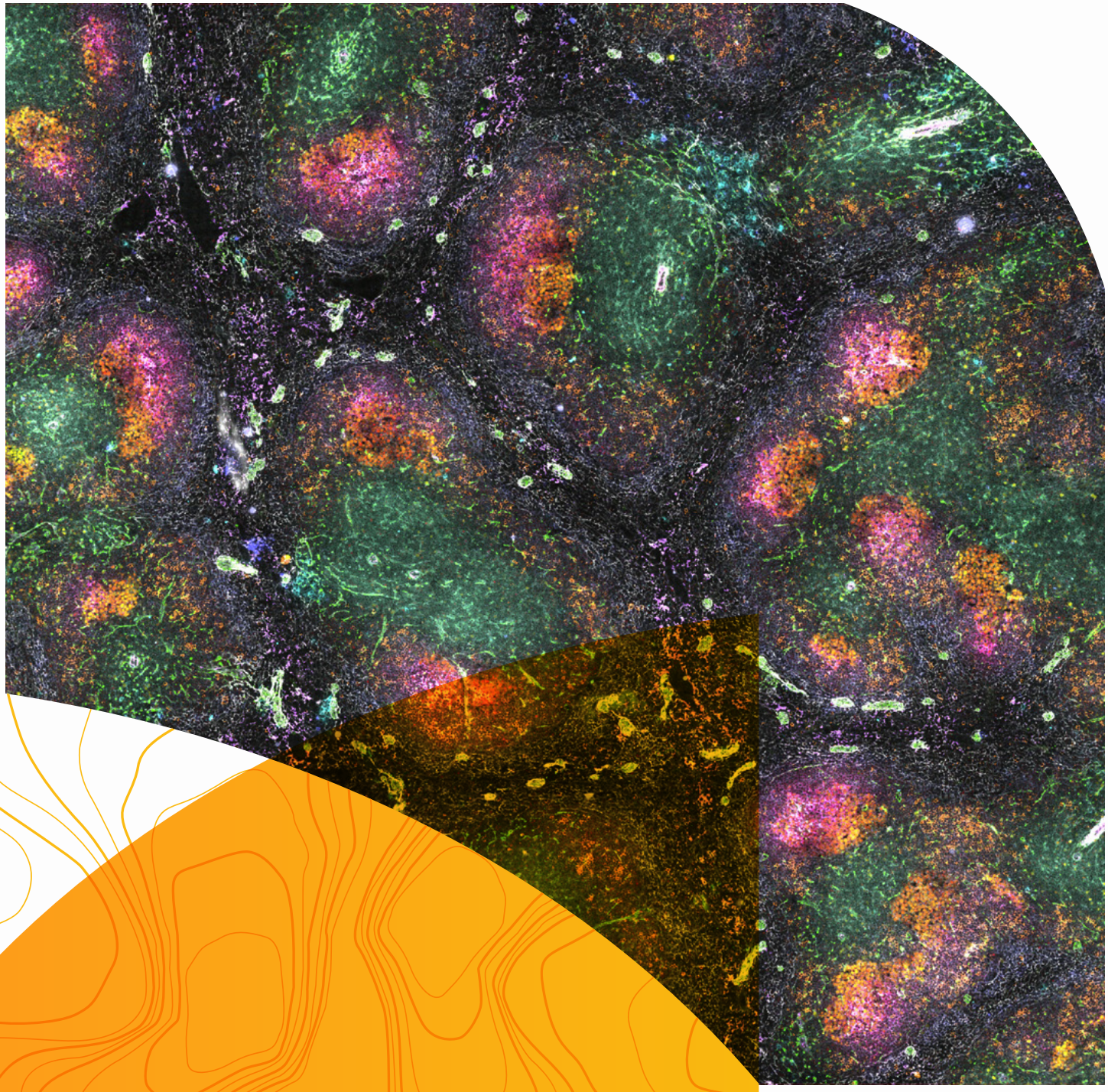


Image shown using new BBSRC funded MACSima technology
Image credit: Isabel San Martin Molina, Babraham Institute

Contents

Executive Summary

The world is facing complex health challenges: ageing population, increasing infectious diseases outbreaks including vector borne diseases, poor nutrition, obesity and many more which impacts the health and wellbeing of animals, humans, and their environment. However, at the same time rapid advances in bioscience discovery and innovation including novel tools, technologies and approaches are making it possible to address these health challenges by providing new knowledge and innovative solutions.

This refreshed 'Bioscience for an Integrated Understanding of Health Strategic Research and Innovation Framework' sets out collective research and innovation roadmap to provide a deep, integrated understanding of fundamental biological mechanisms of healthy systems across the life course as well as promoting One Health and the Replacement, Refinement and Reduction (3Rs) approaches to improve animal and human health and wellbeing.

The framework highlights four themes that represent key opportunities to generate deeper understanding of both what defines and determines health across the life course and the interface between human and animal health. Across these four themes there is an overarching emphasis on deploying world class bioscience and new ways of working to tackle key bioscience questions. Together these themes are intended to promote development of an integrated understanding of the key determinants of health.

- Ageing and health across the life course – to advance the understanding of biological mechanisms of ageing and maintaining cognitive, mental and physical health and wellbeing across the life course
- Food and nutrition for health – to advance the understanding of how food and diet, including their components and nutrients, as well as their interactions and temporal consumption patterns, promote health across the life course
- Combatting infectious diseases and AMR – to understand, forecast, avoid and mitigate animal infectious diseases and antimicrobial resistance (AMR) to improve the health and wellbeing of animals and people
- Transformative technologies for health – to develop, validate, implement and apply tools, technologies, methodologies, and data to understand and manage the health and wellbeing in animals and humans across the life course

These four themes are underpinned by two approaches: One Health and 3Rs of the use of animals in research, which will be embedded into the science and innovation we support.

Utilising our catalysing and convening power, BBSRC will foster collaborative efforts and build effective partnerships across UKRI, Government departments and other stakeholders to translate scientific discoveries into tangible health benefits and sustainable health solutions, leading to significant changes in the lives of animals and people in the UK and around the world.

Glossary

3Rs: Replacement, Refinement and Reduction

AMR: Antimicrobial resistance

BIUH: Bioscience for an Integrated Understanding of Health

Defra: Department for Environment, Food and Rural Affairs

EPSRC: Engineering and Physical Sciences Research Council

ESRC: Economics and Social Sciences Research Council

FCDO: Foreign, Commonwealth and Development Office

JIC: John Innes Centre

JPI-AMR: The Joint Programming Initiative on Antimicrobial Resistance

LMICS: Low- and Middle- Income Countries

MRC: Medical Research Council

NC3Rs: National Centre for 3Rs

NERC: Natural Environment Research Council

SDGs: Sustainable Development Goals

UKRI: UK Research and Innovation

WHO: World Health Organisation

Scope and Context

Research and innovation in the biotechnology and biological sciences play an important role in addressing health challenges. By providing a deep mechanistic understanding of biological systems and bio-based solutions, biosciences make a crucial contribution to the overall health research and innovation landscape.

The world is facing complex health challenges e.g:

- the global population aged 60+ is growing faster than all other age groups. This number will increase to 1.4 billion by 2030 and 2.1 billion by 2050[1]. Ageing is the largest risk factor for numerous diseases. It is projected that with increasing life expectancy, people living with major illness will increase[2]
- poor diet and sedentary behaviour are two of the biggest risk factors, though preventable, for early deaths worldwide[3,4]
- triple burden of malnutrition – overnutrition, undernutrition and micronutrient deficiencies
- at the other end of the spectrum of malnutrition is obesity. According to the World Health Organisation (WHO): 'Paradoxically coexisting with undernutrition, an escalating global epidemic of overweight and obesity – "globesity" – is taking over many parts of the world. If immediate action is not taken, millions will suffer from an array of serious health disorders'[5]
- increasing infectious disease outbreaks (including vector-borne) among animals and humans

However, in the recent years, the public's attitude towards health and wellbeing has gradually been shifting towards 'healthier' living[6] and wellness[7], although this is heavily influenced by socio-economic division[8] and demography[9].

The COVID-19 pandemic has accelerated this thinking[10]. The lessons learnt from the pandemic demonstrate that health is the foundation upon which resilient, productive economies and fair societies are built and global health challenges do not respect national borders[11].

A recent survey showed 8 in 10 adults aged over 18 decided to modify their lifestyle in 2021, with 7 in 10 adults saying that they are motivated to make healthier lifestyle changes[12]. In addition, the role of attaining and maintaining good nutritional status to support the immune system in fighting against infection and promoting health span in later years has been more broadly recognised[13].

This paradigm shift in thinking towards preventing ill health, and enhancing health and wellbeing, will add 'life to years' rather than 'years to life', thereby reducing the cost of healthcare[14,15,16] e.g. a targeted supervised tooth brushing programme to improve the oral health of children aged 0–5 years provides a return of £3.06 for every £1 invested after 5 years and £3.66 after 10 years[17]. The modelling forecasts in the Future of Health in Europe report states, by 2040, a higher proportion of funds (51 per cent compared to 17 per cent in 2019) will target health promotion, illness prevention and health restoration. This shift would lessen disease incidence and severity, altering Europe's expected cost curve and potentially reducing healthcare spending by nearly €250 billion in 2030 and close to €595 billion by 2040[18].'

1 Ageing (who.int)
2 Health in 2040: projected patterns of illness in England – The Health Foundation
3 Poor diet biggest risk factor for early deaths worldwide (medicalnewstoday.com)
4 Physical Inactivity: The Major Risk Factor for Non-Communicable Diseases – PMC (nih.gov)
5 Controlling the global obesity epidemic (who.int)
6 New data reveals how our diets are changing over time – Public health matters (blog.gov.uk);
7 The future of the $1.5 trillion wellness market | McKinsey
8 Current trends suggest a growing socio-economic divide as those who are better off take on board health messages and adopt healthier lifestyles and those from more disadvantaged backgrounds do not. The improvements seen in young people's behaviour suggest that they may take a more positive approach to their health as they grow older.
9 Healthy behaviours | The King's Fund (kingsfund.org.uk)
10 COVID-19 crisis leads to shift in public attitudes about the role of the state | The Health Foundation
11 Healthcare in Europe | Deloitte Insights
12 Seven in 10 adults are motivated to get healthier in 2021 due to COVID-19 – GOV.UK (www.gov.uk)
13 Nutrition, immunity and COVID-19 (bmj.com)
14 Investing in prevention: is it cost-effective? – UK Health Security Agency (blog.gov.uk)
15 Economic benefits of prevention – The Prevention Centre
16 Making the economic case for prevention – UK Health Security Agency (blog.gov.uk)
17 Main heading (publishing.service.gov.uk)
18 Healthcare in Europe | Deloitte Insights

Beyond the COVID-19 pandemic, a broader swathe of (re-)emerging infectious diseases e.g. avian influenza, African Swine fever, Mpox, and Usutu virus and increased prevalence of antibiotic, anthelmintic and antifungal resistance, have all highlighted the importance of a deeper understanding of zoonotic infections and the impacts of the use and misuse of antimicrobials. The interface between animal, environment and human health using a One Health approach is increasingly well understood to be critical to protecting people from infectious disease threats, whilst also consistent with aims to improve the health and welfare of farmed, companion and wild animals throughout their life course.

Role of BBSRC Supported Science

The bioscience and biotechnology research supported by BBSRC makes a critical contribution to broader national and global health research agendas. BBSRC's portfolio uniquely bridges research on healthy human systems and animal disease, health and welfare research, and the food systems which influence nutritional outcomes, animal health, and infectious disease emergence and spread. Whilst research focused on human diseases falls outside of BBSRC's scientific remit, we work in partnership with other funders to maximise the value of shared research objectives and knowledge between studies of human health and animal health, welfare and disease, through comparative 'one biology' approaches, and a 'One Health' approach to zoonosis research.

In 2015, BBSRC published the Bioscience for Health Strategic Research Framework 2015–2020. This document provided the research community and the wider stakeholder community with a roadmap for BBSRC's key expected contributions to the wider health research landscape and guided BBSRC activities to support this area during this period.

Some of the key strategic investments of this period are highlighted below.

Highlights of Key Investments between 2015–2020

Quadram Institute:
a **£50M** BBSRC capital investment established a strategic research Institute at the forefront of a new interface between food science, gut biology, and health, developing solutions to world-wide challenge in microbial food-related diseases and human health.

Food, Nutrition and Health:
a **£7.6M** investment through the Global Challenges Research Fund and Newton Fund underpinned by evidence gathered at the workshop in Kathmandu, Nepal in 2017 with ESRC, MRC, Foreign, Commonwealth and Development Office (FCDO), the Bill & Melinda Gates Foundation and the Agriculture, Nutrition and Health Academy.

Infectious Diseases:
a **£10M** investment in the multinational **Ecology and Evolution of Infectious Diseases Programme** supports transdisciplinary teams to conduct innovative research on the ecological, evolutionary, and social drivers that influence the transmission dynamics of infectious diseases of animals, humans, and plants. BBSRC led the UK effort, bringing together ESRC, EPSRC, NERC and MRC to establish a partnership with three major US funders [National Science Foundation (NSF), National Institutes of Health (NIH), U.S. Department of Agriculture (USDA)], United States-Israel Binational Science Foundation, and the National Natural Science Foundation of China.

Animal Health:
a **£7M** investment to support research on novel strategies to diagnose, prevent, manage, and treat microbiological diseases of swine and poultry in partnership with National Natural Science Foundation of China; Department of Agriculture, Bureau of Agricultural Research from Philippines; Philippine Agriculture and Fisheries Biotechnology Program, and National Science and Technology Development Agency from Thailand.

UK Regenerative Medicine Platform:
received a **£17M** investment in 2018, from MRC, EPSRC and BBSRC to ensure that research addressing regenerative medicine connects seamlessly from discovery science through to clinical and commercial application.

Vector-Borne Diseases (VBD) Networks:
established with a **£5M** investment to convene international communities on specific VBDs areas/ issues. These networks provided pump-priming funding to aid early career research development and a capacity building in Low- and Middle- Income Countries (LMICs).

Animal Welfare Research Network:
brings together the UK animal welfare research community, researchers in related disciplines, and stakeholders with a professional interest in animal welfare issues, to enhance communication and collaboration, and promote high quality fundamental and applied animal welfare research and its implementation.

The UK Science Partnership for Animal and Plant Health:
established in 2016 to provide a new model for cross-government science coordination and collaboration.

International Veterinary Vaccinology Network:
a network of LMICs researchers, funded through the Global Challenges Research Fund, is addressing challenges that are impeding vaccine development for major livestock and zoonotic diseases affecting agriculture in LMICs.

Potential Mpox treatments in licensed drugs

Research at the University of Cambridge, University of Oxford, and The Pirbright Institute investigated how orthopoxviruses, including Mpox, evade our immune defences.

Key Impacts:

- The researchers found that the Mpox virus hijacks a protein called cyclophilin A to counteract the activity of another cell protein called TRIM5 that restricts virus replication, thereby evading our cells' defences. Cyclophilin A is already the molecular target for commonly used drugs and could be repurposed for Mpox.
- This could provide an alternative treatment for Mpox that:
  - is less susceptible to viral drug resistance due to targeting a cellular protein rather than the virus directly
  - could treat multiple poxviruses that use the same hijacking mechanism
  - can be produced far more quickly than a novel drug as they have already passed through clinical trials
- Due to the £2 million invested by BBSRC and the MRC, the formation of the Mpox Consortium during the global epidemic in 2022 helped to facilitate this research.

More durable treatments for Mpox may already be available in currently licensed drugs. Credit: Getty

Tomatoes for vitamin D deficiency

Vitamin D deficiency affects over 1 billion individuals globally, particularly in the Northern Hemisphere, we are reliant on consuming animal products to meet requirements. This is often not sufficient and, as plants do not produce it naturally, there are limited alternatives for vegan and vegetarian diets.

However, research led by Professor Cathie Martin at the John Innes Centre, one of BBSRC's strategically supported institutes, has produced gene-edited tomatoes containing significant levels of vitamin D.

Key Impacts:

Each tomato contains as much vitamin D as two whole eggs which:

- as a widely consumed food, could provide an easily attainable way of increasing vitamin D in our diets
- could provide an alternative to supplementation, helping to reduce tablet fatigue
- as a plant-based source, could reduce our reliance on animal-based products sources of vitamin D

Newly developed tomatoes could provide a valuable and easily-attainable source of vitamin D. Credit: Getty

Framing for a refreshed framework

Noting that considerable scientific and technological progress has been made since the publication of the original strategic framework, it is timely to refresh this document to update key themes and priorities. It is also timely to acknowledge opportunities presented by an evolving contextual landscape, including the creation of UKRI and publication of a range of key strategic documents including the UKRI Strategy and Corporate Plans,[19] BBSRC and other Councils' Strategic Delivery Plans[20] and the UK Innovation Strategy – Leading the future by creating it[21], reinforcing the central role of research and innovation in tackling the largest challenges the world faces from the ageing society to global pandemics, climate change and obesity.

The refreshed **Bioscience for an Integrated Understanding of Health Strategic Research and Innovation Framework** has been developed through iterative consultation with the Bioscience for an Integrated Understanding of Health Strategy Advisory Panel, members of BBSRC's other Strategy Advisory Panels, expert working groups and key stakeholder discussions.

BBSRC's health vision aligns with key UKRI and BBSRC priorities as highlighted in:

- **The UKRI Strategy 2022–2027: Transforming Tomorrow Together** – two of the five strategic themes[22] – Securing better health, ageing and wellbeing and Tackling infections, closely align with BBSRC's health vision and there are significant overlaps with other themes' objectives
- **BBSRC Strategic Delivery Plan 2022–2025**[23] – an Integrated Understanding of Health is one of the four areas where bioscience can deliver world-class impact

The Framework expands upon BBSRC's Strategic Delivery Plan area of an Integrated Understanding of Health by setting out a high-level aim and mission, and highlights:

key priorities for BBSRC within the wider health research and innovation landscape, where bioscience and biotechnology will provide deep and integrated understanding to help address health challenges in the UK and globally

BBSRC's role in catalysing, convening, and collaborating with national and international stakeholders, including research institutes, government departments and devolved administrations, business, charities, and the wider community to generate new knowledge and bio-based solutions to address emerging bioscience opportunities and health trends

the outputs: to lead to a deeper, system-wide understanding of health across the life course in humans and animals

the outcomes: to address key global health challenges, government health policies, contribute to the delivery of the Sustainable Development Goals, and progress towards reducing health inequalities

19 Our vision and strategy – UKRI
20 Our delivery plans – UKRI
21 UK Innovation Strategy: leading the future by creating it – GOV.UK (www.gov.uk)
22 UKRI strategic themes – UKRI
23 BBSRC strategic delivery plan – UKRI

Aim and Mission

Aim

To provide a deep, integrated understanding of the fundamental biological mechanisms of healthy systems across the life course and promote both 'One Health' and 3Rs (Replacement, Reduction and Refinement) approaches to improve human and animal health and wellbeing.

Mission

To generate new knowledge and innovative solutions that will improve animal and human health and wellbeing across the life course. We will do this by convening, catalysing, and investing in research and capabilities that contribute to:

understanding, maintaining, and improving cognitive, mental, and physical health across the life course

advancing understanding of the role of diet to promote health across the life course and ensure nutrition security[24,25]

understanding and preventing infections to improve health and wellbeing in animals and humans through a One Health approach

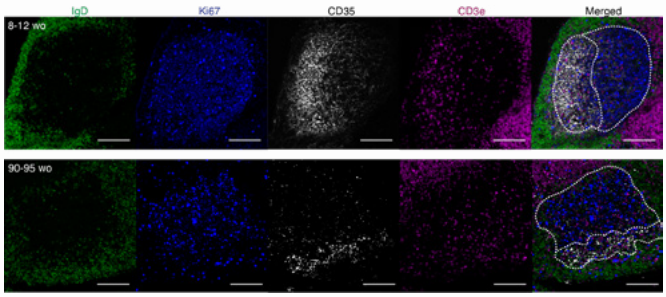
developing, validating, and deriving benefit and impact from data, tools, and technologies to improve animal and human health

24 Nutrition security is more than food security (nature.com)

25 Nutrition security is defined as having consistent access to and availability and affordability of foods and beverages that promote well-being, while preventing – and, if needed, treating – disease. Nutrition security provides a more inclusive view that recognises that foods must nourish all people – Time to shift from 'food security' to 'nutrition security' to increase health and well-being – ScienceDaily

‘Lost’ immune cells partly to blame for reduced vaccine response in older people

Understanding the way our immune response changes as we age holds the key to designing better vaccines and boosting protection for people most at risk. Research published by Dr Michelle Linterman, Babraham Institute, one of BBSRC’s strategically supported institutes, has shown that the organisation of the germinal centre, which is vital to the generation of longer-lived protection following vaccination, is altered in ageing. By demonstrating that these age-related changes can be reversed in mice, the research sets the foundation for interventions that bolster an effective vaccine response. (https://www.nature.com/articles/s41590-023-01519-9)



Scale bars 100µm. LN sections were stained for IgD (green), CD35 (white), Ki67 (blue) and CD3e (magenta).

The spatial organisation of the GC is altered in aged mice: Representative confocal images of GCs from adult (8–12 week-old (wo)) and aged (90–95 wo) BALB/c mice 14 days after immunisation with the model antigen NP-KLH (4-hydroxy-3-nitrophenylacetyl (NP)-Keyhole Limpet Hemocyanin (KLH)) in alum (aluminium salt adjuvant), which enables assessment of the magnitude and quality of the response to vaccines. Courtesy of Michelle Linterman, Babraham Institute.

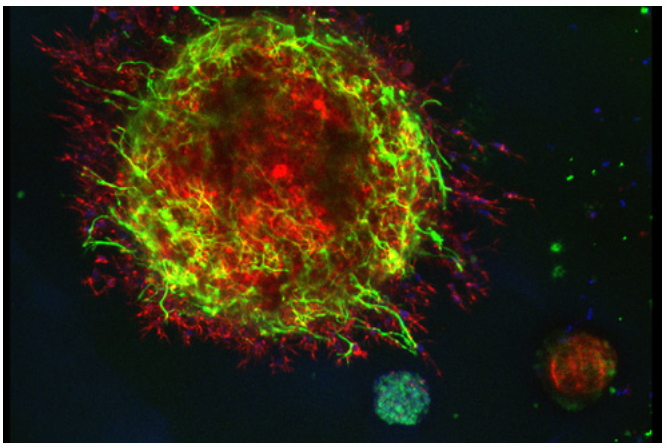
An animal-free cell culture platform for better bioscience

PeptiMatrix is a University of Nottingham spin-out, led by co-founder and Chief Executive Officer Dr Johnathan Curd, which is providing an innovative hydrogel platform for 3D cell culture, which aims to replace the use of animals in research.

BBSRC, EPSRC and NC3Rs funding enabled the development of a short self-assembling peptide hydrogel (SAPH) platform. BBSRC Innovation to Commercialisation of University Research (ICURe) funding supported the commercialisation of the technology, enabling the market research needed for the team to spin out, followed by an Innovate UK ICURe Follow-on-fund grant to expand capacity and accelerate product development.

Key Impacts:

- PeptiMatrix’s SAPH platform is:
  - entirely animal-free
  - fully synthetic with limited batch variability for better reproducibility
  - customisable to match specific tissues
  - usable under brightfield and fluorescence microscopes for better visibility
  - addresses *in vitro* model downfalls, including the lack of complexity and applicability when translating drugs/molecules to clinical trials.

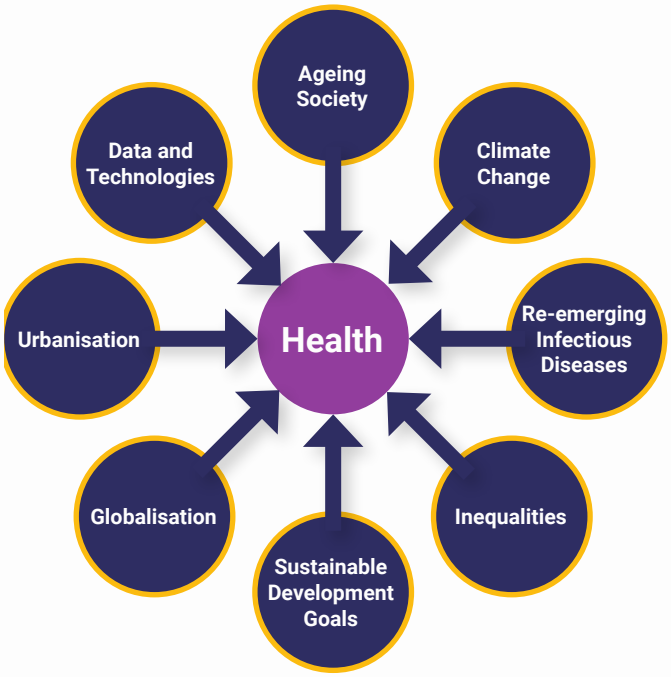


3D cell culture mimics natural extracellular environments without the need for animals. Credit: Peptimatrix

Strategic Drivers

Emerging health drivers are reshaping our world and greatly impacting animal and human health and wellbeing (Figure 1). These strategic drivers must be considered and addressed when developing research and innovation approaches to build a healthy society.

Figure 1: Strategic Drivers



Ageing society

The world's population is ageing. Globally, the population aged 65 and over is growing faster than all other age groups. According to data from World Population Prospects: the 2022 Revision, by 2050:

- one in six people in the world will be over 65 (16 per cent)
- one in four people living in Europe and Northern America could be 65 or over

In 2018, for the first time in history, people aged 65 or above outnumbered children under five years of age globally. It is predicted by 2050 that the number of people aged 65 and over will be twice the number of children aged under five and almost equivalent to the number of children aged under 12[26].

However, as the average lifespan has increased, health span has not and more of these extra years 'of life' are spent in poor health, putting pressure on medical, health and social services. *Addressing the underlying biology of ageing* is one of the missions highlighted in the UK Government's Life Sciences Vision[27] and stresses the need to *'understand the underpinning biological mechanisms and pathways associated with multisystem ageing and to utilise these to discover new diagnostics, therapeutic and medical technology interventions.'* This will enable the discovery and development of targets for therapeutic interventions to better manage the ageing process and reduce the multimorbidity that occurs in individuals as they age. BBSRC has a major role to play in helping to deliver this area.

26 World population prospectus 2022, (un.org)
27 Life Sciences Vision (publishing.service.gov.uk)

Climate change

The WHO states that climate change is the single biggest health threat facing humanity[28]. It is estimated that between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from malnutrition, malaria and other vector-borne diseases, diarrhoea, and heat stress.

Disruptions in the ecosystem, losses of biodiversity and wildlife, fundamental changes in land use, extreme weather conditions and declining quality of air, water and soil have consequences for health, economic development, and livelihoods. Climate change threatens population health through adverse changes in air pollution, and food quality and security leading to the triple burden of malnutrition, displacement, and poor mental and physical health[29]. *Integrated research across the agriculture-food-nutrition-health nexus will enable better understanding of the bio availability and biodiversity of nutrients,* thereby leading to the development of secure and sustainable food systems for health.

Climate change is also driving the incursion of vectors and vector-borne diseases across continents including Europe and into the UK. Extreme climate events such as excessive rainfall and high humidity are major influences that enhance vector breeding and survival, resulting in an increased risk of vector-borne disease epidemics e.g., Usutu, West Nile fever, Rift Valley fever. *Forecasting models are needed to understand the spread of these vectors and associated diseases to prepare for potential outbreaks.*

(Re-)emerging infectious diseases

The twenty-first century has witnessed a wave of severe infectious disease outbreaks both in animals and humans. The 2003 severe acute respiratory syndrome coronavirus outbreak, the 2007 (re-)emergence of African Swine fever virus, the 2009 swine influenza pandemic, the 2012 Middle East respiratory syndrome coronavirus outbreak, the 2013–2016 Ebola virus disease epidemic in West Africa, the 2015 Zika virus disease, the 2019 severe acute respiratory syndrome coronavirus 2 pandemic followed by the 2022 avian influenza outbreak. These all resulted in substantial morbidity and mortality and spread across borders to infect animals and people in multiple countries. *Working together with government departments and policy makers, bioscience research will develop One Health approaches that seek to understand, forecast, avoid and mitigate the increasing threats of infectious diseases to animal and human health aligning with the UK Biological Security Strategy[30], Global Health Framework[31] and Action for Animal Health[32] .*

Inequalities

There is a strong correlation between health outcomes and the level of economic inequality within a given population. The Marmot Review[33], published in 2010, highlighted that 'life expectancy follows the social gradient – the more deprived the area the shorter the life expectancy'. Over recent years, this gradient has become steeper, and inequalities in life expectancy have increased even though global income has risen, and the global poverty rate has fallen.

The Royal Society of Public Health report states that the cost-of-living crisis is a public health issue that affects both physical and mental health. These impacts will be felt unequally and are likely to worsen inequalities in health and health-related activity[34].

A person's genotype, exposure to different environments including diet, and inequity of access to health care and technology can impact on biological, psychological, and social development. These carry significant implications for future physical and mental health and increased risks to both infectious and non-communicable diseases. *Understanding and addressing the biological basis of health inequalities and identifying timely interventions that target adverse health trajectories is key to ensuring health equity.*

28 Climate change and health (who.int)
29 Health and climate change: policy responses to protect public health – The Lancet
30 UK Biological Security Strategy (publishing.service.gov.uk)
31 Global Health Framework: working together towards a healthier world May 2023 (publishing.service.gov.uk)
32 A4AH–Report_FINAL–2023.pdf (actionforanimalhealth.org)
33 Fair Society Healthy Lives (The Marmot Review) – IHE (instituteofhealthequity.org)
34 Our health: the price we will pay for the cost-of-living crisis (rsph.org.uk)

Sustainable Development Goals

The 2030 Agenda for Sustainable Development was adopted by all United Nations Member States in 2015. It includes 17 Sustainable Development Goals (SDGs) and 169 targets representing an urgent call for action by all countries in a global partnership. Health has a central place in **SDG 3: Ensure healthy lives and promote well-being for all at all ages**, underpinned by 13 targets. However, almost all the other 16 goals are either directly related to health or will contribute to health indirectly. The WHO has stated that although progress has been made against all SDGs, the current targets will not be met by 2030[35]. *Working in partnership with other funders, charities, government departments and other stakeholders, is key to addressing the SDGs including urgent healthcare, social and economic challenges.*

Globalisation

Globalisation presents specific and urgent health challenges in infectious diseases, antimicrobial resistance (AMR), food security and sustainability. It has increased the speed and threat of emerging infections including zoonotic and vector-borne diseases, and AMR in animals and humans, with significant socio-economic, health and welfare implications. *A better understanding of the epidemiology and pathogenicity of emerging and re-emerging infections will improve diagnosis and inform the development of novel tools for effective interventions.*

Globalisation affects the nature of the food supply chain, thereby altering the quantity, type, cost, and desirability of foods available for consumption but food accessibility is by no means universal.[36] Food is produced and processed in larger volumes and distributed over greater distances than ever before. Expansion in agricultural trade increases the risks of unsafe food, produced in one country, affecting consumers in another. Unsafe food containing harmful microbes or chemical substances impacts both animal and human health. *A better understanding of the risks posed by microbes and chemicals to health and interventions to mitigate these will improve food safety.*

Urbanisation

Currently only 8 per cent of the world's population live in megacities. Between 2020 and 2050, the proportion of people living in urban areas will shift from 53 per cent to 70 per cent. In 30 years time, cities and towns will contribute two thirds of the world's economic output and consume 80 per cent of the planet's natural resources. Increasing urbanisation will affect health and wellbeing[37], e.g., consumers have become increasingly detached from their food sources, which in turn has altered both consumer choice and demand on food, with an increase in obesogenic food environments and the consumption of foods high in fat, sugar and salt. The high ratio of consumers to producers has placed more pressure on agricultural systems, creating food and nutrition insecurity for both humans and animals. *Healthy, sustainable and nutritious food for all will improve health and prevent the rise in non-communicable diseases.*

Data and technologies

The digital world is rapidly evolving, with advancements being made in health technologies. The UK Science and Technology Framework[38] highlights a number of technologies, e.g. artificial intelligence (AI), digital, that, when integrated with life science research and appropriately implemented in society, they have the potential to dramatically improve health and quality of life by providing innovative bio-based solutions.

Deloitte's Global Future of Health in Europe report states that emergent technologies and digital transformation, AI and open secure platforms will enable a shift from the current reactive-treatment model to a continuous, forward-looking, proactive health management model. This shift will be *focused on prevention and earlier diagnosis,* aimed at sustaining wellbeing and improving the cost-effectiveness of healthcare[39].

While there are benefits to using these technologies, such as quick and easy access to health information, they may also adversely impact our physical, cognitive and mental health. *Understanding the physiological and neurobiological impacts of the digitised world* will ensure that health technologies are developed in parallel with physical and mental health and wellbeing. The utilisation of these technologies will need to be considered carefully in the context of socioeconomic, behavioural, and environmental factors to de-risk furthering existing health inequalities.

35 World Health Statistics (who.int)
36 Y5736E coper per cromalin.pdf (fao.org)
37 Urban health (who.int)
38 UK Science and Technology Framework – GOV.UK (www.gov.uk)
39 Healthcare in Europe | Deloitte Insights

Joining the dots between climate change, livestock systems and zoonotic disease in Tanzania

Research, led by the University of Glasgow, found new links between climate change and zoonoses, along with significant human health, social and economic impacts. This new understanding allows policymakers and researchers to recalculate disease risks and adjust health interventions for farming populations.

Key Impacts:

- identified that climate uncertainty and land-use policies had triggered a shift from farming cattle to sheep or goats in pastoral communities
- highlighted potential health and economic issues from the livestock change, such as the emergence of new diseases
- found the disease ormilo caused 25 per cent of sheep and goat losses
- identified a Rift Valley fever outbreak in an animal host in a new geographical area, linked with climate change, enabling health officials to plan interventions, and highlighting the area for future research

Biotechnology and Biological Sciences Research Council
Natural Environment Research Council
Medical Research Council
Economic and Social Research Council
Foreign, Commonwealth & Development Office
[dstl] The Science Inside
University of Glasgow

Wrinkled 'super pea' could be added to foods to reduce diabetes risk

BBSRC funded researchers at Imperial College, JIC, Quadram Institute and Glasgow University have used two closely related pea genotypes (one smooth, one wrinkled) to explore the contribution of starch structure, food matrix and intestinal environment to postprandial glucose. Wrinkled pea consumption produced higher levels of resistant starch and prevented large sugar spikes after eating.

Key Impacts:

- the use of 'super pea' flour in commonly consumed processed foods could help reduce susceptibility to type 2 diabetes
- the breeding of resistant starch mutations into other staple food crops (e.g. rice and wheat) could help tackle metabolic diseases.

Biotechnology and Biological Sciences Research Council
Imperial College London
Quadram Institute Science • Health • Food • Innovation
John Innes Centre Unlocking Nature's Diversity
University of Glasgow

Addressing national and global health challenges

To generate new knowledge and innovative solutions that will improve animal and human health and wellbeing across the life course, BBSRC has identified four themes (Figure 2):

- **Ageing and health across the life course**
- **Food and nutrition for health**
- **Combatting infectious diseases and AMR**
- **Transformative technologies for health**

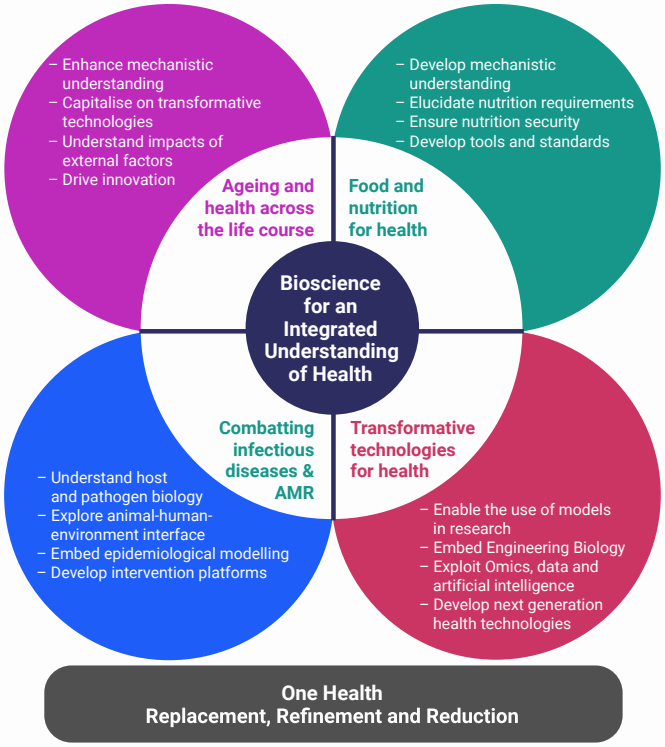
Building on BBSRC research and innovation strengths in discovery bioscience (e.g., immunology, neuroscience, animal science and food science), these four themes represent the key areas of opportunities in developing a fundamental understanding of health across the life course and at the interface of animal and human health.

Underpinning these four themes are two approaches that will be embedded in the science and innovation that we support:

- **One Health:** an integrated, transdisciplinary approach that brings together multiple sectors, disciplines (such as biology, medicine, engineering, economics, environmental, mathematics, social and veterinary sciences), and communities to address the health of people, animals, plants, and the environment. It recognises that the health of humans, plants, and companion, domestic and wild animals, and the wider environment (including ecosystems) are closely linked and inter-dependent. In the context of this framework, a One Health concept is particularly relevant to areas such as food safety, nutrition, the control of vector-borne diseases, zoonoses and combatting AMR. *BBSRC will work with other national and international funders and government departments to ensure research informs policies and practices which mitigate the threats of zoonotic diseases including AMR by adopting a One Health approach and ensure nutrition security whilst preserving natural resources.* Such an approach can be applied to other areas of health research areas including, e.g., ageing and animal welfare.
- **3Rs – Replacement, Refinement and Reduction (3Rs) of the use of Animals in Research:** BBSRC supports, develops, and disseminates the principles of 3Rs which provides an ethical framework for performing more humane animal research. BBSRC expects all its funded researchers to understand, promote and integrate the principles of the 3Rs. This builds on BBSRC's established policy on the use of animals in bioscience research[40] and the National Centre of Replacement, Refinement and Reduction of Animals in Research (NC3Rs) ARRIVE guidelines. *BBSRC will work with NC3Rs, MRC and other UKRI Councils to support research, and the development and implementation of policies surrounding the use of animals in research*

Together these themes and approaches are intended to promote development of an integrated understanding of the key determinants of health, aligning primarily with the UKRI Strategic themes of Securing Better Health, Ageing and Wellbeing and Tackling Infections.[41]

Figure 2: Bioscience for an Integrated Understanding of Health Challenge Areas and Approaches



BBSRC, together with MRC, supports the NC3Rs and the Centre's 3Rs-focused research and innovation schemes by providing strategic funding to the centre.

40 Use of animals in bioscience research – BBSRC (ukri.org)
41 UKRI strategic themes – UKRI

Project OVEL: 'One Health and accelerating vaccines for Ebola and Lassa'

Led by Professor Jonathan Heeney, head of the Laboratory of Viral Zoonotics (LVZ) at the University of Cambridge, in collaboration with Professor Happi at the African Centre of Excellence for Genomics of Infectious Diseases (ACEGID), OVEL has developed surveillance and forecasting systems for Lassa fever. OVEL studied the diversity of Ebola and Lassa within their carrier hosts and how they spread to humans by trapping rats, taking viral samples, and tracking their movements.

Key Impacts:

- helped to establish an in-country capacity to perform immune assays that monitor local immunity to infections
- built a database that is informing vaccine development
- had several successful international collaborations:
  - Microsoft Research, University College London (UCL), and the London School of Hygiene and Tropical Medicine (LSHTM) on the Trinity Challenge "Sentinel surveillance" programme
  - The Public Health Agency of Canada to evaluate vaccine candidates against Lassa, and visits to the Nigerian CDC, enabling continued monitoring of community outbreaks
  - Cambridge spin-out, DIOSynVax, to create vaccines flexible enough to protect against future virus spillovers from animals

The project was funded by the BBSRC and the Department of Health and Social Care via the UK Vaccine Network.

BBSRC is one of the many funders of health research and to successfully deliver our ambitious multidisciplinary health agenda, we will use our extensive catalysing and convening power, developing scales of research and resource coordination that will enhance impact and add value to UK research and innovation. This will include *effective integration and translation of basic bioscience to meet the key societal challenges to ensure health and wellbeing across the life course. In addition, strengthening existing partnerships with national and international funders and policy makers and building new ones in strategic priority areas where clear value can be added.*

The major health challenges e.g., ageing, mental health, infectious diseases, zoonosis, AMR, obesity, and malnutrition, are global and highly policy relevant challenges which need transdisciplinary approaches. We will ensure bioscience research and innovation *enable a more scientific and evidence-based* approach to deliver a healthy and resilient society, thereby, making a critical contribution to the bio-based innovation and policy landscape.

Bioscience for an Integrated Understanding of Health working in partnership with:

Research	Policy	Industry	Public
UKRI Councils	Government	Agri	Direct Dialogue
Research Community	Government Departments	Biotech	UKRI Website
International Funders	Public Bodies	Food	Newsletters and Blogs
Research Institutes and Centres	NC3Rs	Healthcare	Social Media
Charities	Devolved Administrations	Pharma	Public Health Bodies
Learned Societies	International Policy Makers	Veterinary	
		Trade Associations	

Ageing and health across the life course

Building on a strong investment portfolio in fundamental sciences in health research and innovation across the life course and building on long-term strategic investments in world-class national capabilities in ageing research:

we will advance current understanding of the biological mechanisms of ageing with the long-term objective of maintaining and enhancing cognitive, mental, and physical health and wellbeing across the life course.

We particularly encourage and aim to support research and innovation that seeks to:

1. Enhance mechanistic understanding

- adopt life course approaches to understand the biological basis of ageing including diverse populations and species, from pre-conception through to later life, with the aim of establishing a healthy trajectory and preserving system homeostasis, independence, and good health into old age
- develop and validate biomarkers and appropriate outcome measures of ageing for discovery and translational purposes, support the understanding, prediction, and monitoring of biological ageing trajectories, including evaluating and monitoring the impact of interventions
- generate new knowledge to advance regenerative biology, including stem cell and tissue engineering research, to improve the quality of life for the ageing population

2. Capitalise on transformative technologies

- develop a better understanding of the molecular and cellular mechanisms of ageing by capitalising on transformative technologies. These include e.g. single cell sequencing, human induced pluripotent stem cells, omics, and imaging, as well as conceptual breakthroughs in areas of epigenetics, cellular senescence, nutrient sensing, proteostasis and mitochondrial function
- drive the uptake of multi-modal and multi-scale approaches to deliver an integrative understanding of molecular, cellular, and physiological functions across systems and to identify risk factors and predictors of cognitive, mental and physical health and resilience across the life course
- foster innovative approaches to ageing research that draw upon recent advances in engineering biology, digital tools, AI, imaging, and analytical methods, as well as increasing the use of established bioresources

3. Understand impacts of external factors

- unravel the complex array of interacting extrinsic factors that influence ageing and cognitive and mental health. These includes e.g. the roles of nutrition, maternal and paternal health, climate, physical activity, stress, chronobiology, technology, and behaviour, and their interactions with environment, social and economic drivers
- explore the biopsychosocial[42] basis of health inequalities (socioeconomics, population diversity, early life adversity, transgenerational effects, epigenetics, nutrigenomics, exposome) to inform the design of interventions to maximise healthspan

4. Drive innovation

- generate a strong evidence base which is underpinned by appropriate, robust, validated models to facilitate the translation of research on the biology of ageing into practical health, clinical, industrial, psychosocial and policy impacts
- identify pharmacological and non-pharmacological targets with the potential to underpin intervention strategies aimed at improving and extending cognitive and physical function into old age
- collaborate with other disciplines, businesses, policy makers, the public and the UKRI Securing Health, Ageing and Wellbeing strategic theme to develop a holistic understanding of health

42 Biopsychosocial – is a term used to capture the interaction of biological, psychological and social factors which may determine (in this case) health or the differential impact of health inequalities. Equally these 3 factors will interact to determine health span/longevity etc.

We will:

- enhance capacity and capability for research in health, ageing and wellbeing, including support for networking across this theme
- work with other funders and stakeholders to identify, scope and support emerging priorities e.g., ageing immune system, cognitive health, biomarkers of ageing, understanding ageing in diverse populations and species, and tackling key research challenges to generate new knowledge that will improve healthspan
- develop appropriate research models that provide insight into physiological processes that are key for maintaining health in humans
- work with other UKRI Councils to deliver the UKRI Strategic Theme of Securing Better Health, Ageing, and Wellbeing to improve population health, communities, and advance interventions to keep us healthier for longer
- support public engagement to ensure that research priorities are informed by societal views'

Long-term funding enables world-first peptide technology development

Fifteen years of funding from Walgreens Boots Alliance for collaborative research between Boots and the University of Manchester (UoM) has led to the production of Future Renew, a new skincare line that can reverse signs of cumulative skin damage.

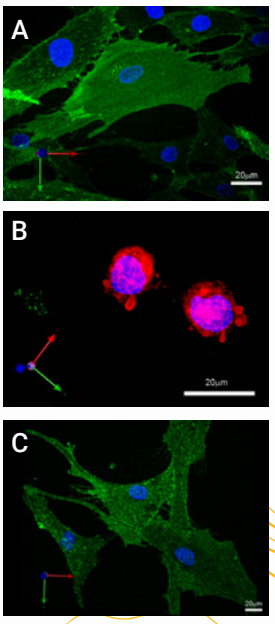
Key Impacts:

- BBSRC-funded UoM research gave insights into the structure of fibrillin and its interactions with other proteins
- *in vitro* testing on cells shows that the peptides promote extracellular matrix proteins that are involved in matrix organisation and function, including fibrillin. *In vivo* testing showed they promoted the expression of extracellular matrix genes and genes which play a vital role in epidermal health
- this study involved novel application of protease cleavage site prediction, so this 'peptide discovery pipeline' is a new way of predicting peptides from protein collections
- BBSRC is now funding a Boots-led Collaborative Training Partnership, with UoM as a partner. These projects, along with 2 BBSRC Industrial Partnership awards to Boots and UoM, will continue to support peptide research and characterisation

No7s discovery pipelines provides novel peptide formulation to tackle skin damage. Credit: Walgreens Boots Alliance

A jump through time – new technique rewinds the age of skin cells by 30 years

Research from the Babraham Institute has developed a method to 'time jump' human skin cells by 30 years, turning back the ageing clock for cells without losing their specialised function. Work by researchers in the Institute's Epigenetics research programme has been able to partly restore the function of older cells, as well as rejuvenating the molecular measures of biological age. This early stage research could eventually have implications for regenerative medicine, especially if it can be replicated in other cell types. Research was funded by BBSRC.



Cells temporarily change shape during transient reprogramming (images of individual cells). Transiently reprogrammed cells are much smaller, and consequently the nucleus takes up much of the cell, there's also to spherical (Image B). All three physical characteristics revert once doxycycline is removed (Image C). The cells were all stained and imaged in the same way showing that fibroblast surface markers (green) are lost as cells are reprogrammed. Images provided by Fatima Santos, Babraham Institute.

Food and nutrition for health

By harnessing expertise across BBSRC research in soil, crop, livestock, food and nutrition science, and human physiology, along with fostering multidisciplinary research and innovation, and working synergistically with BBSRC's Sustainable Agriculture and Food priority:

we will advance understanding of the biological mechanisms through which diet and food, including its components and nutrients along with their interactions and their temporal patterns of consumption, promote a health across the life course.

We particularly encourage and aim to support research and innovation that seeks to:

1. Develop mechanistic understanding

- understand the effect of:
  - diet-mediated cellular and physiological changes on the transition between healthy and unhealthy or dysregulated states including molecular, metabolic, energetic (weight regulation), the effects and the modulating role of the microbiome;
  - the interaction between food components and their impact at specific life stages and longer-term effects
- understand the bidirectional mechanistic role of nutrition and the gut-immunology-brain axis, including the biological and behavioural drivers of food intake (e.g., sensory qualities, appetite/satiety); and to establish the potential for dietary choices to positively influence cognitive, mental, and physical health

2. Elucidate nutrition requirements

- develop a robust understanding of human nutritional requirements across the life course and the effect of changing dietary patterns (timings and consumption) on health including how these may vary with gender, genotype, level of physical activity, changing lifestyles, (chronobiology, stress), physiological and psychological status, ethnicity, and inequalities
- develop a critical understanding of the potential effects and unintended consequences of food innovation/processing and dietary change on nutrient intake and health, including plant-based diets, alternative nutrient/protein sources, fad diets, food (bio)fortification, novel foods, food hypersensitivities, rising consumption of ultra-processed foods and food insecurity

3. Ensure nutrition security

- embed a One Health approach to nutrition security that integrates research across soil, plant, animal and human health to enhance and preserve nutrition across the food chain to promote a healthy lifespan in a changing environment
- improve food safety by better understanding the risks to human health from food by pathogens, parasites, toxins, novel diets and, by-products of processing or other harmful substances, such as allergens, at any stage of the food chain[43]

4. Develops tools and standards

- generate a robust evidence base and the necessary validated, reliable and age-appropriate methods, tools, biomarkers, models, and human intervention strategies to facilitate the translation of underpinning to applied nutrition research to realise the potential health, clinical, industrial and policy impacts for different population groups
- advance robust standardised measures and validated tools to quantify dietary intake and nutrient status to improve the reproducibility of nutrition-related research and data and the efficacy of nutritional interventions
- foster the development and application of emerging biological concepts and technological advances in e.g., nutrigenomics, omics, digital tools, engineering biology and integrative data-driven approaches to better understand inter-individual variability in response to diet to inform the development of personalised nutrition and more effective, better targeted interventions

43 Studies focused on understanding and reducing the incidence of harmful organisms/substances within the food chain are supported, but research focused on pathogenicity or toxicology in humans is not within BBSRC's science remit. Further information on Food safety and nutrition can be found at: https://bbsrc.ukri.org/documents/agriculture-food-security-strategic-framework-pdf/

We will:

- work across the nexus of agriculture, food, nutrition, and health to ensure a One Health approach to nutrition security
- develop mechanistic understanding of the role and requirements of food and nutrition on cognitive, mental, and physical across the life course, including novel and ultra-processed foods
- promote collaborations and connectivity between the food, nutrition and health communities and the food industry to drive research and innovation to develop tools, technologies, and healthy food products
- work in partnership with funders, stakeholders and engage with UKRI Transforming the UK Food Systems Programme and the pan-UKRI food deep dive Sector Champion for Food to improve coordination and connectivity within interdisciplinary research and innovation communities to bring novel perspectives in nutrition research
- work in partnership with UKRI Councils to develop the dynamic, bi-directional causal associations between biology and behaviour to understand the sustainability of interventions to tackle obesity

The 'Super-Soup' for high cholesterol and diabetes

Professor Richard Mithen, previously at the Quadram Institute, successfully founded the Smarter Naturally spin-out. Following over 30 years of research, Smarter Naturally was created to develop food products using ingredients maximised for their natural health benefits.

Key Impacts:

- launched their 'Super-Soup' in 2022, which helps maintain healthy cholesterol and blood sugar levels
- developed GRextra, a unique broccoli variety that has increased levels of glucoraphanin. GRextra is the main ingredient in 'Super-Soup'
- glucoraphanin is converted into sulforaphane in our gut. Multiple studies have linked sulforaphane to reducing the risk of aggressive prostate cancer
- 'Super-Soup' provides a way increasing dietary intake of glucoraphanin to a level needed to achieve potential health impacts
- awarded the Nutra Ingredients Award for Healthy Ageing Ingredient of the Year 2023

'Super-Soup' could be the key to increasing glucoraphanin in our diets. Credit: Smarter Naturally

Human milk oligosaccharides improve 'leaky' guts in adults

A collaboration between Professor Nathalie Juge's group at the Quadram Institute and three industry partners (ProDigest, DSM, and Emulate) confirmed the potential of manufactured Human Milk Oligosaccharides (HMOs) to provide health benefits in adults.

Key Impacts:

- using human-based *in vitro* models and an observational study, the research team demonstrated that HMOs supported the growth of beneficial gut bacteria in the adult gut, modulated immune function, and made the gut barrier less 'leaky'
- this work has supported the translation of infant-focused products to adult ones and specifically informed the development of two digestive health products: Holigos® IBS Restore and Holigos® Maintain

Combatting infectious diseases and AMR

Building on BBSRC's strong investment portfolio of veterinary sciences and long-term strategic investments in world-class national capabilities in animal infectious diseases using a One Health approach:

we will develop a coordinated, transdisciplinary approach to understand, forecast, avoid and mitigate animal infectious diseases, infections of zoonotic origin[44] and AMR to improve preparedness and the health and wellbeing of animals and people in their environments.

We particularly encourage and aim to support research and innovation that seeks to:

1. Understand host and pathogen biology

- increase understanding of:
  - pathogen (e.g. bacteria, fungus, parasite, virus), and vector biology including (re-)emergence, evolution, transmission, and coinfection
  - host (livestock, companion and wildlife) response, adaptation, and disease persistence
  - host-pathogen interactions
  - 'genotype to phenotype' correlation
  - factors that can improve an animal's quality of life, and monitor, measure and improve the welfare standards of farmed and laboratory animals[45]
  - fundamental biological mechanisms of antimicrobial, anthelmintic and parasiticide resistance, and develop approaches for alternative interventions

2. Explore animal-human-environment interface

- advance research across the animal-human-environment interface by building and developing the next-generation detection and monitoring capability framework, and,
- understand the links between disease (re-)emergence and spillover events from animals to humans and *vice versa*, with socio-economic drivers and behaviours within animal-based food production and trade systems, to inform the creation of effective, culturally, and environmentally appropriate mitigation strategies to tackle zoonoses and reverse zoonoses

3. Embed epidemiological modelling

- bringing together human, veterinary, and environmental data for surveillance of infectious diseases and using modelling approaches for predicting transmission dynamics of disease (and/or AMR) and effectiveness of interventions to support veterinary health, public health, and the agricultural industry
- understand the impacts that globalisation, trade, climate change, changing environments, animal and human health economies and behaviours have on drivers, and transmission of infectious diseases and AMR

4. Develop intervention platforms

- informed by understanding of host and pathogen biology, develop and validate novel 'plug and play' platform technologies (e.g., veterinary vaccines, diagnostics, therapeutics, vector control) for rapid and effective intervention to tackle animal infectious diseases, zoonoses and reverse zoonoses including AMR
- develop and apply predictive tools and enhanced epidemiological models to assess the risks of disease and spill over including zoonotic spread
- build integrative data infrastructure which is user-centred and distributed, where data ownership is equitably maintained and controlled whilst still allowing for data sharing
- develop appropriate model systems (e.g., large animal, organoids, *ex vivo* explants models etc.) using 3R approaches for infection, disease, and transmission

44 Including zoonoses, reverse zoonoses, epizootics, vector-borne and anti-microbial resistance.

45 In 2016, BBSRC established and funded the UK Animal Welfare Research network (AWRN) to help foster multidisciplinary collaboration within the UK animal welfare research community and to benefit animal welfare research by creating links between animal welfare researchers and the broader academic community.

We will:

- work with national and international funders and government departments to embed a One Health approach in infectious disease research and innovation and to ensure that One Health research feeds effectively into policy decisions and informs new approaches to tackling infections
- work with UKRI Councils to deliver the UKRI Strategic Theme of Tackling Infections e.g. flagship programmes in epidemic preparedness and tackling AMR
- provide agile and rapid responses to endemic and (re-)emerging diseases (e.g., avian influenza, African swine fever) of animals and diseases that have potential to spill over in humans
- in collaboration with business, Defra and devolved administrations, support research and innovation to enhance health and welfare of animals
- build on previous support for transdisciplinary research partnerships with the US, China, and Israel, to model the complex transmission dynamics of infectious diseases of humans, animals, and plants, enabling effective UK and global controls and with JPI-AMR to support collaborative transdisciplinary research to fill knowledge gaps on AMR
- support key national capabilities that support infectious diseases and veterinary vaccine research including our strategically funded institutes: The Pirbright Institute, and The Roslin Institute at the University of Edinburgh

Tracking how human behaviour affects the spread of Avian influenza virus

Researchers led by the Royal Veterinary College investigated how human behaviour in Bangladesh is affecting the transmission of avian influenza virus (AIV). Researchers including both scientists and social scientists, analysed a range of poultry production systems to find factors that influence the spread of the virus.

The team found evidence of AIV in the air of Live Bird Markets and the respiratory passages of the workers. They could also show the differences in how workers handled the birds and protected themselves.

Key Impacts:

- demonstrating and sharing the value of interdisciplinary working through dissemination and supported studentships
- findings have been used to draft the National Avian and Pandemic Influenza Preparedness and Response Plan
- project findings fed back into training for poultry production stakeholders

UKRI Biotechnology and Biological Sciences Research Council | ZELS | RVC Royal Veterinary College University of London

Improved approach to mastitis control

Bovine mastitis is an inflammatory disease of the udder and is a major barrier to the sustainability of dairy farming worldwide. Mastitis treatment and control accounts for over 30 per cent of all antibiotic use in dairy cattle. Annual losses exceed £170m in the UK; 38 per cent of the total direct costs of disease. *Streptococcus uberis* is the most common pathogen associated with bovine mastitis. It is now known that different strains of *S. uberis* have different transmission and infection characteristics with different disease outcomes. Researchers at the University of Nottingham can differentiate them using mass spectrometry. Their software makes predictions about the behaviour of mastitis pathogens and thereby improves clinical decision making on-farm. The results are being used by Small- and Medium-sized enterprise (SME) industrial partner, Quality Milk Management Services Ltd, to provide a service to dairy farmers for *S. uberis* strain typing.

The University of Nottingham

Transformative technologies for health

New tools, technologies and approaches are developing at a rapid pace and transforming bioscience research enabling deeper understanding of complex biological processes. Working together with BBSRC's Transformative Technologies and Rules of Life priorities:

we will develop, validate, implement and apply tools, technologies, methodologies, and data to understand and manage the health and wellbeing in animals and humans across the life course.

We particularly encourage and aim to support research and innovation that seek to:

1. Enable the use of models in research

- develop and validate novel research models (animal and non-animal technologies) in line with 3Rs principles that accurately reflect human and animal physiology across the life course, enabling the advancement of discovery and translational health research
- improve correct choice of model in research by supporting comparative research that will enable using multiple species to investigate and compare common mechanisms and processes to determine physiological relevance of a model thereby improving the predictive power of models

2. Embed engineering biology approaches

- exploit biological understanding and engineering biology approaches to enhance animal and human health through innovation in prevention, diagnosis, and therapeutics, including universal platforms that enable a rapid response to emerging zoonoses
- using engineering biology, regenerative biology, and stem cell approaches develop novel technologies and solutions such as engineered cells/tissues/networks and biomaterials for health research and innovation
- develop genetic (e.g., genome editing, epigenetics) and engineering biology approaches to dissect molecular pathways and map the relationship between genotype and phenotype to improve health

3. Exploit data driven approaches and artificial intelligence

- apply structural biology and support multi-modal and multi-level (e.g., physiological systems, imaging, engineering biology) research to characterise animal and human systems at multiple scales and to allow dynamic, real-time tracking of molecular and physiological processes including *in vivo*
- enable data-driven approaches through the provision of data standards (e.g., FAIR data), data science expertise, and data sharing platforms, helping to unlock novel insights on the mechanistic basis of health from the wealth of available data across BBSRC's research communities
- develop and apply robust, transparent, and interpretable, AI, machine learning and computational approaches to enable the interrogation and integration of large datasets from different sources and modalities, helping to unravel the complexity of health and probing the basis of health inequalities

4. Develop next generation health technologies

- integrate biological data (e.g., health biomarkers) with sensor and digital technologies (digital health) for the development and application of wearable and other digital devices, paving the way for personalised and targeted approaches to health protection in both animals and humans across the life course
- advance bioprocessing research and innovation that will enable the biomanufacturing of veterinary vaccines, biopharmaceuticals and other biological health-promoting products informed by biological understanding
- capitalise on advances in fundamental neuroscience and behaviour research to inform the development of future health-related technologies, including neurotechnologies
- harness biological understanding of microbial communities and their host interactions (e.g. microbiomes and biofilms) to underpin novel and rational approaches to the maintenance and promotion of health

We will:

- encourage the development and validation of models and non-animal technologies working with NC3Rs, other funders and stakeholders to provide the tools necessary for research and innovation
- support interdisciplinary collaborations that integrate an understanding of neuroscience and AI
- work in partnership with UKRI councils to enable the application of engineering biology principles and AI approaches to health research and innovation
- support development of key intervention strategies and platform technologies to tackle animal diseases and antimicrobial resistance
- drive the new knowledge to advance regenerative bio logy, including stem cell and tissue engineering research, to improve the healthspan

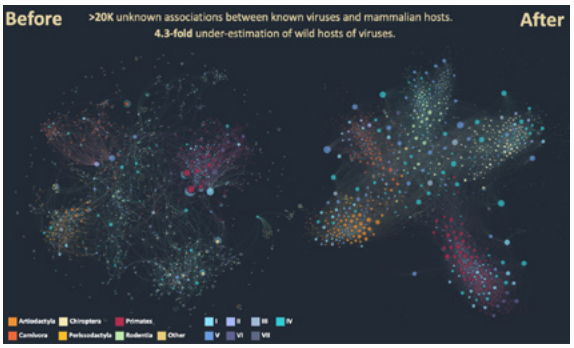
Big data approach to understand disease transmission and emergence

Interdisciplinary funding from BBSRC, NERC and MRC, has helped establish the ENHanCEd Infectious Diseases Database (EID2), an open-access database that annotates and integrates data on pathogens, vectors, hosts, and locations.

EID2 is open access and has a broad range of applications. It's a valuable tool in our arsenal to combat emerging infectious diseases.

Key Impacts:

- EID2 data was used to investigate potential mammalian hosts for coronaviruses, discovering 40-fold more host species for 4 or more subtypes, compared to those currently known
- a study using EID2 data to investigate 157 European pathogens estimated that 63 per cent were climate sensitive, with 82 per cent of pathogens driven by rainfall, temperature, humidity, and wind speed
- EID2 data was applied to find optimal temperatures of vector-borne diseases, for both the pathogen and its vector



Credit: Maya Wardeh and Matthew Baylis, University of Liverpool

GCRF Project Develops Several Biopharmaceutical Products in South-East Asia

A collaborative Global Challenges Research Fund project, led by the University of Kent, to build production capacity in Thailand has resulted in several potential biopharmaceutical products. This has been made possible by knowledge exchange and building collaboration.

Key Impacts:

- the accelerated progress of a porcine virus vaccine, currently in the animal testing phase
- improved yields of a monoclonal antibody for use against Dengue fever
- the project has produced cell lines that express three anti-cancer products, including Herceptin
- the project provided antigens for an African Swine fever test, for the National Institute for Veterinary Research, Vietnam
- developing anti-viral molecules for the Thai shrimp industry, currently undergoing efficacy trials
- developing fish pathogen vaccines, still in early-stage

Outputs

BBSRC Bioscience for an Integrated Understanding of Health investments will:

- enable high-quality research which produces new knowledge and understanding of the fundamental mechanisms that contribute to health and dysfunction across the life course in animals and humans
- support the development of new tools, technologies, and computational approaches to better understand the causes and ameliorate the impacts of zoonotic disease in people and animals (e.g., effective, and efficacious veterinary vaccines, diagnostics and digital health tools)
- establish multidisciplinary and transdisciplinary communities to address major societal health issues (e.g., ageing, obesity, epidemic preparedness)
- deliver a cohort of trained experts who can apply multidisciplinary and transdisciplinary approaches to address key challenges in animal and human health
- establish new and improved collaborations and partnerships with key stakeholders (e.g., business, end-users, and policy makers), including the co-development and co-design of research and innovation programmes that address key challenges in animal welfare and animal and human health
- build key partnerships within the UK and with Europe, India, Southeast Asia, South America, and USA to address health challenges
- leverage additional support, both financial and non-financial, to develop and sustain the research and innovation for bioscience of health
- facilitate engagement activities that inform stakeholders, users, and the public how bioscience research is helping to protect and maintain the health and wellbeing of animals and humans across the life course

Outcomes and Impacts

The outputs of BBSRC Bioscience for an Integrated Understanding of Health investments will enable the realisation of BBSRC's vision for Bioscience for Health, underpinning the delivery of wider benefit and impact.

For example, they will:

- enable the development of new paradigms and approaches based on the emergent properties of a more complex and holistic understanding of lifespan based on the connections between disciplines
- embed a One Health approach in infectious disease and nutrition research
- integrate bioscience for health research and innovation with medicine, mathematics, engineering, environmental and social sciences research to address major health challenges
- facilitate enhanced and more effective mechanisms for embedding research within the policy development cycle
- accelerate the translation of research into health policy and public awareness, to underpin adoption of health-promoting choices and practices
- deliver trained people who apply new knowledge and skills within academia, industry, government, and civil society organisations
- ensure that BBSRC remains a partner of choice for bioscience for health research and innovation
- deliver innovative solutions that mitigate the impacts of climate change on animal and human health
- contribute to addressing Sustainable Development Goals and reducing health inequalities
- improve the health and wellbeing of humans and animals across the life course, in the UK and beyond

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Biotechnology and Biological Sciences Research Council

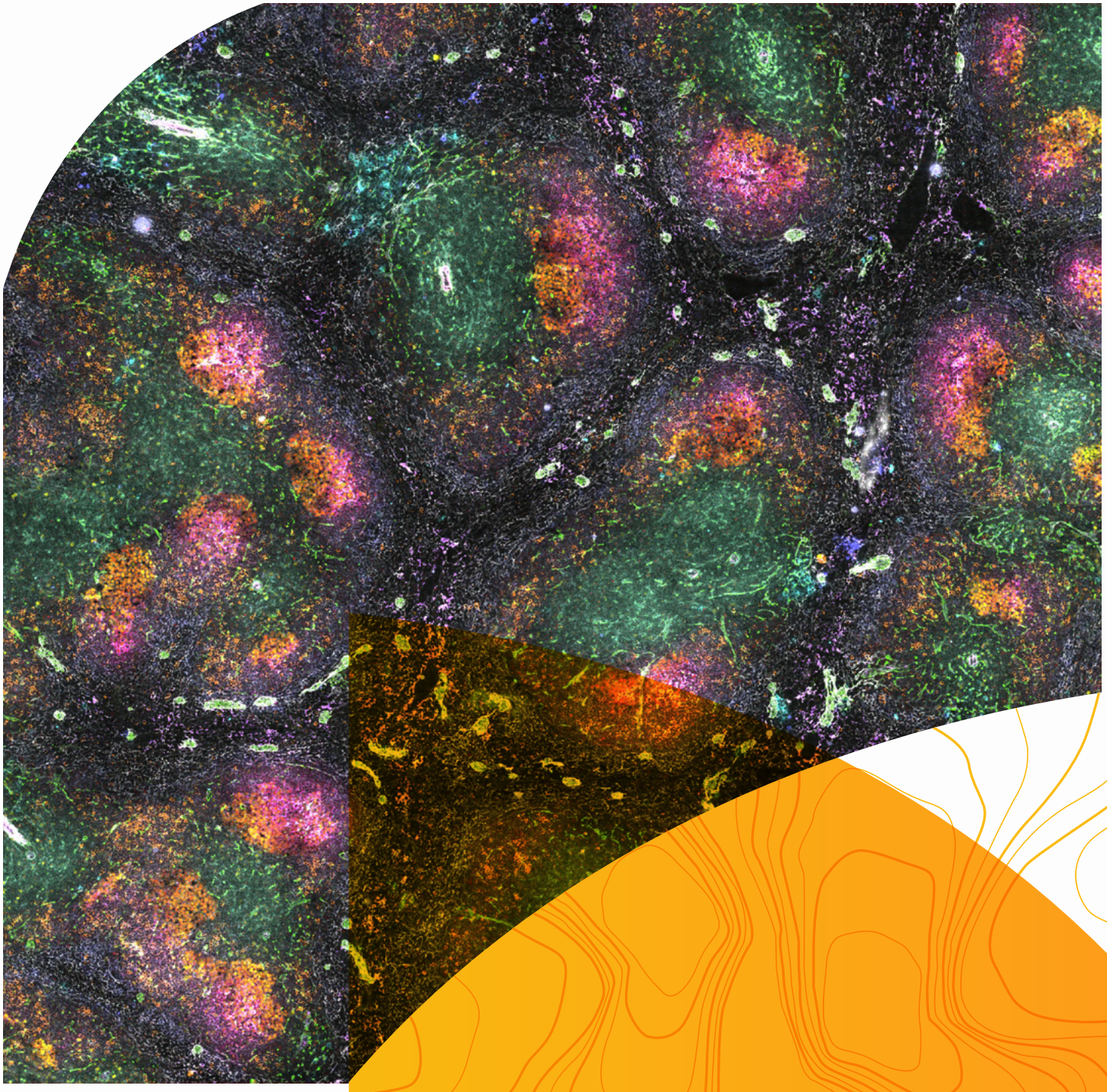

Image shown using new BBSRC funded MACSima technology
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