Institution: University of Reading
Unit of Assessment: 6 Agriculture, Food and Veterinary Science
1. Unit context and structure, research and impact strategy

1.1 Introduction and context

The University of Reading (UoR) is the only university in the UK to have held a top ten QS World University Ranking for Agriculture and Forestry from 2017-2020 inclusive and held the top UK ranking in this area throughout the entire REF period. This global reputation reflects the continued commitment of UoR to invest in people and infrastructure to enhance one of its strongest areas of research. The Unit sustains a critical mass of over 350 researchers collaborating across an array of relevant disciplines that enables us to pursue a truly interdisciplinary approach across the entire food system (see figure 1). The Unit benefits from the largest and most influential group of economic and social scientists focused on agriculture and food in the UK. We have longstanding expertise in integrating large, complex and diverse datasets to provide insight and impact spanning global food systems, and the ability to synergise quantitative with qualitative approaches to inform both policy and practice. The Unit is one of the cornerstones that places UoR in a unique place within UK HEIs to address the global challenges of managing climate change, food and nutrition security, environmental and human health, and sustainability.

Over this REF cycle, we have expanded from a strategy that focused on parts of the food chain, to one that addresses the whole food system, which includes a range of actors and inter-linked activities associated with the production and consumption of foods. We foster collaborative working across the University and externally, and engage extensively with research partners, industry and stakeholders worldwide. The Unit's approach to impact has been strengthened by investments that support large-scale partnering with users of research to promote innovation and entrepreneurship. Successful implementation of the strategy outlined in our 2014 Environment Statement has placed us in a strong position to capitalise on our expertise and capabilities to address Sustainable Development Goals and global societal challenges in relation to agriculture and food. For example, UoR played a leading role in the successful development of the EIT-Food KIC, a €430M research platform to transform the food system (**Williams**), complemented by the UoR-led BBSRC FoodBioSystems DTP (**Methven**), delivering the next generation of agriculture, food and nutrition researchers and industry specialists. More recently we were awarded one of four transdisciplinary projects funded from the UKRI/GFS/government £47.5M 'Transforming the UK Food System for Healthy People and a Healthy Environment Strategic Priority Fund' programme (**Wagstaff**). We are distinctive in our ability to carry out research encompassing the entire food system and we are structured to facilitate the fulfilment of this ambition.

1.2 Unit structure

The Unit (Figure 1) sits within the interdisciplinary Agriculture, Food and Health (AFH) research Theme, one of four Themes that underpin collaborative research across the University of Reading. AFH comprises six Research Divisions, each with 20-40 core research staff plus technicians, research assistants, post-doctoral researchers and PhD students within a shared research area. Three Divisions within AFH map directly to UoA6: Sustainable Agriculture and Food Systems (**SAFS**, n=32); Food and Nutritional Sciences (**FNS**, n=30) and Agri-Food Economics and Social Science (**AFESS**, n=20). SAFS and AFESS are populated by staff within the School of Agriculture, Policy and Development, whilst FNS is populated by staff from the Department of Food and Nutritional

Sciences, which sits within the School of Chemistry, Food and Pharmacy. Each Division has a Research Division Leader (RDL) to help stimulate and strategically guide research both for their Division and collectively as a Community of Practice, and a Research Impact Leader (IL) to promote and support impact activities. The Research Dean for AFH takes a strategic overview of research within the Theme, providing leadership, practical support to develop research opportunities and promotes collaborations that foster interdisciplinary working between Research Divisions and across the wider university.

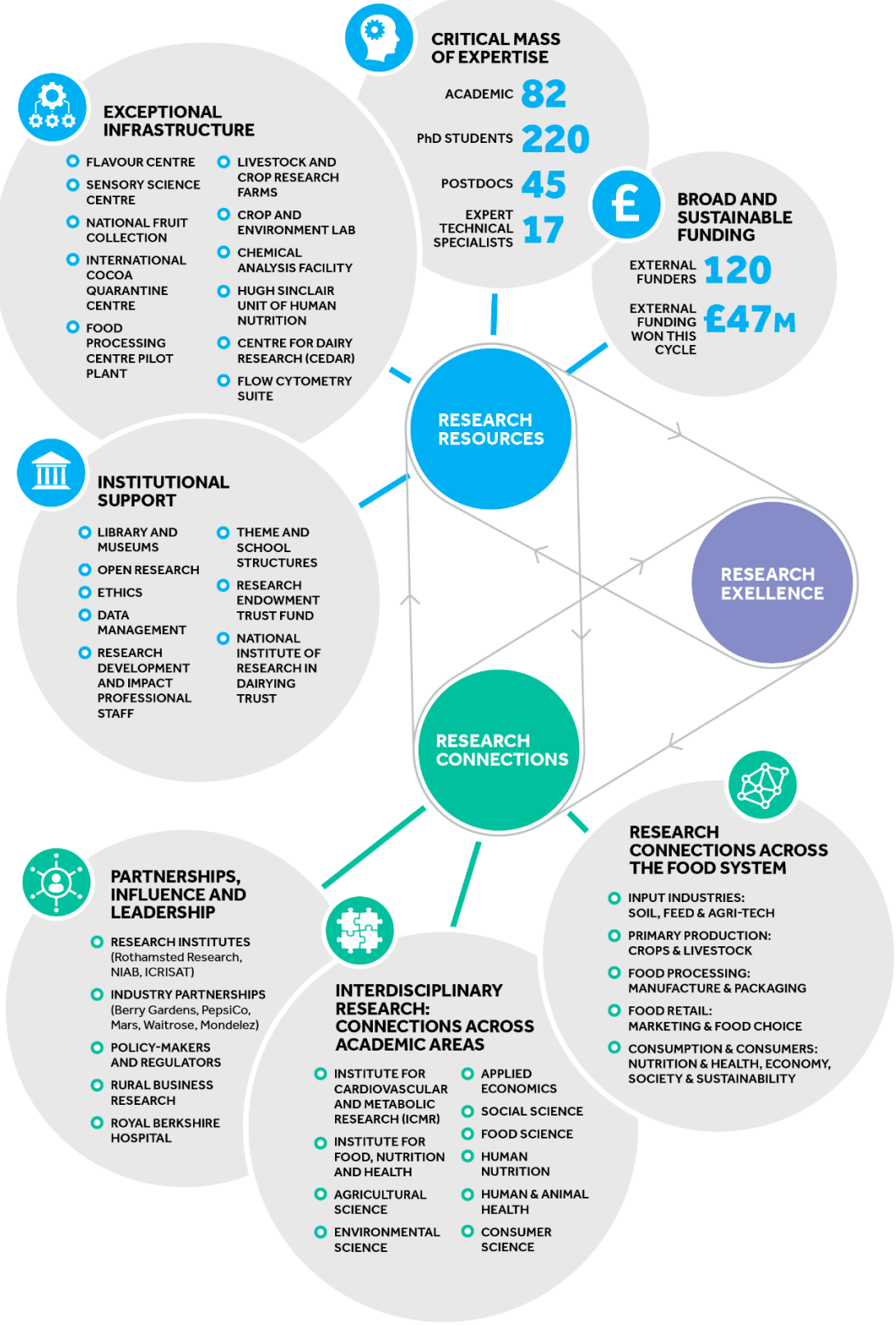

Figure 1. A summary of the research environment within our Unit

1.2.1 Support for interdisciplinary research

In this REF period the University reconfigured its research support and governance structures to specifically enable interdisciplinary research, moving away from school and faculty structures to Research Divisions and Themes (see IES). This approach supports the Unit to take a ***food systems*** approach that integrates STEM subjects with humanities and the social sciences in order to bring about the scale of change and insight that we seek to achieve.

The AFH Theme is underpinned by a number of Interdisciplinary Research Centres (IDRCs) that form part of our strategy to facilitate and support holistic interdisciplinary working. The Institute of Food Nutrition and Health (IFNH), formed in 2016, is key to enabling staff across the Divisions to work together and with others on a national and global scale. IFNH provides a vehicle to form and develop international partnerships and collaborations, notably through supporting EIT Food grants, the Ceres Agri-Tech Knowledge Exchange Partnership and partnerships with CGIAR centres such as the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). Research within the Unit also benefits from collaboration with other IDRCs such as our Walker Institute (centred on climate resilient development; UoA7), the Institute for Cardiovascular and Metabolic Research (nutrition related health; UoA3) and the Centre for Integrative Neuroscience and Neurodynamics (diet and cognition; UoA4).

The InnovateUK Agri-Tech funded Agrimetrics continues to enable key issues facing the agriculture and food industries to be addressed using data-driven approaches and has matured during this REF cycle to become a self-sustaining organisation.

1.2.2 Research Divisions within the Unit

Agri-Food Economics and Social Science **AFESS** (RDL **Srinivasan**) represents the largest collective of applied economists and social scientists in the UK focused on the agri-food sector and undertakes interdisciplinary research across the food system, encompassing food and agriculture policy, health and nutrition, and the environment. Our research incorporates agricultural, environmental, and behavioural economics, focusing on issues central to higher and lower-income countries, including how to provide sufficient, safe, and nutritious food; the impact of agriculture on the environment; and managing natural resources such as tropical forests for both livelihood and ecological benefits. AFESS contains the Agricultural Food and Investigation Team (led by **Bennett**) who undertake the Defra-funded Farm Business Survey as part of the Rural Business Research (RBR) consortium (see Section 4.2). The Division's work, in collaboration with national governments, international agencies, NGOs, commercial organisations, community groups and others, sustains the Unit's strategy for influencing policy at national and international scale and ensures that our research has real-world impact.

Sustainable Agriculture and Food Systems **SAFS** (RDL **Hammond**) is driven by the global challenge of how to produce sufficient, safe and nutritious food to meet the needs of a growing population, ensuring that our production systems do not damage the environment or waste resources. The Division comprises the Departments of Sustainable Land Management, Crop Science and Animal Sciences. Staff from SAFS provide academic leadership for the Waitrose Collaborative Training Partnership (**Potts**) and the Berry Gardens CTP (**Hadley**). They work on the sustainable intensification of crop production systems through the study of plant genetics and physiology, crop modelling and seed science, expand knowledge of the links between animal-derived foods and consumer health and broaden our understanding of the environmental cost of using animals as food producers and its mitigation. The relationship between land use, biodiversity and ecosystem services drives a portfolio of projects in the Centre for Agri-Environmental Research. Research within the

Division supports policy and drives change on farms and in managing ecosystems nationally and internationally.

Food and Nutritional Sciences **FNS** (RDL **Charalampopoulos)** has a global reputation for innovative research that enhances food product and process sustainability, improves the organoleptic and nutritional quality of food, and evaluates impacts on health, cognition, nutrition, the human microbiome and well-being. The Division comprises the Nutrition Research Group (known as the Hugh Sinclair Unit for Human Nutrition), Food Research Group and Food Microbial Sciences Group. FNS leads the FoodBioSystems DTP (**Methven**) which exemplifies our interdisciplinary and holistic approach to research. Staff expertise covers a vast discipline reach, leading to an interdisciplinary approach to many projects, and is complemented by our many industry partners spanning the food system. Staff from FNS advise government on food-related policy development with our research impacting industry practices, government policy, behavioural change, and the nutrition and health of citizens.

The three research divisions enable research across the entire food system, influencing both practice and policy e.g. the BBSRC-funded "Development of novel value chain from cocoa pod husks in Indonesia: Technological, environmental and socio-economic challenges of a value chain" project was led by **Charalampopoulos** (FNS) and included **Hadley**, (SAFS) **Srinivasan, Balcombe** (AFESS).

1.3 Delivery on REF2014 research strategy

Our REF2014 overarching mission was to carry out world-leading research to better understand the interactions between components of the ***food chain*** to deliver improvements in the agri-environment, productivity, surety of provision and human health. Over the 2014-2020 REF cycle we have developed more influential ways of conducting and communicating our research and developed new strategic international collaborations that enable us to meet our objectives of enhancing the sustainability and resilience of global ***food systems***. Delivery on our REF2014 plans is evidenced as follows:

- **Expand the reach of our research**: evidenced by an increase from 182 (2014) to 210 (2020) papers per year. 20.9 % of papers are in the top 10 field-weighted citation percentile and 4.3 % are in the top 1 field-weighted citation percentile (of papers from the same year; SciVal). Three staff (**Gibson, Spencer, Potts**) have remained in the ISI Highly Cited Researchers list, which recognises the production of multiple highly cited papers that rank in the top 1% by citations for field and year in Web of Science.
- **Support the development of the next generation of researchers in academia and industry:** evidenced by our continued successful recruitment of a large and international cohort of PGR students, PDRA's and ECR's; over this REF cycle our PhD students came from over 60 countries and our PhD cohort in 2020 was 220 strong.
- **Increase annual research income**: we continue to attract exceptionally high levels of research income (see section 3), with £47M of funding won during this cycle.
- **Increase the global reach of our unique resources**: we provided underpinning capability to support data and genetic resources that are used by researchers and businesses worldwide e.g. the International Cocoa Quarantine Centre, Farm Business Survey, curation of the National Fruit Collection at Brogdale.
- **Influence policy relating to agri-food at national and global level:** We provide advice that shapes policy (see section 4.1.5) and the research landscape overseas e.g. review of CGIAR Research Programme on grain legumes (**Midmore, Dunwell, Wagstaff**). The Unit has a strong track record of leading research on the Common Agricultural Policy and continues to

work with Defra on the co-design of the replacement Environmental Land Management Scheme and with the Agriculture and Horticulture Development Board (AHDB) on farmer engagement strategies. The Unit was a partner in Defra's Sustainable Intensification Platform. **Dunwell** is Chair, Defra Advisory Committee on Releases to the Environment, 2020-23, **Robinson** is Specialist Advisor for House of Lords Select Committee on Food, Poverty, Health and the Environment and **Potts** is a member of Defra's Pollinator Steering Advisory Group. **Lovegrove** is Deputy Chair of the Scientific Advisory Committee on Nutrition, which advises the government on dietary policy. We helped form an All Party Parliamentary Group (APPG) on the Human Microbiome to advise MPs, Lords and other key opinion leaders on the impact of poor gut health and the positive consequences for UK productivity if gut health of the population can be improved (**Gibson, Walton**; Impact Case).

1.4 Strategic research objectives beyond 2021

Our strategy is to increase ambition and ***move beyond the food supply chain*** to work with greater inter- and trans-disciplinarity and ***address food system challenges*** in a more holistic way. Hence the Centre for Food Security evolved into the Institute for Food Nutrition and Health, and our overarching research Theme of Agriculture Food and Health facilitated our vision of a systems level approach.

Our vision is to provide world-leading research that drives sustainable agricultural and food production for a healthy planet and healthy people. The unique expertise collectively present at UoR encompasses climate science, agriculture, food, nutrition and soil science alongside economic, social and psychology research excellence. We are positioned to lead the global perspective on linking food, health and the environment and to provide the research needed to drive change in government, business and citizen behaviours to achieve the UN Sustainable Development Goals.

To enable delivery of our vision we will achieve the following **objectives** over the next **five years**:

- Building on our achievements, we will continue to undertake world-leading innovative agriculture, environmental and food systems research that addresses Sustainable Development Goals e.g. SDG 2.2. and SDG2.4, zero hunger, improved nutrition, sustainable food production systems, resilient agricultural practices, maintain ecosystems, strengthen capacity for adaptation to climate change, improve land and soil quality; SDG3.4 reduce premature mortality from non-communicable diseases; SDG12.1 sustainable consumption and production; SDG12.3 reduction of food loss and waste.
- The large collaborative food systems initiatives that we are already leading e.g. the FoodBioSystems DTP and our SPF Food Systems project on transforming the UK food system for disadvantaged communities will be delivered over the next five years and the outcomes from the research will be leveraged to develop future synergistic partnerships that will increase the impact and visibility of our research.
- External profiles of our staff, together with our distinctive expertise in economics and social sciences directly focused on agrifood systems, leads us to influence and shape policy. Specific areas we look to address in the next five years include: working with government to develop policy that addresses the health drivers of the human microbiome and helps mitigate diseases associated with poor gut health; informing the UK National Food Strategy; influencing national dietary guidelines and UK policy on food composition that leads to a reduction in salt, sugar and saturated fat in the diet; working with UK government and international policy makers to develop environmental and farming policies that support sustainable and regenerative agricultural practice and strong ecosystems services.

- We will make strategic use our National Institute for Research into Dairying (NIRD) Trust Fund (see section 3.4) to invest in agriculture and food infrastructure, equipment and people to support research excellence in the Unit, with tens of £M's available over the next REF cycle. The funds will facilitate strategic partnerships with key international organisations, research institutes/centres of excellence and commercial organizations e.g. UN, CGIAR, other Universities in the top 10 QS World University Ranking for Agriculture and Forestry. These partnerships will create a global community of agri-food research excellence, build capacity and skills through shared PhD students and career development fellowships, and jointly tackle the challenges experienced in many different farming and food systems environments across the world.

1.5 Impact strategy

Our strategy is to ensure that our research meets end user needs by forming collaborative partnerships and co-creating impact. We undertake purposeful long-term collaborations with government bodies, industry bodies, companies and wider stakeholders to ensure relevance of our research on policy, commercial organisations and wider society. The desire to generate real world impact motivates our researchers and the championing of applied research is a distinctive feature of UoR, with our strategic mission being "to transform lives at a local, national and global scale." The University resourced a major strategic investment in impact since REF2014 with which our Unit has engaged strongly.

1.5.1 Facilitating and achieving impact

The Impact Lead (IL) from each Research Division promotes the research impact culture and works with individual research groups to identify routes for transforming their research into practice (see IES section 2.3). Each IL is supported by the University's Impact Development Manager for the AFH Theme who provides expert insight into developing and capturing impact, working as a team with the IL and researchers to develop impact strategy for key projects. The Building Outstanding Impact Support Programme (BOISP) provides a structured approach to identify, develop and deliver impact and 18 projects in the Unit have been supported since 2014, ranging from those at an early stage of development to those that have matured and been selected as our Impact Case Studies (ICS) for REF2021; other impactful projects have been highlighted and supported throughout this assessment period. Our submitted cases are a small subset and have been selected to demonstrate the breadth of impact on policy, economics and society across the food system, from biodiversity and ecosystems services management (**Potts**, **Garratt**: pollinators), to primary production innovations such as novel polytunnel films (**Hadley**), to farming practices and food products developed to bring human health benefits (**Givens/Lovegrove**: polyunsaturated fats; **Gibson**: prebiotics; **Spencer**: polyphenols).

The Impact Development Manager works with the Knowledge Transfer Centre and Research and Enterprise Services to identify emerging areas and to provide input on funding streams. This support helped **Senapathi** secure a NERC Knowledge Exchange Fellowship (2019-2022) on Enhancing Landscapes for Biodiversity and Multiple Ecosystem Services to develop transparent, evidence-led processes to optimise land use choices to best meet the needs of different communities. The project will create a knowledge hub comprising stakeholders from different communities coming together to (a) gain information from existing projects, (b) inform researchers of evidence needs and (c) share real-world experience and good practices. The same team assisted **Rose**, Elizabeth Creak Associate Professor of Agricultural Innovation and Extension, to secure funding from the Elizabeth Creak Trust for The Centre for Effective Innovation in Agriculture as part of a consortium of five UK universities who will collaborate to address the gap between scientific research on innovation and

real-life farming experience. The Centre will focus on how research and development investment can best support innovation to be adopted by farmers.

1.5.2 Future support for impact

This Unit is particularly well placed to leverage international impact because of the volume of research delivered on a global scale across a range of agricultural systems, commodities and environments. Our global reputation is built on our history of providing education and research that has impact on agricultural, ecological and food systems across the world with our alumni in key positions to drive change at scales ranging from smallholder farmer cooperatives through to multinational global corporations.

1.6 Support for open research

Our staff benefit from and contribute to open research initiatives, for example using the MRC epidemiology database at Cambridge or Biobank information and contributing to the Farm Business Data from Defra. We were the first UK university to publish a statement on open research (see IES). In addition to our open access repository for publications (CenTAUR), we established an institutional Research Data archive in 2015, to host data which cannot be deposited in disciplinary archives and our commitment to reproducibility is reflected by our early membership of the UK Reproducibility Network, which we joined in January 2020. The University constituted a new Committee for Open Research and Research Integrity, chaired by **Yaqoob**. Our open research web pages have links to our internally funded Open Research Action Plan, Open Research handbook and case studies of open research at UoR.

The Unit is in the process of appointing Open Research Champions for each Research Division and is encouraging applications from people at a range of different career stages to continue to build a culture of research openness. A dedicated data manager supports grant applications and researchers are encouraged to use international repositories for data such as genomic or phenotyping e.g. NCBI, CropStore. Researchers are increasingly using bioRxiv for the deposition of preprints to increase the accessibility of our research to others. The genetic resources curated by the International Cocoa Quarantine Centre and the National Fruit Collection are available to other users, thereby forming unique open-access living research platforms for the wider scientific community to use.

1.7 Supporting a culture of research integrity

Procedures are in place to ensure the highest standards of research integrity and Quality Assurance in Research based around the University's Ethical Framework, including the University Code of Good Practice in Research, which is required reading for all researchers. Ethics approval procedures are well-established within the Unit, with local ethics committees in FNS and APD; staff from the Unit also sit on the University Ethics Committee. Local ethics committees are supported by members of administrative staff who guide researchers through the process. Intervention trials using NHS patients are subject to approval from NHS Research Ethics Committee. The Department of Food and Nutritional Sciences holds a Human Tissue Act licence (**Jackson**). We invested in REDCap (Research Electronic Data Capture), a web-based application to ensure participant-based research data remains GDPR compliant, with **Jackson** a member of the REDCap Management Board.

The Head of both Schools submitting to this Unit sit on the University Animal Welfare Ethical Review Body (AWERB) committee which reviews relevant projects from licence holders and takes a broader view of the use of animals in research at Reading. The University is a signatory to the 'Concordat on Openness on Animal Research' in a commitment to help the public understand more about animal research and in 2018 its dedicated web pages were shortlisted for an Openness in Animal Research

award by Understanding Animal Research. The Centre for Dairy Research (CEDAR) cows are part of a 570 strong commercial dairy herd owned by the University Farm, plus additional animals are reared at Sonning for sale to the beef industry. All animals undergo routine testing for TB, along with other susceptible species such as camelids.

2. People

2.1 Introduction

Our academic achievements are a reflection of all staff associated with the Unit who provide a positive and supportive environment for our researchers. This includes dedicated central university support e.g. Research Development Managers supporting grant preparation, contracts officers, finance administration, procurement, legal services, ethics, business engagement and communications. Some central support colleagues are embedded within our Unit, such as our two EIT Food Partnerships Managers.

Our Farms Manager ensures that our crop and livestock farms meet the needs of our researchers and manages 15 farm workers. Research is enabled by our Technical Manager for the Crops Research Unit at Sonning Farm, Research Manager and Research Co-ordinator at CEDAR Hall Farm and Technical Manager of our Crops and Environment Laboratory (CEL) on the Whiteknights campus. Field-based research is supported by technicians who facilitate production trials and assess crop, dairy and meat quality. Specialist technicians manage the International Cocoa Quarantine Centre that supplies disease-free cocoa germplasm globally.

Dedicated technicians provide expertise to analyse food and to support economic modelling and sustainable land use. The manager of our 100m^2 Food Processing Centre and a senior technician support study design and delivery, facilitating the processing, packaging and analysis of foods, e.g. UHT processing, ice-cream making, freeze drying, baking, nano filtration and 3D food printing. Our Sensory Science and Flavour Centres also have technical specialists. The Hugh Sinclair Unit of Human Nutrition has a full-time unit manager and three research nurses. We maintain a volunteer database of >5000 individuals, enabling recruitment for studies that require particular demographics or risk factors.

2.2 Staff development strategy

Development and retention of staff employed within the Unit is a priority, with a focus on developing research leadership. To this end, academic staff develop annual Personal Research Plans (PRPs), helped by mentors and line managers. Staff have considerable flexibility in relation to the research they pursue and have an opportunity to influence the research strategy of the Unit. Staff are provided with a range of support and development opportunities, available through a central UoRLearn platform that enables staff to record their Continuous Professional Development (CPD). Undertaking CPD is required within our Personal Titles promotions process.

All new staff are assigned a mentor and all have annual Performance and Development Reviews with their line managers. Mentorship for personal titles promotion applications and for a whole range of aspects of academic life, from managing work-life balance to supervising a growing research group, is provided across the Unit. For academic staff a probationary meeting occurs within six weeks of appointment to agree objectives which will span the normal three-year probationary period. Staff then meet with their line manager on a regular basis to review progress against the objectives. The Academic Probation Review Sub-Committee reviews progress against objectives at 18 months and three years, with the option for exceptional staff to be confirmed in their permanent role at the earlier timepoint.

The Concordat to Support the Career Development of Researchers has been championed by the Heads of Schools in the Unit who have used all-staff meetings to highlight the opportunities it presents to PIs and researchers, running Q&A sessions, and explaining the wide range of development activities that could be undertaken – and how these could enhance both career development of the individual whilst simultaneously bringing softer benefits to the research group and wider environment.

A host of research leadership opportunities allow staff to understand the broader research landscape and emerging priorities of funders. These include heads of School Research groups (mid-upper levels), our BBSRC and NERC application Review Groups, Research Division Leads, Impact Leads (mid-career), membership of the University Committee for Research and Innovation, Committee for Research Infrastructure (ECR representation, **Bell**). Our PVC for Research and Innovation (**Yaqoob**) is a highly successful researcher from this Unit.

The University of Reading was a founding signatory of the Technician Commitment in May 2017; our professional services and technical staff are core members of the Unit and facilitate (and in some cases lead) research, frequently co-authoring publications from the Unit. Many of our technical staff hold PhDs and degrees in the area of their work. We actively encourage and pay for our technical staff to seek professional accreditation status as Registered Science Technicians (RSciTech), Registered Scientists (RSci) and Chartered Scientists (CSci). A research technician recently received a Registered Scientist commendation for her CPD work from the Institute of Food Science and Technology. Two Research Technicians have taken the opportunity offered to study for Professional Doctorates registered at the UoR through the AgriFood Training Partnership. Our support for the professional development of our technical staff has led to us being named as a Science Council Employer Champion.

2.3 Staffing and recruitment policy

Within the period, our staffing strategy reflected our 2014 research plans and was linked to Division and School 5-year operating plans. The strategy has been to recruit at all levels to areas seen as distinctive research strengths of the Unit as well as those identified as of increasing strategic importance to the Unit's research excellence. In doing so we have ensured built-in succession planning for areas that are cornerstones of our international research reputation within the Unit, such as agri-food economics and social science and gut microbiology. At the REF census date, 38% of eligible staff were Professor, 20% Associate Professor, 23% Lecturer, 19% Senior Researcher/Researcher.

Only 15% of our appointments are fixed term contracts and these are largely due to the external nature of their funding; we redeploy these staff into new projects wherever possible. We are committed to appointing applicants who are both individually excellent and committed to our ethos of shared success; a crucial part of our interview process involves finding out what background work our applicants have done to identify collaboration opportunities with their potential colleagues. We therefore appoint staff who seek to work across the broader research interests of the Unit and to collaborate on inter-disciplinary research.

New appointments have been made in the area of economics and social science, substantially enhancing research capacity in areas identified in the 2014 research plans: consumer behaviour and food marketing (**Macready** and **Asioli**), health economics (**Zanello**), farm production economics (**Gadanakis**) agricultural innovation and policy (**Rose**). Leadership by economist members has been recognised internally and externally resulting in moves to leadership roles: Professor **Bennett** was

appointed as a Research Dean and Professor **Tiffin** was seconded to Agrimetrics as Chief Scientific Officer.

We made appointments to enhance our research into the impacts of climate change on food systems and biodiversity, and to maintain capacity for research on crop and livestock production systems. These include *Lecturers*: Threats to food production systems from changing climates (**Bishop**), temperate horticulture (**Bell**), food matrices (**Grundy**), epidemiology of crop pathogens (**Mikaberidze**), insect ecology in crop production systems (**Girling**), mathematical methods applied to the resilience of soils in response to environmental stresses (**Todman**), sustainability of animal agriculture (**Ray**), sustainability of dairy production systems (**Stergiadis**), dairy animal welfare (**Meagher**). *Senior Research Fellows*: dairy cow diet impact on human health (**Kliem**), growth and quality of meat products (**Juniper**), ecosystems services (**Garratt, Senapathi**). *Professor*: soil ecology (**Tibbett**).

Key appointments have invested in ECR talent to enhance food and nutritional sciences research including food processing (**Rodriguez-Garcia, Mavroudis**), food waste valorisation (**Chatzifragkou**), gut microbiota (**Walton, Wijeyesekera**), sensory/flavour science (**Lignou**), nutrition and cardiometabolic health (**Mills**), appetite (**Clegg**). Mills and Clegg were appointed through Hugh Sinclair Trust funds.

2.4 Support for ECRs

All ECRs have a mentor to provide guidance regarding development of research ambitions and careers. New academic appointments are given reduced teaching and administrative loads (typically <50% for ~3 years) to enable them to develop their research careers. They are provided with start-up funds to spend on personal/career development, plus departments have pump priming funds for ECRs. A range of training is offered to ECRs and the University's Research and Enterprise Services provides one-to-one support for ECRs applying for funding and developing collaborations. Many PDRAs complete training to become associate fellow/fellow of the HEA to support future academic careers. Several internal research funding schemes give priority to ECRs, e.g. Research Dean's annual research pump priming scheme, similar schemes by IFNH, RETF (section 3.4) and Heads of Schools, and the University's GCRF QR fund where agriculture and food are priority areas. Allocations are made for ECR's from the internal Annual Research Infrastructure Funds and from external funds, such as research council capital awards. Recently, ~10% of our World Class Laboratory Initiative award (£108K) was directed to ECR's, thereby funding equipment for **Bell, Cheng, Rodriguez-Garcia, Mills** and **Todman**.

2.5 Enabling time for research

Academic staff draw on University-level and Unit-level support to provide meaningful time for research. The University supports research leave, often with matched funds from the School, for teaching buy out for 1-3 terms. Support is prioritised for staff who can demonstrate a clear plan for research activity that will take place as a result of being awarded research leave. At Unit level we generate meaningful amounts of time through School-level sabbatical schemes by adjusting teaching timetables and student allocation so that staff can free up all or most of a term to work on a specific research activity. This often helps staff who have substantive field work overseas. Part-time staff are provided with the same opportunities as full-time staff.

2.6 Facilitating engagement beyond the University

Research staff are proactively encouraged to engage with business, third sector and public bodies; this engagement is key to underpinning the Unit's reputation for policy influence and research that

is relevant to stakeholders across the food system. The University recently welcomed Bill Kilgallon as a Royal Society Entrepreneur in Residence who will work with staff to assist with commercialisation of research. The University hosts Parliamentary Office of Science and Technology (POST) training courses which are delivered by officials from POST and Select Committees, and funds ~10 places each time, giving researchers at any stage of their career the opportunity to learn how to engage with UK Parliament.

2.7 Recognising and rewarding excellence

Staff who excel at engagement beyond the university are nominated for our annual Research Engagement and Impact Awards, recognising those who undertake high-quality engagement and impact activities (e.g. **Tibbett, Potts, Garratt**), and/or have contributed to capacity building in this area. Rewards committee considers cases for an additional increment for staff on grade 6 and cases for research intensive staff (including PDRAs) to move from grade 6 to grade 7 (lecturer equivalent) by meeting the criteria of sustained excellence; many are underpinned by permanent contracts. We also have a scheme for awarding lump sums and vouchers to reward one-off activities of note.

2.8 Research student environment

The Unit provides a stimulating environment for students to develop their research skills, expertise and knowledge; they are welcomed to all-staff School talks, Research Division coffee mornings where new project ideas are discussed and they represent their communities on School Health and Safety, Wellbeing Inclusion Diversity & Equality committees, Joint Academic and Technical Group and Sustainability Group.

2.8.1 Recruitment of doctoral students

The Unit led in shaping University policies for recruiting doctoral students having developed a Diversity & Inclusion policy and associated strategies for widening participation for its leadership of the BBSRC FoodBioSystems DTP. Given the international reputation of UoR in the Unit area, we attract students from all over the world where agriculture and food are significant contributors to their home nation's economy, giving scholars an opportunity to experience a research environment that doesn't exist in their own country. A wide range of mechanisms exist for doctoral study, including part-time, working away from the University (e.g. at a research institute in the UK or overseas), thesis by publication (for example for research technicians who have a number of papers in a particular area to their name), and professional doctorates that enable study whilst working. The fees for these non-standard options enable participation by people who would not otherwise be able to afford a standard fee. Students are always interviewed by their prospective supervisors before being offered a place.

2.8.2 Training partnerships and other funding sources

The Unit's Food Security BBSRC-funded DTP (2012-2019; £3.4M) was followed by the FoodBioSystems DTP awarded in 2019 (£12M) and is committed to providing CASE, placement, training and internship opportunities. The DTP funds >15 four-year standard studentships and 6 CASE studentships per year and will deliver the next generation of scientists (>120 PhD graduates) The Unit is a partner in BBSRC CTPs with Berry Gardens and Waitrose and a Marie Curie Training Network in Sustainable Technologies. The Unit led the BBSRC funded FoodATP (2011-2016) and AgriFood Training Partnership (2017-present) providing modular postgraduate training and professional doctorate degrees for agrifood industry professionals, with >90 registered students at UoR.

Sponsorship for doctorates comes from wide-ranging sources including Industrial CASE, Government departments, charities and companies, the University's RETF, the Reading-Rothamsted Alliance, AHDB, EU funding and overseas scholarships, meaning that we work across a scale ranging from a small charity (John Goldacre Foundation) to large multinationals (GlaxoSmithKline, Mondelez).

2.8.3 Monitoring and supporting student progression

Each student has ≥ two supervisors with one having primary responsibility, chosen according to the needs of the student and their research interests. Experienced academic supervisors work alongside more junior colleagues to give the latter a supported route to build their research groups. In this REF period, 274 UoA6 research students were awarded PhD compared to 210 in REF2014, averaging 3.56 awards per submitted staff FTE. 82% of full-time students submitted within 4 years.

Students have (and take) the opportunity to attend a wide range of research seminar series. They celebrate their own research through showcase events, e.g. the annual Research Symposia in each Department, which are organised by a student committee and attended by every PhD student. The Graduate School hosts an annual Doctoral Research Conference at which, in addition to PhD Researcher of the Year presentations, there are numerous competitions (film, poster, photo, poetry, rap) which ensure high engagement.

A learning needs assessment is undertaken by students at the start of their PhD and a training programme agreed. Subject-specific training within the Unit is complemented by the Reading Researcher Development Programme (menu of >100 sessions), many led by academics from the Unit. The Unit's membership of IFSTAL (Interdisciplinary Food Systems Teaching and Learning) has been a significant success (providing training to >1500 students) and in 2019 transitioned from IFSTAL to EFSET (European Food Systems Education and Training) via EIT Food funding. Through IFSTAL/EFSET we provide PGR students with holistic understanding of the food system and its challenges, uncover intervention strategies, and help to contextualise strategies within their chosen speciality or discipline.

Our PhD students have been recognised through externally awarded prizes such as:

- Winners of the BBSRC Biotechnology Young Entrepreneurs Scheme competition
- Postgraduate Student Award from the Nutrition Society (2015, 2017, 2018).
- European awards for best thesis in Sensory Science (2016) and Flavour (2016), leading to leadership programme places (2018)
- IFST Young Scientist winner (2018)

2.9 Commitment to equality and diversity

Heads of School have responsibility for ensuring that equality and diversity are embedded within their activities. Their Wellbeing Inclusion Diversity and Equality (WIDE) Committees meet 1-2x/term, representing staff and students from each research division across many roles. Schools have BAME Staff and Student Networks. The Networks and WIDE committees have a mission to identify and address issues affecting staff at all levels from all backgrounds; we have examined and adjusted our committee structures to ensure that staff with protected characteristics and the relevant professional expertise are represented at every level. Of the Unit's REF2021 eligible staff population, 39% are women, 66% are British (10% of BAME heritage) and 34% international (9% BAME). 16% per cent of women in the Unit are Professor and 16% are Associate Professor. 10% of Professors and 6.7% Associate Professors are of BAME heritage. Of the two Heads of School, one is female, School Management Board in SAPD is 31% female; in SCFP 41% are female. One of the three research

Division Leads is of BAME heritage. In relation to research students, 60% of our current cohort are female and 52% of BAME heritage. SCFP holds an Athena Swan Silver Award, SAPD Bronze, and the University has Athena Swan Silver.

Workload models take account of individual responsibilities; annual monitoring ensures workloads are appropriate to the individual whilst providing all staff with opportunities for development and advancement. There is a strong ethos that no member of staff should be disadvantaged by any of the nine protected characteristics of the Equality Act. Staff are provided with support in terms of equipment and ways of working etc e.g., making allowance for caring responsibilities, disabilities and for religious practices.

Part-time and full-time staff have the same career opportunities; most posts have the potential to be part-time and/or job-shared. Adjustments needed for disability are made; staff can return to work from absences associated with maternity leave or ill health flexibly or part-time as suits their needs. In these cases, staff are allocated a light teaching load or a sabbatical period for a year to enable them to recover their research activity e.g., **Mills, Lewis**. Consequently, Mills submitted a New Investigator grant (amongst several others) and Lewis is Research Division Lead-elect. Shared parental leave is common and (male) members of the Unit take leading roles in the University's Parent and Family Network, for example lobbying that resulted in the University nursery opening during vacations to support research active staff. Role models for flexible working exist at the highest level from our Unit, with PVC Research and Innovation operating as a job share and a Dean post is occupied by part-time staff.

Staff may experience a variety of circumstances that negatively impact their ability to evidence sustained attainment of promotion criteria e.g. caring responsibilities, ill health, Covid-19. Every applicant has the option of submitting a Personal Circumstances form alongside their promotion case, which is agreed with their Head of School, and which stands as a record of how their circumstances have impacted promotion criteria. At no point is the applicant expected to reveal the precise nature of circumstances, so confidentiality is maintained.

In addition to the WIDE committee, SCFP has a Wellbeing Champion (**Chatzifragkou**), a role created after a School Away Day in September 2019 which centred on wellbeing. Chatzifragkou has subsequently undertaken staff surveys to benchmark stress, anxiety and its causes (Feb 2020) and is currently running a follow up survey and focus groups, using the HSE Management Standards and talking toolkit for tackling work-related stress, with our head of University Health and Safety. Chatzifragkou also identifies and supports individual staff wellbeing cases, making use of the extensive University wellbeing resources where appropriate. Staff can access professional counselling through the Employee Assistance Service, plus many other resources linked to self-care and group support.

2.9.1 Consideration of equality and diversity in forming the REF submission

In construction of the REF submission, all decision makers have undergone training in Equality, Diversity and Inclusion, and managing unconscious bias. To develop our submission, a UoA lead was appointed through open competition and, through the RDLs, ensured outputs were read and scored internally by staff from across the submission, with ~3 individuals independently scoring each output. Results and feedback were shared with the authors via our ROSS database to ensure transparency. All staff returned their highest ranked output and the remaining submission was populated with the highest scoring outputs, ensuring all outputs were compliant. We reflected on the outcomes of the University's interim Equality Impact Assessment (2020) and bias analysis (2021) which identified no statistically significant differences for protected characteristics in our selection.

3. Income, infrastructure and facilities

3.1 Funding strategy and attainment

The Unit has secured significant external funding from a diverse range of sources, amounting to £48M of research income won across the REF period which represents an average of £6.9M per annum, rising to £7.8M in 2018/19 and equating to £89k/FTE/year across our 77.15 FTE submission. Our funding success rate from 796 standard research grant and fellowship applications is 27%. A distinctive aspect of our Unit is the breadth of our **120 external research funding sources**, supporting **366 project awards**, demonstrating the resilience of our funding streams (Figure 2).

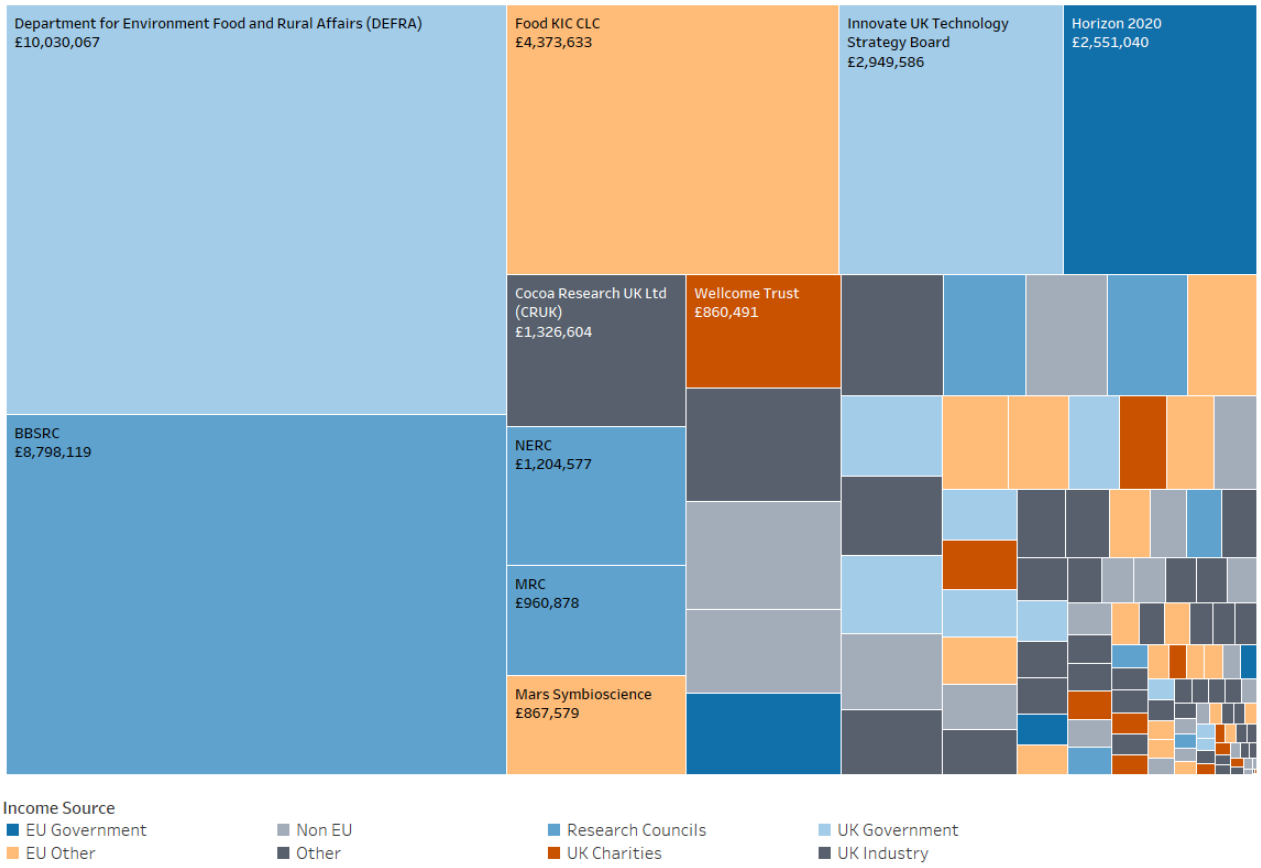

Figure 2. Sources and value of funding income over the 2014-2020 REF period. Size of box is in proportion to funding received; colours indicate different funder types.

Many of our funding sources provide repeat cycles of income, enabling us to run significant long-term projects and as a consequence to deliver substantial impact from our work e.g. the Farm Business Survey provided £4.9M from 2014-2020 and EIT Food provided £5.8M from 2017- 2020.

This funding base underpins the volume of high-quality outputs and ICS associated with this and future submissions.

3.1.1 UKRI

- **BBSRC SARIC** funding **(£838k**)/**Defra** funding **(£3.6M**) for 'Investigating diverse forage mixtures to optimise ruminant animal production, nutrient use efficiency, environmental impact, biodiversity and resilience'.
- **BBSRC DRINC** funding (**£575k**) for 'Mechanistic assessment of the acute and chronic cognitive effects of flavanol/anthocyanin intervention in humans'.

- **MRC funding** (**£783k**) for 'Reducing cardiovascular disease risk through sustainable replacement of saturated fatty acids in milk and dairy products'.
- **BBSRC GCRF funding** (**£573k**) for 'Traits and technologies to boost North African protein self-sufficiency'.
- **BBSRC funding** (**£560k**) for 'Food Processing Waste and By-products utilisation network (FoodWasteNet)'.
- **ESRC funding** (**£519k**) for 'Cognitive Biases and Behavioural Segmentation in Food Demand'.
- **NERC funding** (**£501k**) to investigate 'Degradation of Odour signals by air pollution: chemical Mechanisms, plume dynamics and Insect-Orientation behaviour (DOMINO)'.
- Reading leads one of four **£6M** projects funded by **UKRI/government** in the Transforming the UK Food System for Healthy People and a Healthy Environment call to enable transdisciplinary research on 'Co-production of healthy, sustainable food systems for disadvantaged communities' to shape the future UK food system and influence the evolving National Food Strategy.

3.1.2 EU

EU funding is substantially enhanced by the EIT Food KIC (2017-20) with UoR receiving ~£5.8M to date over 88 consumer-focused food projects. EU funding for Horizon 2020 includes:

- **£432K** for work to reduce nitrite in meat products (Phytome).
- **£393K** for advancing the cattle sector through better use of technology (SmartCow).
- **£365K** for investigating biodiversity and pollinators in the agricultural landscape (PoshBee).
- **£325K** for Linking farmland Biodiversity to Ecosystem services for effective eco-functional intensification (LIBERATION).

3.1.3 Industry Funding

Engagement and co-creation of research with industry and end users is an important part of our work. In addition to large-scale work with industry through EIT-Food and InnovateUK, we have secured direct support for individual projects from a large range of companies and industry bodies including:

- **£4.1M** for curation of the National Fruit Collection.
- **£3.5M** from Innovate UK for the formation of Agrimetrics, the Agrifood Data Marketplace.
- **£4.9M** for undertaking the Farm Business Survey on behalf of Defra.
- **£1M** from Cocoa Research UK for research into climate change effects on cocoa.
- **£429k** from the Cocoa Research Association for running the International Cocoa Quarantine Centre.
- Participation in the **£4.7M** CERES Agri-Tech Knowledge Exchange Partnership.

3.2. Investment in exceptional infrastructure

Staff are mainly housed within purpose-built Agriculture and Food buildings containing 8133m^2 of laboratories and research facilities, supported by the additional bespoke facilities below. These facilities enable us to work across the whole food system e.g. MRC-funded RESET project used cows at CEDAR, milk was processed into dairy products in the Food Processing Centre, and

assessed in the sensory suite, human health outcomes were assessed in the Hugh Sinclair Unit of Human Nutrition.

From 2014-2020, the University has invested nearly £5M in infrastructure to support our research, including:

- >**£200k** in updating and enhancing field and postharvest analysis capabilities (plot scale machinery, NIRS capabilities, new grain nitrogen analysis equipment).
- **£450K** University investment in above- and below-ground crop phenotyping technology for field and controlled environments.
- Multispectral 3D imaging and field scale soil moisture monitoring capabilities delivered through Distributed Temperature Sensing fibre optic cables.
- Redevelopment of controlled environment facilities, including a new home for the **International Cocoa Quarantine Centre** and a unique modified environment orchard (0.6ha) in the **National Fruit Collection** to undertake long-term study of UK apple genotypes to warmer temperatures.
- Analytical equipment for assessing the interfacial rheological characteristics of food matrices, a tribology system and oral processing devices to monitor the textural and mouthfeel properties of food, chemical analysis equipment (e.g. HPLC, GC-QToF, DIONEX-MS, clinical analyser), a simulated moving bed chromatography system, and a triple quad LC-MS-MS instrument for metabolic profiling.

3.2.1 Livestock and Crop Research Farms

The Unit has **two farms, commercial grade glasshouse and polytunnel facilities, and high-specification controlled environment facilities for plant and animal production.** These provide underpinning research support for the wider farming and scientific community e.g. bovine TB studies; specialist pig housing and production for Pirbright that are used for animal vaccine trials; llamas that provide nanobodies for vaccine development, including for Covid-19 vaccines.

The farms are managed commercially, cover approximately **750ha**, and include a **570-head dairy herd** at our **Centre for Dairy Research (CEDAR).** The facilities at CEDAR provide constant access to livestock in a commercial setting that can be used for research. Infrastructure investment at CEDAR during the REF period includes:

- **£2.2M** for additional farmland (75 hectares);
- **>£1.5M** for additional livestock research infrastructure, including:
    - A new transition cow unit
    - An expanded meat and growth research unit
    - Refurbished and refitted controlled environment rooms for animal research including pigs and poultry
    - Four indirect calorimeters together with metabolism stalls and cattle yards to enhance our infrastructure for research on greenhouse gas emissions, nitrogen use efficiency and the sustainability/resilience of animal production systems.

3.2.2 Crops Research Unit (CRU)

The CRU is equipped to produce arable and horticultural crops at plot to field scale, with >2,000 trial plots drilled annually. It has adopted and developed remote/automated phenotyping systems and has postharvest facilities to evaluate grain and fruit quality. CRU supports long-term field facilities

including low-input rotation which mimics organic production systems, in production since 2003, to facilitate side-by-side comparisons with conventional production systems. We also maintain replicated plots consisting of three different rotational intensities. The CRU benefitted from the addition of three new double span polytunnels for soft fruit production, including commercial grade table-top strawberry production facilities and new laboratory and workshop facilities to support research. The development of a Free Air Diesel and Ozone Enrichment (FADOE) facility, funded through a NERC Capital Infrastructure grant to **Girling** (£200k), is being used to explore the impacts of common air pollutants on insect behaviour and insect-mediated ecosystem services.

3.2.3 The Crop and Environment Laboratory (CEL)

Year-round capability to grow any terrestrial plant in environments mimicking anywhere across the globe provides the capability to test responses of existing and novel germplasm (including GM) to predicted future climate patterns, and how to extend production seasons and locations. This complex includes: 12x Weiss-Technik Fitotron cabinets with full temp, light, day length, RH and CO_2 control; 6x Weiss walk-in growth rooms with temp, day length control; 6x Saxil CE chambers; Factorial glasshouses with automated irrigation systems, heating (25°C uplift), supplementary lighting and day length control; 5.5ha of experimental grounds where installations enable small-scale fieldwork.

3.2.4 Food Processing Pilot Plant

The Food Processing Centre (FPC) includes the largest food processing pilot plant in UK academia. It is a registered food business and provides significant research capacity to manufacture food for human consumption. Over the REF period there has been investment in a range of food processing equipment including an extensive refurbishment of the dairy processing area (**£900K**), as well as the addition of new thermal processing equipment, bakery ovens, freeze driers, and packaging equipment (**£130K**).

3.2.5 Hugh Sinclair Unit of Human Nutrition (HSU)

The HSU has the personnel and facilities required for human clinical intervention studies including nurses, trained phlebotomists, catering facilities, and equipment for collection, storage and analysis of biological material. It facilitates over 1100 volunteer visits per year and has six clinical rooms, with three of them devoted to vascular function assessment using different cutting-edge techniques, including laser Doppler imaging and Flow Mediated Dilation.

The Unit received investment of **>£300K** from the University to construct an additional fully equipped clinical room. Funds from the Hugh Sinclair Trust have been used to employ an additional specialised research nurse (total of 3 research nurses). The Unit has also invested in a Dual Energy X-ray Absorptiometry scanner, to determine bone density and body compositional analysis, and in two cognitive testing rooms.

3.2.6 Sensory Science Centre (SSC)

SSC operates in partnership with MMR, a private sensory company, and enables high quality organoleptic evaluation of foods of all kinds to address consumer and food industry challenges. The Centre offers two separate suites of 16 and 12 state-of-the-art booths designed according to ISO standards with controlled lighting, ventilation and temperature, a dedicated kitchen and a separate room for panel vocabulary development and training. The CompuSense platform is used to support our research. The Centre uses a panel of trained sensory assessors who characterise and evaluate the organoleptic qualities of a wide range of products. A database of >5000 people enables consumer liking or preference panels to be formed.

3.2.7 The Flavour Centre

The international reputation of this Centre is built upon its ability to undertake analytical flavour and aroma chemistry using state-of-the-art instrumentation including a highly sensitive multidimensional gas chromatography system (GC-QToF) allowing acquisition of full metabonomic data from complex samples. Our GC-Olfactometry platform has been key to a study on parosmia and anosmia, which has allowed the discovery of vital underpinning science behind the impact of Covid-19 on some patients' ability to smell. Staff from the Centre run the annual International Flavourists Course, developed with the British Society of Flavourists and financially supported by the International Federation of Essential Oil and Aroma Trades.

3.2.8 Gut Model and Flow Cytometry Suite

Our pioneering continuous culture colonic microbiology models are used to plan prospective dietary intervention studies, thereby obviating the need for animal model work. Both in vitro and in vivo approaches are supported by flow cytometry approaches for quantitative gene probing of microbial genera/species, as well as assessment of different cell phenotypes by cell surface markers, intracellular cytokine or transcription factor expression, apoptosis, cell activation, cell proliferation and differentiation in culture. Metabolites are measured in our Chemical Analysis Facility (NMR, MS). As such, we are able to correlate microbial shifts with functional assessments in response to interventions.

3.2.9 Institute for Cardiovascular and Metabolic Research (ICMR)

ICMR brings together scientists to understand the development of cardiovascular diseases, and the underlying obesity-related metabolic diseases. Facilities in ICMR include *in vitro* and *in vivo* imaging equipment, which include a FlexStation Multi-Mode Microplate Reader and confocal microscopes. Researchers from the Unit and ICMR collaborate to research the impact of nutrition, diet and lifestyle on cardiovascular and metabolic disease risks.

3.2.10 Loddon Observatory

Together with the Department of Geography and Environmental Science, **Hammond** leads the Loddon Observatory, working in collaboration with charities, public sector, business and other research organisations to address 'global' challenges, through co-development of sustainable solutions within the Loddon Catchment e.g. **CALIBRE**: Co-delivery of food and climate regulation from temperate agroforestry (**Lukac**, NERC, £178k) which synergises cross-disciplinary skills in Agriculture, Forestry, Environment, Economics and Policy.

3.2.11 Consumer, Economics and Social Sciences

Economics and social science facilities include a new (2020) and mobile Behavioural and Experimental Social Sciences (BESS) laboratory, extensive computing facilities, virtual environment facilities and monitoring and tracking equipment (e.g. eye tracking) that enables the study of consumer intentions.

3.2.12 Shared Institutional Infrastructure

As well as specialist lab and field infrastructure, our staff use a raft of shared central University facilities including the **Chemical Analysis Facility (CAF)** and the **Centre for Integrated Neuroscience and Neurodynamics (CINN).**

CAF is a state-of-the-art instrument facility that provides NMR spectroscopy, mass spectrometry, X-Ray diffraction and scattering, vibrational spectroscopy, thermal analysis, electron microscopy, X-ray microanalysis, spectroscopic imaging (Infra-red, Raman), visible light microscopy and scanning probe microscopy (AFM). Within the Unit, the facility is used to analyse of diverse subjects including

environmental pollutants, food contaminants, food structure, phytochemical/metabolite identification/quantification, and design of complex polymers for the horticultural industry.

Facilities in **CINN** include a 3-Tesla Siemens Trio research-dedicated functional magnetic resonance imaging (MRI) scanner; two high-density electroencephalography (EEG) systems, a high-resolution MRI-compatible audio-visual stimulus display systems, with integrated high-speed eye tracking; a MRI- and EEG-compatible transcranial magnetic stimulation (TMS) system and MRI-compatible bioelectric physiological recording system.

In addition to these two specialist facilities, the following are also available to us:

- Relevant Library and Collections resources in the **Museum of English Rural Life.**
- The University's new (2020/21) Health and Life Sciences building provides new laboratories and experimental facilities.
- The University's Thames Valley Science Park is the base for >80 start-up and established companies, many of whom collaborate with our researchers e.g. Clasado, Dextra Laboratories, Herbalife.
- We have collaborative agreements with the **Diamond Light Source (DLS;** FoodBioSystems affiliate partner) and the **national synchrotron science facility**, which have been used by Unit researchers to characterise macromolecules with biological significance.

3.3 Operational and scholarly infrastructure supporting research and impact

3.3.1 Professional Resources

Our IES outlines our professional structures. The Unit works very closely with:

- The **Knowledge Transfer Centre (KTC)** supported the development of 110 industry-partnered projects in the Unit during the REF period.
- **Research and Enterprise Services (RES)** provides guidance and advice from concept to contract, with support tailored to each individual's research specialisms and career stage (see section 2.4). Within RES, the **Impact Team** gives full-lifecycle support for research impact within and beyond the REF.
- **Administrative support for research** is provided by 11 School-based staff who assist academics and researchers with ordering, conference and travel booking, ethics applications, financial management of grants and event/meeting support.

3.3.2 Technical Specialists

We have a large team of highly-skilled technical and laboratory staff who provide vital expertise for our research. Many are specialists in particular areas or methods e.g. operating and managing gut models work, sensory, food or clinical trials, food processing, large animal calorimeter experiments, animal feeding trials and controlled environment crop experiments.

3.4. Significant funds to support strategically important research and impact

3.4.1 Internal Funding Support

We have access to multiple internal funds to support research and infrastructure development within the Unit including:

- The **University Strategic Fund**: supported five academic posts over the period.

- UoR's **Research Endowment Trust Fund** (RETF; ~£1.2million p.a. available to internal projects).
- A targeted **Research Infrastructure Fund (RIF).** University allocations from RIF supported large-scale strategic investments such as the £385K "Plant Resource Use Phenotyping Platform" at Sonning and £100K for tribology, rheology and computerized jaw tracking equipment.
- The Unit has been a priority area for **internally awarded GCRF funding** with £473K awarded during 2018-2020. We have also received >£250K of **University-allocated HEIF funding.**

3.4.2 National Institute of Research in Dairying Trust (NIRD Trust)

We also have unique access to funding from the **NIRD Trust** which is targeted to support research in agriculture and food at the University **(~£100M reserves in 2020).** Over this REF cycle, this has funded **£1.5M** of projects, including large-scale calorimeter chambers for metabolic research in dairy science.

4. Collaboration and contribution to the research base, economy and society

4.1 Working in partnership; developing impact from consortia research

We continue to develop and grow partnerships, having recently signed up to the Global Plant Based Food Ecosystem, and became the first UK partner in the global Menus of Change University Research Collaborative. We have formed a strong partnership with the CGIAR institute ICRISAT, leading to reciprocal staff mobility. Examples of established partnerships during this REF cycle are:

- We were one of five partners who led the European Institute of Innovation & Technology **EIT Food** bid, with the North West Co-Location Centre based in Reading. This is a **7-year €420M** EU-funded food system consortium with 60+ core partners comprising research institutions and food companies across 13 countries in Europe and beyond. Major companies (e.g. Nestle, PepsiCo, Sodexo, Waitrose, Bosch and Siemens) are partners together with many smaller food companies including start-ups. Academic and research partners currently include Universities of Cambridge, Queen's Belfast, Aarhus, Hohenheim, Helsinki, Madrid, Turin and Warsaw, Technical University of Munich, and Quadram Institute. Since commencing in 2017, Reading has undertaken 88 projects with consortium partners developing innovative products and services that directly impact the food industry to improve the food supply chain.
- We are a founding partner (with Universities of Cambridge, East Anglia, Hertfordshire and Lincoln) in the **Ceres Agri-Tech Knowledge Exchange Partnership**, a unique platform founded in 2018 through a **£4.8M Research England Connecting Capability Fund award** to identify, incubate, and run commercially viable agri-tech development projects. Funding is coupled with **>£15M** commitments from technology investors and UoR currently has two projects running.
- We are core members of **Agrimetrics,** a Centre for Agricultural Innovation funded by **Innovate UK** that includes Rothamsted Research, NIAB and SRUC**.** The Scientific Director (**Tiffin**) is Professor of Applied Economics within our Unit. The Centre, based at UoR, provides expertise in data science, smart analytics, bioinformatics and knowledge exchange for the agri-food sector. Agrimetrics has developed commercial innovations such as Field Explorer that uses/connects data from a wide range of sources relevant to agrifood.

- **Rural Business Research** (RBR) is a long-standing consortium (**Universities of Reading, Cambridge, Newcastle and Nottingham, Askam Bryan College, Duchy College**). RBR provides data and information to farmers, policy makers and others. It undertakes the **Defra-funded annual Farm Business Survey** and works closely with government in relation to the provision of farm business, performance, environmental data and statistics to inform policy at national and EU levels, providing valuable benchmarking data for farm businesses. The team at UoR (lead: **Bennett**) has responsibility for RBR operations management, playing a key role in a range of research projects examining land use, rural economy and the farming industry.
- We are consortium members of EU-funded **SmartCow** which integrates important European cattle research infrastructures. CEDAR is a **LEAF (Linking Environment and Farming) Innovation Centre** and has a role in communicating practices to help deliver more sustainable food and farming.
- We led the EU-funded **Cereal Renaissance in Rural Europe: Embedding diversity in organic and low input food systems (CERERE)** involving 26 UK/EU partners. Impact includes discovering the health benefits derived from eating whole and ancient grains such as a significant reduction in the risk of chronic non-communicable diseases.
- The Unit led the **BBSRC FoodWasteNet Network** (2014-2019) and is a key partner in the follow-on **Biomass Biorefinery Network** (2019-2024). The **BBSRC-funded Horticultural Quality and Food Loss Network** (**£500k, 2020-24**) is jointly led by Reading and Cranfield Universities with 19 other universities, research institutes, civil organisations and government departments on its Management and Advisory Boards and already >200 members. These networks include academia, industry and NGOs, providing a collaborative, multidisciplinary approach drawing on our excellent basic science to inform innovative solutions for their sector.
- **Bennett** is part of the coordinating group for the **BBSRC-funded Animal Welfare Research Network,** now in its 6th year of activity and with over 800 scientist members. The network promotes high quality fundamental and applied animal welfare research with particular emphasis on supporting ECRs.
- We were a consortium partner in **PROHEALTH**, **(EU-funded, €11.9M, 2013-2018**), researching sustainable pig and poultry production systems. UoR focused on economics and social science, demonstrating how improved animal health/welfare benefits all actors in the supply chain.
- We are a partner in The **UKRI GCRF TRAde Development and Environment (TRADE) Hub** which aims to make sustainable trade a positive force in the world by tracing its impact throughout supply chains on biodiversity from a biophysical, social, political and economic point of view.

4.1.1 Knowledge Transfer Partnerships

Ten KTPs have been undertaken by the Unit with commercial partners during the period. KTPs and a number of innovative R&D projects undertaken in collaboration with **Ella's Kitchen** have helped support the company throughout its journey from being a start-up to becoming the leading multi-million-pound baby food brand. Simon Dale, Ella's Senior Technical Manager, says "without University of Reading there's no way we could have done it."

4.1.2 NHS Trusts

The University has developed a strong strategic relationship with the **Royal Berkshire NHS Foundation Trust**, which provides access to facilities, patients and clinical samples for collaborative projects, particularly in the area of gut health. The partnership is jointly funded **(£1.15M over 3 years**) with the Unit benefitting from ~£75K for collaborative projects e.g. effects of dietary nitrates on heart health. We are an associate partner in **Southampton's Biomedical Research Centre** funded by the **National Institute for Health Research**. Our role is to supply expertise in relation to food and nutrition.

4.1.3 Training Partnerships (see also section 2.8.2)

We participate in numerous Doctoral Training Partnerships, including:

- The **Food Security DTP** (**2015-2019; £3.4M, BBSRC**) included five partners: Reading, Surrey, Lancaster, Southampton Universities plus Rothamsted Research.
- The **Reading-led FoodBioSystems DTP** (**2019-2024; £12M, BBSRC**) also partners Aberystwyth, Brunel, Cranfield, Queens Belfast and Surrey Universities, plus EIT Food Co-Location Centre North West Ltd, British Nutrition Foundation, Science and Technology Facilities Council Food Network+ and the Diamond Light Source as Associate partners, plus >50 industry, NGOs, learned societies committed to providing CASE placement, training and internship opportunities.
- We are a lead partner in the Science of the Environment: Natural and Anthropogenic Processes, Impacts and Opportunities **SCENARIO DTP** with the University of Surrey (**2014-22; 2019-27, £2.7M, NERC**).
- We are a core partner in the Quantitative & Modelling Skills in Ecology & Evolution **QMEE CDT** with Imperial College (**2017-23, £2.8M, NERC**)

We led the Food Advanced Training Partnership (2012-2018) and Agrifood Training Partnership (2019-present), providing postgraduate level taught and research training to food industry professionals, totalling >£4.1M. Professional development activity has received a further £350k of funding by EIT Food to lead the development of a pan-European framework. These activities are enhanced by our leadership of the Interdisciplinary Food Systems Teaching and Learning (**IFSTAL**) and European Food Systems Education and Training (**EFSET**) (see section 2.8.3).

4.1.4 Industry collaborations

The Unit performs translational research in collaboration with our large industrial partner base, which includes key multinational players in the food system (e.g. Syngenta, John Deere, Arla, PepsiCo, Mars, Nestle) and numerous UK and international SMEs, leading to new concepts and improved products and processes. Moreover, we provide contract services to industry through Centres described in Section 3.2 which have engaged with >100 companies and also offered consultancy (e.g. Jacobs Douwe Egberts, Mars, Mondelez).

4.1.5 Policy Makers and Regulators

We have a substantial track record of engagement with policy issues such as those outlined in section 1.3. In this REF cycle we have responded to emerging Brexit scenarios and policy need for analyses, information and expert opinion, e.g. on co-designing post-Brexit Agricultural Policy and the role of research in UK Parliament.

4.2 Key contributions towards a diverse and inclusive society and improved economy

- Our research contributes to equality and a diverse and inclusive society in the UK and globally. Volunteers from diverse ethnic populations which are reflective of the UK population are recruited into our human nutrition studies, allowing translation of research outcomes to the wider population.
- Over the last three years we have developed close links with the 'Crime Reduction Initiative' and the 'Salvation Army', facilitating new research which engages with vulnerable minorities. Funding has been secured for a pilot intervention study in homeless and minority groups which access food banks in Oxford and London.
- The nutrient analysis database is continually updated with foods from multi-cultural populations, which ensures our ability to accurately determine dietary intake in all groups. Collaborations in Thailand, India, Brazil and Sri Lanka over the past year have allowed evaluation of the interaction between genes, nutrition and health in global populations with an ambition for inclusivity.
- Through a GCRF rapid response project (**Wagstaff**, **Daymond**, **Hadley**) in Dominica we ran training schools and provided field guides to support cocoa orchard recovery post Hurricane Maria; we also provided cocoa germplasm that shows tolerance to tropical diseases of cocoa from the International Cocoa Quarantine Centre.
- In 2019, the University signed a research agreement with ICRISAT to work together on how crops can provide a healthy and sustainable diet for future generations

4.3 Ensuring the sustainability of the discipline

Our size and reputation within our areas of research means that we have a responsibility to act as good academic citizens, contributing to the ongoing sustainability of our disciplines including:

- **Lovegrove** has been a member and Deputy Chair of the UK Scientific Advisory Committee on Nutrition (SACN) advising government and Public Health England on dietary policy; member of the International Life Sciences Institute's working groups (on Nutrition and Cognitive Function; Saturated Fatty Acids and Health (Chair); Diet and Metabolic Syndrome) together with **Spencer;** and an expert advising the European Food Safety Authority (EFSA) with **Kuhnle.**
- **Kuhnle** is a member of the UK Food Standards Agency Committee on Toxicity. **Tiffin, Balcombe** and **Macready** also have advisory roles with the Food Standards Agency.
- **Wagstaff** is on UKRI working groups for Agriculture Food and Health and Covid-19 and Global Food Systems.
- **Srinivasan** advises the Secretariat of the International Treaty on Plant Genetic Resources for Food and Agriculture.
- **Gibson** is a Member of Governance Body, Microbiome Otago, New Zealand; Science Adviser, Tianyi Health Sciences Institute, Zhenjiang, China and Visiting Professor, Imperial College, Institute for Global Health Innovation, London.
- **Bennett** has provided advice to the UK government (both Houses) and other organisations (such as the British Veterinary Association) on economic aspects of farm animal health, welfare and trade, including the implications of Brexit and post-Brexit policy. He has been a Trustee and Member of Council of the foremost animal welfare science charity, the Universities Federation for Animal Welfare, and of the Humane Slaughter Association. He was a member of the Sustainable and Responsible Investment Committee of the Insight

Global Farmland Fund (New York Bank of Mellon) advising on sustainable use of farmland and animal welfare.

- **Rose** provided evidence on the Environmental Land Management scheme to the Environmental Audit Select Committee. He provided information and evidence to the National Food Strategy Team on ways to support the adoption of agricultural innovations by farmers.
- **Robinson** was a board member of the Lancet Countdown and advised the WHO and Wellcome Trust.
- **Reynolds** serves on advisory boards and committees for Defra, British Society of Animal Sciences and as a member of the BBC Rural Affairs Advisory Committee.
- **Ellis** is a Director of the Board of the World Vegetable Center, Chair of the Advisory Board of the UK Vegetable Gene Bank, and a Trustee of the National Fruit Collection Trust.
- **Potts** has served on the UN Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services (IPBES): Co-Chair; European Commission's European Pollinator Monitoring Scheme Expert Group (2018-2020; Chair); Co-Chair of the IUCN Wild Bee Specialist Group of the Species Survival Commission (2020-) and member of the Horizon 2020 Societal Challenge 2 Advisory Group; Defra's Pollinator Expert Advisory Group (2013-2016); Pollinator Advisory Steering Group (2016-); Sustainable Intensification Platform Research Advisory Group (2015-2018); Member of the National Centre for Universities and Business Food Economy Task Force (2013-2015); Advisor to EFSA, European Parliament, DG Agriculture, DG Environment, FAO, CBD, UK Parliamentary Office of Science and Technology (with **Tibbett**); Waitrose Agronomy Group (with **Wagstaff**), Innocent Drinks and Co-op Biodiversity Strategy.

4.4 Influence of our staff

4.4.1 Awards:

- **Keshavan Niranjan** – Distinguished Service Award by the International Association for Engineering and Food (2019); Fellowship of the International Academy of Food Science and Technology (2020)
- **Ian Givens** – BBSRC Innovator of the Year (2015)
- **Vimal Karani** – Nutrition Society Silver Medal (2020)

4.4.2 Membership in Research Council Committees, assessment panels and working groups including:

- Programme Advisory Group for the GFS Food Systems Strategic Priority Fund (**Williams**)
- BBSRC DRINC Steering Group (**Yaqoob**), BBSRC Strategy Panel (**Spencer**), BBSRC Follow-on Funding Committee (**Charalampopoulos**), BBSRC DTP Panel (**Yaqoob**), BBSRC Committee B (**Shaw** Deputy Chair**,** 2015-2019).
- MRC Review Committee; Population and Systems Medicine Board (**Lovegrove**); Global Nutrition Panel (**Yaqoob**).
- Academy of Finland Food Panel (**Wagstaff**, Chair), Swedish Research Council (**Wagstaff**) and REF2021 UoA6 Panel (**Wagstaff**).
- Industry advisory boards e.g. Quaker Pepsico, Kellogg's, Apetito, (**Gibson, Methven, Rastall**).

- Farm Animal Welfare Committee (**Bennett**) chairing the Ethics, Economics, Education and Regulation Committee.
- Advisory Committee for Releases to the Environment ACRE (**Dunwell**, Chair).
- Review panel for the **Spinoza Prize** (**Tibbett**).
- Board of Standards Committee (Australian Academy of Science) 2015-present and sole international partner on the Australian Cooperative Research Centre for Transformations in Mining Economies **(Tibbett).**
- UKRI, DfID-funded global Zoonoses and Emerging Livestock Systems programme M&E group and **the UKRI Zoonoses and One Health Advisory Group (Bennett)**.

4.4.3 Example committee membership of Learned Societies and Associations:

- Nutrition Society, UK and Ireland (**Lovegrove** – President 2019-2023)
- British Grassland Society (**Reynolds** President 2018-19)
- SCI Committee Food Group (**Oruna-Concha, Parker, Mills**)
- AfN Accreditation Committee (**Lovegrove** (Chair 2014-2019), **Clegg**)
- International Scientific Association for Probiotics and Prebiotics (**Gibson**, Co-Founder and Board Member)
- Member of Advisory Board of the Agricultural Economics Society (**Tranter**)

4.4.4 Organisation of conferences:

Staff have led the scientific organisation of numerous national and international conferences (e.g. the Pangborn Sensory Science, Weurman Flavour Research symposia, Total Food International, Food Chemistry, Nutrition Society, Gordon Research, Eucarpia Leafy Vegetables and Royal Society of Chemistry conferences.

4.4.5 Editorships:

Several staff are Editor-in-Chief and Editor in high impact factor journals such as Journal of the Science of Food and Agriculture (**Hadley,** Executive Editor), Nutrition and Aging (**Spencer**, Editor-in-Chief), Journal of Food Engineering (**Niranjan**), Food Chemistry (**Elmore, Charalampopoulos**), Journal of Molecular Horticulture (**Wagstaff**), Soil Research (**Tibbett,** Editor-in-Chief), European Journal of Nutrition (**Kuhnle**) and Environmental and Resource Economics (**Robinson**, Co-Editor), Journal of Food Composition and Analysis (**Elmore**, Editor-in-Chief).

4.4.6 Public Engagement

Every year, Unit staff participate in numerous international conferences, give public lectures, contribute to broadcast media, and are involved in strategic events that raise our research profile (e.g. Food Matters Live, Royal County of Berkshire Show).

- In 2014, we led gut microbiology demonstrations at Universities Week (Natural History Museum, London) and BBSRC's Great British Bioscience Festival. The latter resulted in the 'Colon Café' exhibit, now housed at Winchester Science Museum. From 2015-2016, the Reading gut model was present in the Science Museum, London as part of an exhibition on cravings, reaching >6m visitors, then moving to the Manchester Science and Industry Museum.

- A regular exhibition at Kew Gardens, highlighting the importance of pollinators to the food we eat, reaches more than 2,000 visitors each year.
- Exhibits at the Royal Society Summer Science Exhibition and the Soil Security Programme (SSP) highlighted our soils research, reaching 14,000 visitors, including 2,500 school children.
- Our research has been highlighted by BBC and independent radio and television stations in the UK and elsewhere, and many times in the printed press. Examples include Jimmy's Farm (BBC/C4), Secrets of your Supermarket Food (Channel 5), Horizon (BBC) and the Royal Institution Christmas Lectures.
- Researchers are involved in public engagement communication and education projects, including 'Games of Foods', 'Don't be a Food Waster', 'Food TrustTracker' and 'WeValueFood'; all funded by EIT Food. UoR is a founder member of FutureLearn and the Unit has launched six Online Open Courses (MOOCs) which have engaged over 42000 participants.
- We host regular Open Farm events for local families with activities and displays drawn from our research.