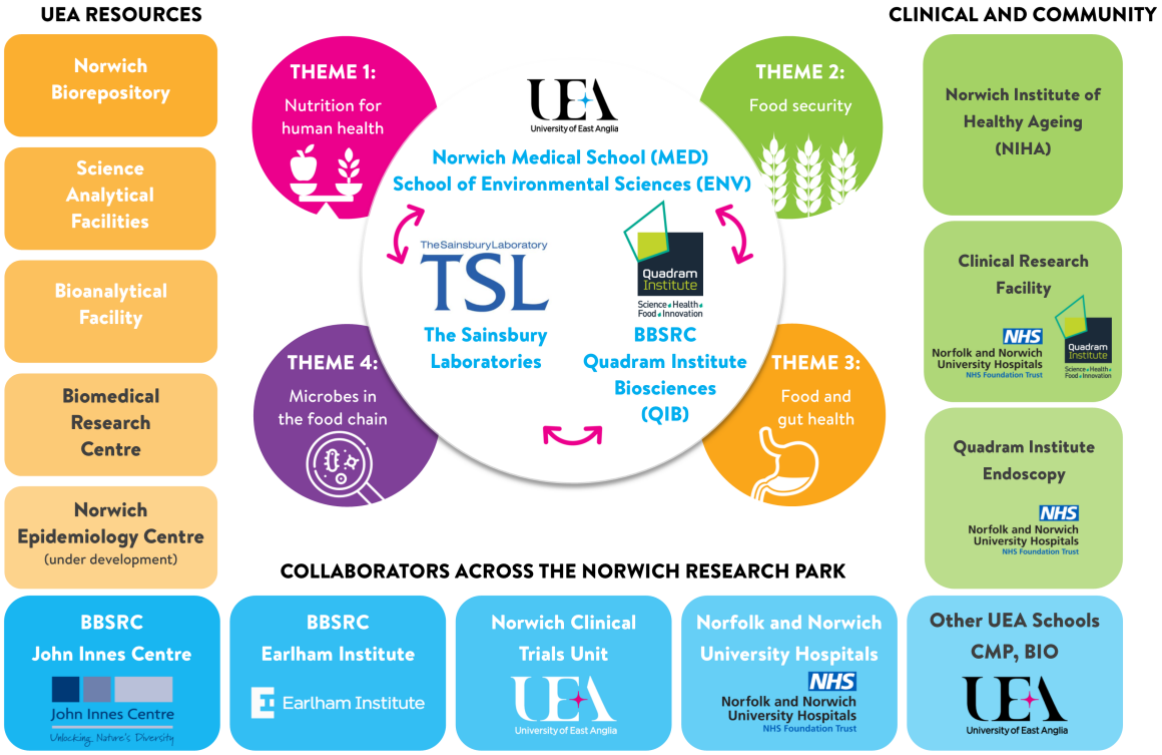
Institution: University of East Anglia

Unit of Assessment: 6 - Agriculture, Food and Veterinary Science

1: Unit Context and Structure, Research and Impact Strategy

Figure 1. Unit Context and Structure



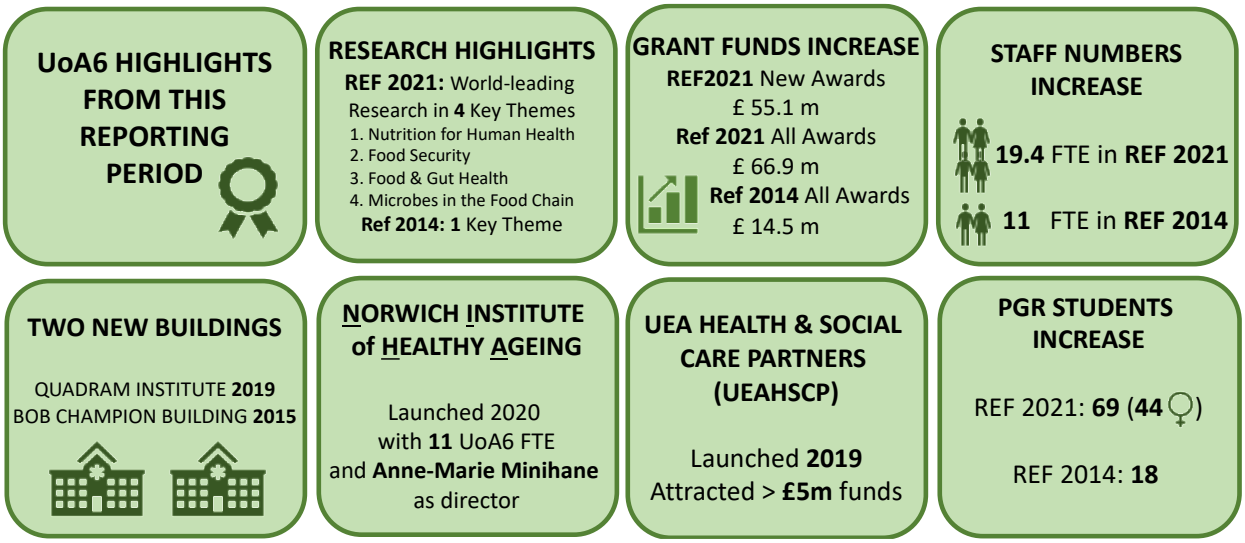
1.1 A research environment enabling excellence-with-impact. Home to the **University of East Anglia (UEA),** a **research-without-boundaries** ethos permeates the **Norwich Research Park (NRP)**. Its 150 companies and 3000 researchers and clinicians include **nine Fellows of the Royal Society** providing a **vibrant environment** for sustained **interdisciplinary research** delivering excellence-with-impact. This submission showcases academics with a common interest in Food and Agriculture from:

- **Norwich Medical School** (**MED**) accomodates **eleven UoA6 academics**. Sitting within the **Faculty of Medicine and Health** (FMH), it is integrated with **Norfolk and Norwich University Hospitals NHS Foundation Trust** (NNUH).
- The **School of Environmental Sciences** (**ENV**) where **Stephen Dorling** works is shedding light on the diverse ways in which weather and climate affect food security.
- **Created in 2016,** the **Quadram Institute Biosciences (QIB)**. With **Ian Charles** as Director, QIB is a state of the art, BBSRC-funded centre for food and gut health. **Seven UoA6 researchers** are based here.
- **The Sainsbury Laboratory (TSL)**, where researchers **Peter van Esse** and **Matthew Moscou** investigate plant-microbe and plant-pathogen interactions vital to global food security.

Our context and structure are shown in Figure 1. We have strong links to our local community through the **UEA Health and Social Care Partners** (**UEAHSCP,** established 2019, Section 3.2) and the **Norwich Institute of Healthy Ageing** (**NIHA**), established 2020 (Section 3.2). Our

REF2021 return for UoA6 comprises 21 academics (13M: 8F, 19.4 FTE) who participate in collaborative and multidisciplinary science. Their work spans molecules to populations - from **farm to fork to faeces.** Our research provides world-class step-changes in our understanding of food and health. Strong national and international impact occurs through excellent links with industries, Non-Governmental Organisations such as the WHO, and Health Care providers. By using our income-generating success to invest in people and infrastructure we have substantially developed this UoA. In a competitive environment we have increased the number of academic research staff from 11 FTE to 19.4 FTE, and our grant awards from £14.5m to £55.1m.

Figure 2. UoA6 Highlights from this REF Reporting Period



1.2 Sustainable progress on strategic goals for research and impact. We address **global strategic challenges** under four themes mapping to the UN Sustainable Development Goals (SDG):

- **Theme 1: Nutrition for human health**, countering the epidemic of **food-related ill health**: 1 in 5 deaths are attributable to poor diet (*SDG3: Good Health and Wellbeing*).
- **Theme 2: Food security**: a pressing challenge with half the global population malnourished (*SDG2: Zero hunger and promote sustainable agriculture*).
- **Theme 3: Food and gut health**, linking food, the gut microbiome and the gut-liver-brain axes (*SDG3)*.
- **Theme 4: Microbes in the food chain**, veterinary science and food intersect as **zoonotic pathogens** menace the health/productivity of our livestock (*SDG2*).

In REF2014 we presented a research strategy that delivered excellence and advanced knowledge in **Theme 1: Nutrition for Human Health**, investigating stratified nutrition, musculoskeletal function, cognitive and cardiometabolic health. The main objectives were to deliver studies examining the impact and mechanisms of dietary components, including flavonoids, dietary fats and micronutrients, on major age-related chronic diseases. Selected research highlights demonstrating that the REF2014 objectives were met are presented in Box 1 and Figure 2.

Through investment in people and infrastructure we have co-ordinated research across the NRP, enabling our world-leading research to encompass three new themes, addressing SDGs, with significant success (Box 2-4). Most UoA6 MED researchers work in the new Bob Champion Research and Education building where they are close to other UoA6 colleagues in the Nearby

QIB and TSL laboratory. Their proximity, facilitates the interaction and collaboration essential for team science, as does the wide variety of research resources available across these three sites (Section 3.2).

1.3 Interdisciplinary and translational research.

Our commitment to interdisciplinary and translational research is epitomised by the establishment of **two vibrant new interdisciplinary institutes**: the **£80m** Quadram Institute (QI, 2019, Section 3.2) containing QIB, and the Norwich Institute of Healthy Ageing (NIHA, 2020, Section 3.2).

The QI Science Strategy Committee, chaired by Pro-Vice-Chancellor Dylan Edwards, has been operating since 2016 and has brought together MED and QIB researchers with clinicians from NNUH and the Biorepository. It has helped steer the recruitment and cross-appointment of staff in this UoA, as well as joint clinical academic posts between UEA and NNUH.
Staff submitted to UoA6 have significant links to industry. For example, **Peter van Esse** works with the 2Blades Foundation whose mission is to carry out fundamental research with industrial partners and bring solutions to market (Section 4.4).

Box 1 (Theme 1): Nutrition for Human Health Research

Dietary strategies for weight management and metabolic complications: **Aedin Cassidy** reported that (i) dietary intake of **flavonoids** is inversely **associated** with **weight gain** (*BMJ* 10.1136/bmj.i17).

Impact of dietary flavonoids on cardiovascular health: A randomised control trial by **Peter Curtis** found consuming one cup of **blueberries** per day in those with metabolic syndrome led to improvements in cardiometabolic biomarkers (*AJCN* 10.1093/ajcn/nqy380).

Plant-based diet and cognition/mental health: **Anne-Marie Minihane's** analysis of the **EPIC-Norfolk** cohort showed associations between a **Mediterranean diet and cognitive function** (*AJCN* 10.1093/ajcn/nqz114)

Micronutrient research: (i) in a multicentre trial **Inez Schoenmakers** reported that **vitamin D taken during pregnancy** did **not** lead to increased bone mineral content in offspring (Lancet Diabetes Endocrinol 10.1016/S2213-8587(16)00044-9), while **Susan Fairweather-Tait** showed that a **Mediterranean-like diet** with **vitamin D3** supplements **reduced the rate of bone loss** (*AJCN* 10.1093/ajcn/nqy122).

Maintenance of skeletal muscle in older age is critical to reducing frailty, falls and fractures. In the **EPIC-Norfolk** cohort **Ailsa Welch** demonstrated strong associations between magnesium intake and skeletal muscle mass (*Clinical Nutrition* 10.1016/j.clnu.2018.01.014).

Box 2 (Theme 2): Food security

Understanding plant defence mechanisms and developing strategies to improve resistance to infection affecting 10-30% of global crops: In *Genome Biology* 10.1186/s13059-018-1392-6) **Matthew Moscou** reported a novel clade among **NRL plant immunity proteins** in grasses.

There are no commercial cultivars with durable resistance to Asian soybean rust: **Peter van Esse** (*Nature Biotechnology,* 10.1038/nbt.3554) reported cloning a pigeonpea gene that confers **resistance to Asian soybean rust**. The soybean is the most economically important bean in the world.

Stephen Dorling's climate modes (*Nature Climate Change,* 10.1038/nclimate2735) predicted significant decreases in annual precipitation for southern Africa by the 2080s leading to **reduced water availability and crop yield** and informed on political and economic strategies to mitigate these effects.

Box 3 (Theme 3): Food and Gut Health

Michael Müller's group showed in *Hepatology* that fine-tuning of **Sirtuin 1** expression is essential to protect the liver from **cholestatic liver disease** (10.1002/hep.30275).

Lindsay Hall reported in *Nature Microbiology* the pioneering use of **long-read metagenomics** to detect and characterise pathogens and antimicrobial drug resistance in preterm infants (10.1038/s41564-019-0626-z).

Simon Carding demonstrated in *Microbiome* that Bacteroides thetaiotaomicron-derived outer membrane vesicles promote regulatory dendritic cell responses in health but not in inflammatory bowel disease (10.1186/s40168-020-00868-z).

Box 4 (Theme 4): investigating Microbes in the Food Chain

Animal gut microbiomes are crucial to the health and productivity of food animals. **Mark Pallen** characterised the **chicken gut microbiome** (*Genome Biology*, 10.1186/s13059-020-1947-1).

In *Genome Research*, **Ian Charles** has pioneered the application of **TraDIS** (Transposon-directed insertion-site sequencing) to identify genes in foodborne pathogens involved in survival (10.1101/gr.254391.119).

1.4 Openness, reproducibility, and integrity in research. Outputs are uploaded within three months of acceptance to the UEA Digital Repository. In compliance with REF requirements, 98% of UoA6 submitted outputs are open access. The university is extending open access to underpinning datasets, facilitating reproducibility. Fourteen UoA6 academics use BioRxiv.org and MedRxiv.org extensively to make information available prior to acceptance.

Researchers are strongly advised to register clinical trials and five UoA6 staff are listed on clinicaltrials.gov (**Anne-Marie Minihane**, **David Vauzour**, **Lindsay Hall**, **Simon Carding**, **Alastair**

Forbes). **I**n line with NIHR requirements, results of trials are made available through publication in peer reviewed journals and NIHR monographs. Requests for access to individual patient data from trials supported by the Norwich Clinical Trial Unit (NCTU, Section 3.2) are considered by the relevant trials oversight committees or by the Chief Investigator and NCTU Executive Committee if the trial has completed.

At University level (see REF5a) UEA maintains a Research Integrity Office and is a signatory of the revised 2019 Universities UK *Concordat to Support Research Integrity* and the *Concordat on Openness in Animal Research*. In 2018, the University revised its Research Ethics Policy and all staff are held to its requirements. At unit level, research integrity and ethical standards are ensured via numerous mechanisms:

- revisions to the UEA level policies are highlighted in our weekly MED bulletin circulated by the Dean. Similar dissemination mechanisms operate at TSL and QIB.
- research involving human subjects and tissues is reviewed as appropriate by the FMH Ethics Committee and/or by the NHS Health Research Authority.
- We place a strong emphasis on the importance of research integrity and ethics in the induction of staff and students.
- UEA Animal Welfare and Ethical Review Body reviews all animal research applications.

1.5 Research plans 2021-2027

Aim: Maintain the NRP as a world-leading centre for research in the four key themes of the unit.

Objectives

1. **Grow Centres of Excellence**
   - 1.1. Continue to invest in technologies and infrastructure.
   - 1.2. Promote interdisciplinary research from molecules to populations, with integration of basic and clinical research.
   - 1.3. Ensure the continued success of NIHA following launch (Section 3.2).
   - 1.4. Launch a Norwich Epidemiology Centre providing infrastructure for data analysis through links to UEA's School of Computing (CMP), to co-ordinate existing NRP databases and to streamline access to publicly available datasets (e.g. UK Biobank, CPRD, ELSA, EPIC, ECLIPSE).
   - 1.5 Continue to effectively communicate the excitement and impact of our research.
2. **Keep Norwich on the world stage**
   - 2.1. Continue to integrate research with common themes from QIB, TSL and UEA.
   - 2.2. Further improve links to partner organisations outside the NRP, building on the UEA Health and Social Care Partnership and building or extending international partnerships.
3. **Promote translation and research impact**
   - 3.1. Further enhance links between epidemiological studies and laboratory science, incorporating state-of-the-art biochemistry, molecular and genetic analyses, cell and animal models and imaging techniques to deliver fresh insights into mechanisms and efficacy of interventions.
   - 3.2. Further enhance links with industry, engage with end-users and establish new partnerships with the NHS.
4. **Continue to enhance the quality of our research, research impact and increase research funding**
5. **Continue building capacity, making Norwich the destination of choice for research**
   - 5.1. Inspire the next generation: Grow our capacity to support Early Career Researchers, improving recruitment and facilitating career development.
   - 5.2. Recruit and/or work with more Clinician Scientists.
   - 5.3. Ensure staff satisfaction and promote an environment that nurtures careers.

5.4. Follow best practice in equality, diversity and inclusion, building on Athena SWAN Silver status successes of BIO, ENV and MED at UEA with the ambition to achieve Gold status. Achieve Athena SWAN status for QIB and TSL.
5.5. Secure additional funding to expand postgraduate research.
5.6. Improve postgraduate training in translational research and in data management/informatics.

1.6 Our Impact strategy.

Over the assessment period, a culture change has seen impact become integral to our activities. To achieve this shift, we:

- appointed **Associate Deans of Innovation** (Michael Hornberger (FMH) and Brian Reid (SCI)) who develop and oversee enterprise links. Opportunities for impact include NRP workshops focussed on the Industrial Strategy Challenge Funds: e.g. Transforming Food with key personnel from the Knowledge Transfer Network.
- appointed a **Royal Society-funded Entrepreneur-in-Residence** (David Dent), former Chair of the BBSRC Follow-on Fund panel.
- identified key stakeholders to enable research translation to impact, including clinical colleagues, industrial partners, and policy makers. Evidence includes the launch of QI (Section 3.2), a direct interface with clinical colleagues, and the TSL 2Blades group led by **Peter van Esse**, which generates industrial partnerships performing proof of concept studies to tackle crop disease (Section 4.4).
- use **impact champions** to identify impact cases. Cases are reviewed annually at the Faculty and PVC level. This structure enabled five excellent Impact Cases to be developed, with two selected for this submission (**Sophien Kamoun** (UoA5) and **Lee Hooper** 1M:1F) using an inclusive, transparent process (Section 4.4)

Approaching REF2021, four workshops were held to allow presentation of potential ICS and assist with writing. **Writing meetings** have been held bimonthly for each ICS, bringing together academics, the UEA Impact Team, the Associate Dean of Research and the Academic Director for Innovation. Throughout this process, academics like **Lee Hooper** applied successfully for funds from the UEA ICS budget.

In addition, we have highlighted the **importance of research impact** through

- Inclusion of impact within staff annual assessments.
- Introduction of annual **university and faculty prizes for Innovation and Impact**.
- Encouragement of UoA6 staff to pursue local **UEA Innovation Proof of Concept Funding** (£9,600 awarded), **UEA Innovation Development Funding** (£65,500), **UEA PVC impact fund** (£42,863), **UEA ADR fund** (no longer run, £1,976), **UEA Associate Dean for Innovation Funds** (£10,565), and **UEA GCRF Faculty Discretionary Funds** (£25,886). Grand total awarded to UoA6 £156,390.
- Pursuing commercialisation opportunities by filing patents protecting intellectual property in multiple countries. We have seven patent filings during this period: including from **Simon Carding**, **Ian Charles**, **Martin Warren** and **Matthew Moscou**.
- TSL received £7.4m from research contracts with commercial companies and £3.4m from patent royalties (**Matthew Moscou**, **Peter van Esse**, Section 4.4).
- Five iCASE PhD studentships funded. These include: **Matthew Moscou** with KWS Saat, focused on disease resistance in wild barley, **Simon Carding** together with EI on Systems Biology of Gut-Microbe Interactions and **Stephen Dorling** with a NERC iCASE Studentship (with the Met Office).
- Impact is rewarded through FMH Faculty Prizes (Section 2.2) and the UEA Impact and Innovation Awards.

2. PEOPLE

2.1 Staffing strategy. A major task was the **recruitment of first-class research staff** to the new **Quadram Institute**, including

- **Ian Charles** as Director
- **Mark Pallen**, **Alison Mather**, **Matthew Gilmour** as leads for the *Microbes in the Food Chain* programme (Theme 4, Section 1.2).
- **Martin Warren** as lead for the *Food Innovation and Health* programme.

- **Ian Charles** and **Martin Warren** have experience of working in **industry**, including start-ups, strengthening our **capacity for impact**. Both were appointed within this REF period.
- **Mark Pallen** is the director of the multi-institutional £7.7m (total) MRC CLIMB and £1.9m (total) CLIMB-BIG-DATA projects, strengthening our capacity in **microbial bioinformatics and genomics**.
- Recruitment of **Alison Mather** in 2017 into a position jointly funded by the **Food Standards Agency** strengthens links with this key government agency.

Efficiency and fairness in recruitment are ensured by regular mandatory in house training in *Recruitment and Selection*, *Diversity in the Workplace* and *Unconscious Bias*. All Category A staff returned to this unit are on long-term contracts. As 12 unit staff (8M, 4F) have now **reached professorial level**, we are **succession planning** by investing in early-to-mid career scientists such as **Gwenaelle Le Gall (ECR)**, **David Vauzour (ECR)**, and **Alison Mather**. This will help us to sustain the vitality and impact of our research. ECR are encouraged to join supervisory teams for PhD students in other groups. They are required to achieve a Postgraduate Certificate of Higher Education Practice, and have reduced teaching for up to 24 months. **ECR are** mentored on writing and submitting grant applications by staff experienced in grant capture, and are encouraged to attend training on grant writing and research supervision.

2.2 Staff Development. Since 2016, we have implemented Best Practice Guidelines for research associates based on the *Concordat to Support the Career Development of Research Staff*. Progress, support and career development are now monitored and implemented through:

- **Annual appraisals: supportive and reflective**, these set future objectives, assess what has hindered past progress,suggest solutions and beneficial training, and help researchers to plan their career progression.
- **Research activity planning** is carried out three times a year by the Director of Research, Associate Dean for Research and the PVC for Research and Innovation. It provides a strategic overview of PhD supervision, grant activity, research impact, and outputs. For QIB, reporting is to the Institute's Science Strategy Board. Research activity reporting informs the development of strategic research objectives, and more recently on the response to COVID-19. For TSL, responsibility lies with the TSL Director in consultation with Research Group Leaders and the external Scientific Advisory Board.

To facilitate career progression, staff have access to over forty **on-site career development courses** provided by the UEA Centre for Staff and Educational Development. Since Sept 2016, MED staff have benefited from **development funds** (~£650 available per person p.a.) to support external training and conferences. Within TSL, investments for training are made on a case by case basis. For example, members of **Peter van Esse's** group attended externally facilitated master classes in scientific leadership and entrepreneurial skills development (£1,500 per person). Within QIB 1.5% of the core BBSRC budget is ring-fenced for training and development for staff at all NRP institutes. Both in house training and external courses are funded.

Since 2014, all staff have been able to attend annual promotion workshops and speak to a promotion mentor to facilitate the promotion process. **Matthew Moscou** and **Peter van Esse**

became Group Leaders at TSL, and **Lindsay Hall** became a Group Leader at QIB. **Ailsa Welch** was promoted to Professor of Nutritional Epidemiology, **Stephen Dorling** to Professor of Meteorology and **Lindsay Hall** to Professor of Intestinal Microbiome.

Our 39 (23F:16M) **research associates (RAs)** are integral to our research activities. They have **protected time** (five days per year) to develop their career aspirations, e.g. attending conferences, careers events and grant-writing workshops, and innovation focussed projects. We are implementing a project to raise the online profile of our RAs by highlighting and celebrating their research knowledge and expertise. From a dedicated fund for staff development, RA beneficiaries within **MED received an average of £920 funding since 2016** to support career development including training opportunities, conference fees and travel costs. Bridging funding is available to bridge gaps between grants and, since 2018, we have offered relocation expenses to RAs. **In a 2018 satisfaction survey, 74% of our RAs said MED is a satisfying place to work.**

Within QIB the **Quadram Institute Post-doctoral Society (QIPS)** is open to and run by post-docs (also open to PhD students). QIPS runs fortnightly Coffee Break informal sessions for its members. The 2Blades Foundation at TSL offers Master classes for postdoctoral scientists which provide a foundation in the skills needed for entrepreneurial or corporate environments. In FMH our Annual Research Prizes recognise the vital work of our RAs and other researchers. Three UoA6 returnees have been successful including one ECR:

- Papers by **Peter Curtis** won £1,000 in 2016 and 2017.
- A paper by **David Vauzour** (ECR) won £1,000 in 2018.
- A paper by **Yongping Bao** won £1,000 in 2018.

UEA and TSL are signatories to the *Technicians Commitment*.

Regular social events are run for staff:

- MED Soirée held monthly
- MED-i-Cake: a monthly social coffee morning
- Coffee Break Science held fortnightly in the QI.
- TSL has regular retreats and social events: these include days out for research groups and meals and parties for the whole lab.

2.3 Postgraduate Students. UEA is an acknowledged leader for doctoral training research and has secured **prestigious DTPs** relevant to UoA6 staff. Successes include PGR appointments from:

- the well-established **BBSRC NRPDTP** now in its third incarnation—the previous programme hosted >165 PhD students, **Matthew Moscou**, **Lindsay Hall** and **Simon Carding** all supervised PGR students on this funding. Related to this are BBSRC iCase PhD studentships (**Matthew Moscou**, **Simon Carding**).
- the recent £5m Wellcome Trust **Edesia: Plants, Food and Health PhD programme**: a unique cross-disciplinary programme from crop to clinic initiated by UoA6's **Aedin Cassidy**. Students are currently rotating in the groups and laboratories of involved academics including **Gwenaelle Le Gall**.

During this REF period 69 PhDs (44F) were supervised by UoA6 academics (34 as primary supervisor). Through our DTPs we have recruited 20 BBSRC NRDTP PhD students. Funding sources for PhD studentships also include BBSRC funding (18), 2Blades funding, John Innes Centre, charities (e.g. Big C), and industry funding (e.g. Unilever).

UEA launched a **Doctoral College** chaired by the PVC for Research and Innovation, to oversee the management, training and co-ordination of activities for all postgraduate students at UEA. Postgraduate students with supervisors in

- MED are overseen by the FMH Graduate School.
- Faculty of Science are overseen by the SCI Graduate School.
- QIB and TSL are managed by the Norwich Bioscience Institutes (NBI) Graduate School.

The training pathway for postgraduate researchers is informed by the **VITAE-Researcher Development Framework**. A collaborative training needs analysis is made with the supervisor 8 weeks after appointment and revisited every year. Each student has access to over 40 modules as well as a training budget of £1000. Training modules are all available to QIB and TSL PhD students via UEA. In addition, QIB and TSL PIPS students (BBSRC DTP funded) undertake a 3-month placement. **The Doctoral Training and Employability Group** reporting to the Doctoral College Executive, meet every month to discuss employability development. They monitor student feedback as measured through the Postgraduate Research Experience Survey. In 2019 85% of students were satisfied with their experience of a research degree programme. UEA and QIB PGR students can participate in **i-Teams**, gaining experience outside of academia with training in commercial awareness. UEA has two career advisers dedicated to working with PGR students, including providing training sessions on “Self-awareness and Exploration”, “Applying and Doing” and “Launching”.

Our Research Students Forum captures students’ views, needs and feedback and has led to a number of new initiatives, including lunchtime **Bitesize seminars** (two students per month) with pizza and drinks provided. We provide a weekly **Breakfast Club** for networking, as well as an annual high profile external speaker event and an annual FMH PGR conference. Within QIB Quadram Student Forum provide a student voice and helps integrate new and visiting students into the student body.

Originating from an anonymous PGR student survey called the Honesty project in 2015, UEA developed a comprehensive mental health strategy, the COURAGE project, which received £300K in external funding matched by UEA. In 2018 the COURAGE project piloted new approaches to prevention, intervention and cultural change around mental health and wellbeing among PGRs. It is led by UEA and linked with UEA’s Student Union and other partners.

2.4 Equality, Diversity and Inclusion. QIB, TSL and UEA embrace Equality, Diversity and Inclusion in line with UKRI Policies and Standards. Our initiatives span **personal support** (e.g. flexible working and return-to-work strategies), and **practical support** (e.g. mechanisms for changing work practice resulting from changes in circumstance, physical infrastructure changes and technology investment to support disability). The highlights of improvements in Equality and Diversity during this REF period are shown in Figure 3.

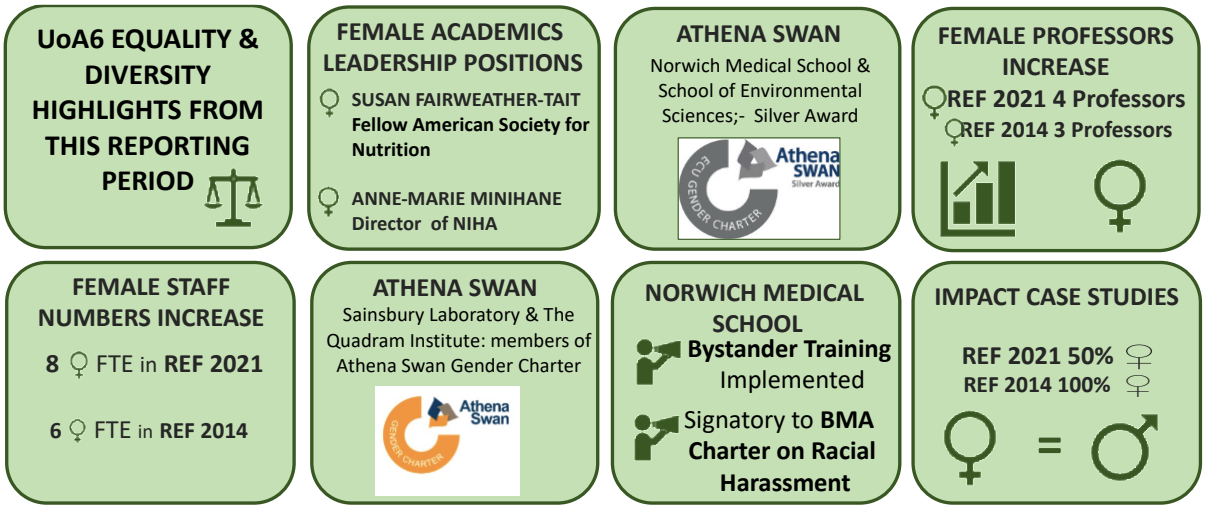
MED and ENV are **Silver Athena SWAN Award holders,** and QI and the TSL are signatories to the Athena SWAN Charter. Developing practices/processes to remove obstacles that prevent female and **Black Asian and Minority Ethnic (BAME)** staff from achieving their full potential is a priority for all institutions with staff submitted to this UoA.

Gender issues are considered in our promotion and rewards systems. We provide annual **Promotions Master Classes** for all staff, successfully **encouraging and supporting females**

to apply for promotion, (three of our female staff were promoted to professor in this REF period). Regular signposting of policies on maternity/paternity, adoption leave and family friendly and flexible working occurs. A Flexible working policy is available at UEA, QIB and TSL; all staff can request flexible working arrangements.

Researchers from across the NRP have access to ResNet a contact, support and information network for women, promoting career development and awareness of employment opportunities for female researchers. **Lindsay Hall** is a committee member for ResNet. In MED, we encourage study leave and staff can apply for one semester of study leave for every six semesters of service. For example, **Anne-Marie Minihane** took a highly productive research sabbatical in 2019, visiting the University of Illinois and Swinburne University Australia, leading to a successful NHMRC Australia, MedWalk grant application (2020-23, total AUD1.8m, **Anne-Marie Minihane** Overseas Chief Investigator).

Figure 3. UoA6 Equality and Diversity Highlights from this REF Reporting Period



Equality and Diversity training is mandatory for all members of staff. Care is taken to ensure all committees - including Health and Safety, Promotion, Ethics – are gender balanced. Key roles including theme leads and project leaders are monitored to ensure gender diversity. **Unconscious Bias training** is compulsory for all school committees and staff with key school roles. All appointment panels contain gender-balanced membership and since 2014 we ensure all recruitment material demonstrates equality and diversity. MED has appointed a Lead for Diversity and Inclusion addressing issues across all protected characteristics, and has set up a **BAME Working Group** Group. This group's activities include include (i) Bystander Intervention Training addressing racism, microaggressions, sexism and trans/homophobia (ii) interventions improving mental health for Ethnically Diverse students, (iii) developing mentorship programmes. MED has signed up to the BMA Charter on Racial Harassment.

3. INCOME, INFRASTRUCTURE AND FACILITIES

3.1 Research Funding. Over the past six years, we have significantly increased research funding:

- **£97m to** construct **new buildings (Section 3.2).**
- **£66.9m** in active grant funding during the assessment period (as PIs, Co-PIs and researchers) including **£55.1m** in new awards (see Fig. 4). As QI Director, **Ian Charles** holds the QIB Core Capability Grant worth **£19.9m** (BBSRC).
- **£8.4m** spent on **equipment infrastructure**.

Figure 4. UoA6 Grant Income in REF2021 Period

Grant Income **All Awards** in REF2021 Period									
BBSRC **£39.3m**	ESRC **£1.2m**	MRC **£1.2m**	EPSRC **£439k**	NIHR **£1.9m**	UK Charities **£2.7m**	UK Government **£1.9m**	UK Industry **£842k**	EU **£1.3m**	Other Sources **£16.0m**
Total Value Awards UoA6: £66.9m									

Grant Income **New Awards** in REF2021 Period									
BBSRC **£34.2m**	ESRC **£1.2m**	MRC **£1.2m**	EPSRC **£439k**	NIHR **£1.4m**	UK Charities **£2.6m**	UK Government **£666k**	UK Industry **£178k**	EU **£609k**	Other Sources **£12.7m**
Total Value Awards UoA6: £55.1m									

UEA's strategy for generating research income is to maintain a supportive culture of grant applications.Two committees of senior FMH academics provide internal peer review and application improvement support prior to submission. Overall success rate in MED (including grants and consultancies) increased from 38% applications successful in 2010-2013 to 55% in 2016-2019. TSL uses an informal network to support grant writing and submissions. QI employs a Grants Facilitation Process (GFP) which includes a monthly ideas clinic, Academic Speed Dating events, a grants knowledgebase folder, and grantsmanship bootcamps. To achieve larger, multi-partner grants (consortia), we apply the same mechanisms, supported by administration from the International Research Project Manager and European Funding Manager within the University's Research and Innovation Services. Our success is demonstrated by the competitively funded **large projects and consortia as shown in Box 5.**

Box 5 Research funding recruited/held by UoA6 academics

Theme 1 Nutrition in Human Health

Anne-Marie Minihane has won BBSRC responsive-mode funding as PI:

- **£436k** *Enhanced cognition through dietary modulation of neuroinflammation in high risk APOE4 carriers* (BB/M004449/1)

Anne-Marie Minihane has won funding as Co-PI on an **NIHR EME project:**

- **£889k** *The efficacy and mechanisms of action of n-3 poly-unsaturated fatty acid supplementation in people with non-steroidal exacerbated airways disease and uncontrolled asthma.* (NIHR129910)

Anne-Marie Minihane has won funding as PI from **Alzheimer's Research UK**

- **£758k** *MedEx research programme* involving UEA, Newcastle University, University of Birmingham and the University of Aberdeen

Theme 2 Food Security

Peter van Esse has been PI of grants to the 2Blades Foundation worth

- **£7.4m** from Corteva/DuPont, Bayer/Monsanto during the REF2021 period.

Theme 3 Food and the Gut

Simon Carding has held a QIB institutional award (BBSRC):

- **£2.3m** *Changes in gut microbe-host interactions and their impact beyond the gut* (BBS/E/F/000PR10355)

Lindsay Hall has held a QIB institutional award (BBSRC):

- **£1.9m** *Determinants of microbe-host responses in the gut across life* (BBS/E/F/000PR10353)

Theme 4 Microbes in the Food Chain

Ian Charles won as PI responsive-mode funding from the BBSRC:

- **£623k** *Understanding the ecology of Listeria and its interactions with microbiomes in food processing facilities to inform biocontrol strategies* (BB/P017282/1)

Mark Pallen has held a QIB institutional award (BBSRC):

- **£1.388m** *Microbial Communities in the Food Chain* (BBS/E/F/000PR10351)
- **£472k** *Microbial pathogens: from Ecology to Synthetic Biology* (BBS/E/F/00044414)

Mark Pallen won funding early 2020 from the MRC:

- **£1.9m** *CLIMB-BIG-DATA: A Cloud Infrastructure for Big-Data Microbial Bioinformatics* (MR/T030062/1) (Section 4.2)

Alison Mather has won responsive-mode funding from the BBSRC as PI:

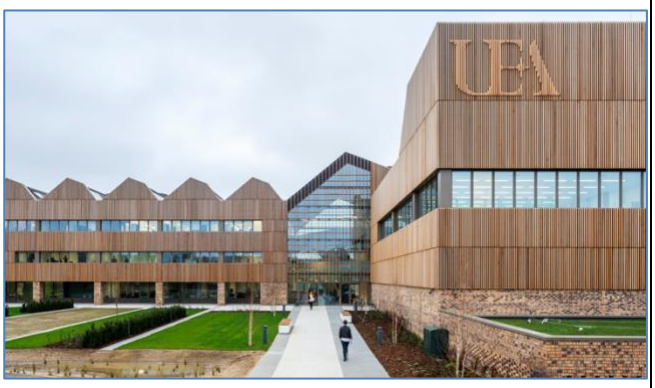
- **£314k** *Drivers and dynamics of antimicrobial resistance and Salmonella in Brazilian pig and poultry production* (BB/S018913/1)

Lindsay Hall has a QIB institutional award (BBSRC):

- **£793k** *Defining foetus-microbiota interactions* (BBS/E/F/00044409)

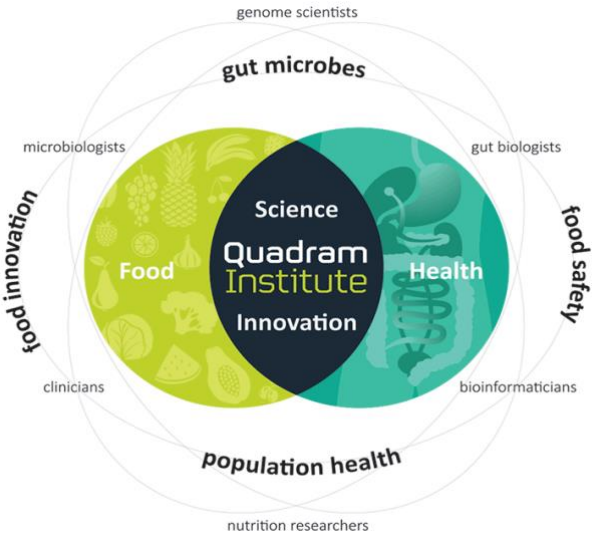
3.2 Infrastructure and Facilities. Our infrastructure includes two **new state-of-the-art** buildings:

The **£17m Bob Champion Research and Education building** (right) opened in Feb 2015. It provides facilities for translational research, including a Biorepository, Cancer Biomarker Diagnostics Laboratory and Mass-spectroscopy Bioanalytical Facility.
It accommodates laboratory-based research on antibiotic resistance and gastrointestinal diseases, including most of the UoA6 MED researchers.



The **£80m Quadram Institute (QI)** — built with funding from BBSRC, UEA, NNUH, and the Institute of Food Research— opened in 2019 to address global challenges in food and gut health. It has three components.

- **Quadram Institute Bioscience (QIB):** researching the composition and structure of food, human digestion and physiology, gut health, immunology, the impact of the microbiome on health and microorganisms throughout the food chain.
- **Quadram Institute Clinical Research:** Norwich's Clinical Research Facility for human intervention studies conducting clinical trials in metabolic medicine, cardiology, neurodegenerative diseases, cancer and gastroenterology.
- **Quadram Institute Endoscopy,** one of the largest gastrointestinal endoscopy units in Europe with 40,000 procedures per annum.



The Quadram Institute's unique interdisciplinary portfolio

Co-location of these two buildings with components in the Norfolk and Norwich University Hospital helps **synergise interactions between basic science themes and clinical research** to deliver a step-change in understanding the role of food in health, and it enhances our ability to carry out **interdisciplinary research on food and gut health**. Recruitment of new world-class researchers to the **QIB** (Section 2.1) underpins the **vitality and sustainability** of our research environment.

Our UoA6 **laboratory research infrastructure** includes the following facilities

- **The Norwich Biorepository** established with the aid of a **£2.1m grant from BBSRC ensures** equal focus is given to preserving human tissue and **the microbiota** within it. The investment included equipment to allow high throughput sample handing, nucleic acid extractions and storage. It also funded bioinformatics equipment, including the **Achiever LIMS** and the **Cogstack** data-management system. The Biorepository collects samples and data for **research projects targeting COVID-19** including the development of an immunisation strategy. It also accommodates large sample sets linked to molecular

data from QIB's BAMBI, (**Lindsay Hall**), MOTION and PEARL studies (**Simon Carding**), documenting the life history of the human gut microbiome.
- UEA's **IT/Computing Service Systems** support research computing including a High-Performance Computing cluster for analysing genome and transcriptome data.
- The **Biomedical Research Centre**, used in collaboration with the School of Biological Sciences (BIO), includes a mouse facility with intravital imaging **and a germ-free unit.**

We access other research facilities across the NRP:
- **Single Cell Analysis** at the Earlham Institute, Sequencing and Bioinformatics at the Earlham and Quadram Institutes.
- **3T-MRI facility** at the NNUH, to which UEA contributed £500k.
- UEA's new £3.4m **Wellcome-Wolfson Brain Imaging Centre (MRI facility)**.
- UEA's **Science Analytical Facility**, with Bio-imaging, Structural Imaging, X-Ray Imaging, NMR, Mass Spectrometry, Elemental Analysis and Stable Isotope Analysis.
- TSL has Mass Spectrometry, Bio-Imaging, Functional Genomics. TSL invested £767k as matched funding to secure a BBSRC grant with JIC for £2.1m for state-of-the-art **Mass Spectrometry Equipment**.
- TSL invested £450k in **Laser Confocal Microscopy**.

We have installed and expanded interdisciplinary structures to ensure our research connects with and impacts the wider society:

The **Norwich Institute of Healthy Ageing**, NIHA), led by **Anne-Marie Minihane** consolidates research links across the NRP. NIHA is home to more than 200 researchers (**Minihane**, **Vauzour**, **Hooper**, **Curtis**, **Carding**, **Müller**, **Welch**, **Schoenmakers**, **Fairweather-Tait**, **Warren** and **Le Gall** from this UoA).

NIHA **enhances our interdisciplinary translational approach**. Its core members are MED, QIB, NNUH, Public Health Norfolk and other local government agencies, Primary Care, East of England population and local SME partners. Nutrition and health sit at the heart of this vital new institute with a focus on
- translation of behavioural change into health (e.g. improving habits around healthy eating, physical activity, smoking, alcohol, sleep, medicine adherence and social isolation).
- bridging the translational 'valley of death' to deliver impact from our discoveries through improved physical and mental health across the population.

The Norwich Clinical Trials Unit (NCTU) was fully registered as a UK Clinical Research Collaboration trials unit in 2013. It has grown from a small unit of 5 staff (2013/14) to over 30 staff (2019/20). The CTU's NIHR grant income has also increased **from £38k per year (2013/14) to >£2.5m per year (2019/20)**. In early 2020, the NCTU had >10,000 patients enrolled in clinical trials and under active follow up from >500 clinical sites throughout the UK and Northern Ireland. The RESTORE ME (**Simon Carding**) and PUFA (**Anne-Marie Minihane**) studies are currently being supported by the NCTU. The NCTU provides training and methodological advancement in trial design, conduct and analysis, and has ongoing

collaborations with researchers at UEA, NNUH, the Norfolk and Suffolk Foundation Trust (mental health), the Norfolk and Waveney CCG (primary care), and the universities of Cambridge, Sussex, Nottingham, Hertfordshire and University College London.

Since 2018 **UEA's IT & Computing Service** has injected additional capital investment in support of a number of key strategic technology initiatives. This totalled £4m in 2018-19, £5m in £2019-20, and will total over £7m for 2020-21.

4. COLLABORATION AND CONTRIBUTION TO THE RESEARCH BASE, ECONOMY AND SOCIETY

4.1 Research collaborations are essential for tackling strategic challenges and are **tightly integrated with external organisations** including

- other academic institutions (e.g. Eastern Arc)
- the NHS, especially NNUH
- social care structures
- industry
- government bodies (e.g Food Standard Agency)

To enhance collaboration, we established the **UEA Health and Social Care Partnership (UEAHSCP)** in 2019. This formal partnership comprises 12 health and social care organisations with 45k staff working across East Anglia. Within two years, UEAHSPC has invested £200k and attracted over £5m in research funding for activity aligned to the needs of our local population, including UEA-led NIHR grants of £2.4m and £1.93m. It provided seedcorn funding for projects led by UoA6 researchers: £7.5k for **Alastair Forbes'**, MALNUT project, £5.5k for **Inez Schoenmakers'** Vitamin D project and £15.5k for **Ailsa Welch's** Child Nutrition Project.

The Eastern Arc (easternarc.ac.uk) is a collaborative initiative linking Universities at East Anglia, Kent and Essex. Since 2019, it has injected £70k into joint projects. An exciting collaborative project between QIB and University of Kent is looking at new approaches for COVID-19 vaccine delivery (section 4.4).

4.2 National/international collaborations/networks led by UoA6 staff

Anne-Marie Minihane is involved in the **APPLE Tree programme** (Active Prevention in People at risk of dementia through lifestyle, behaviour change and technology to build resilience), the MRC-funded **NuBrain** (UK consortium for optimal nutrition for healthy brain ageing) and the Alzheimer's Research UK funded **MedEx-UK** (The Mediterranean Diet, Exercise and Dementia Risk Reduction Programme).

Aedin Cassidy and **Susan Fairweather-Tait** participated in the €12m EU FP7 NU-AGE project *New Dietary Strategies Addressing the Specific Needs of the Elderly Population for Healthy Ageing in Europe*, encompassing a **large multidisciplinary consortium** (**30 partners** from **16 EU countries**) involving nutritionists, biogerontologists, immunologists and molecular biologists from the most prestigious institutions in Europe, five large food industries, eight traditional food companies and one biotech SME.

David Vauzour and collaborators from QIB, Earlham Institute, Nottingham Trent University, and the Universities of Milan, Florence, and Siena, performed research highlighting the paramount importance of the gut-brain axis in ageing. This research provides a strong rationale to devise therapies aiming to restore a young-like microbiota to improve cognitive functions and combat the declining quality of life in the elderly.

Inez Schoenmakers collaborated on vitamin D and maternal and neonatal health with the Universities and MRC units of Cambridge, Southampton, Oxford, Sheffield and Gothenburg.

Yongping Bao collaborates on enhanced anti-cancer activity of nano-sulforaphane with the National Center for Nanoscience and Technology, Beijing.

Lee Hooper led **an international team** from the UK, USA, Palestine, Japan, Netherlands, Switzerland, Australia, Sweden and France to undertake the **Cochrane Review** *Clinical symptoms, signs and tests for identification of impending and current water-loss dehydration in older people*.

Mark Pallen led the **MRC CLIMB** project and leads the successor **CLIMB-BIG-DATA project.** Both involve a **consortium of academics and computer scientists** across multiple UK universities (UEA, Warwick, Birmingham, Cardiff, Swansea, Bath, Leicester), together with the QIB and the MRC Unit in the Gambia. CLIMB has

- won **international recognition** via 2017 Wire Readers' Choice Awards in Best Use of High Performance Computing (HPC) in Life Sciences and Best HPC Collaboration in Academia, Government or Industry
- provided **training in bioinformatics** to thousands of academics, students and clinical microbiologists across the UK, Palestine, Gambia and Vietnam.
- become an **essential national capability** for microbiologists in the UK, serving >900 users and >300 research groups scattered across >85 research institutions — from Edinburgh to Exeter, from Belfast to Norwich—spanning universities and government agencies (e.g. PHE, PHW, APHA).

The CLIMB infrastructure was pivotal to UK efforts to **sequence coronavirus genomes**.

Peter van Esse co-coordinated the **International Asian Soybean rust genome sequencing consortium** with eleven research and industry partners in the UK, USA, Germany, France and Brazil. He also supervises international Bayer contracts, which included collaborators in USA and Brazil working on Asian Soybean Rust.

Stephen Dorling is co-investigator on the Horizon 2020 SECLI-FIRM project, *The Added Value of Seasonal Climate Forecasting for Integrated Risk Assessment*, with eight partners from the UK, Italy, Netherlands and France.

4.3 Contribution to the Research Base. Unit members contribute to the sustainability of their disciplines through membership/leadership roles in professional societies, editorial boards, membership of funding panels including MRC, BBSRC and UKRI, peer review of outputs, conference keynote talks, conference organisation, and training research students and postdoctoral researchers:

- **Anne-Marie Minihane** is a member of the REF2021 UoA6 sub-panel. She is a Rank Prize Funds Nutrition Committee Member; Scientific Advisor and Academic Advisor to the Nutrient Optimisation Task Force of ILSI Europe; UK representative on the External Communication and Public Trust working group Federation of European Nutrition Societies (FENS).
- **Michael Müller** is the scientific director of NUGO, an international Association of Universities and Research Institutes focusing on the joint development of the research areas of molecular nutrition, personalised nutrition, nutrigenomics and nutritional systems biology; member of the MRC Population health and System Medicine panel; member of the MRC UK Nutrition Research Partnership panel; member of the scientific evaluation committee for the JPI call "(STAMIFY)". He was a member of BBSRC SAB Bioscience for Health (2014-2019).
- **Michael Müller** and **Susan Fairweather-Tait** were panel members for the MRC GCRF call on Food Nutrition and Health (2019).
- **Susan Fairweather-Tait** served as an expert for the European Food Safety Authority NDA Panel from 2009-2018; was a member of the US National Academies of Sciences

Committee on Harmonization of Methods for Estimating Nutrient Intake References (2017-2018); was appointed chair for a FAO/WHO expert group on nutrient requirements for children (2020-present); is a member of the FSA Advisory Committee on Novel Foods and Processes (2020-2023); member of the new Nordic Nutrition Recommendations Scientific Advisory Group and the Technical Advisory Group for Global Anemia Exemplars; was appointed as Chair of the UK Nutrition and Health Claims Committee (UKNHCC) advising on scientific evidence behind nutrition and health claim applications.

- **Martin Warren** was a member of the BBSRC Appointments Board 2016-2019.
- **Alison Mather** is a member of the Microbiology Society AMR Advisory Group; member of the Scientific Advisory Board (2019-2021) of the Canadian Genomics Research and Development Initiative project on AMR; member of the Wellcome Drug Resistant Infections Epidemiology and Surveillance Panel.
- **David Vauzour** is the ILSI Europe Co-chair of Nutrition and Mental Performance Task Force, and Chair on many expert groups at ILSI.
- **Inez Schoenmakers** is an advisor on vitamin D and nutritional rickets to the WHO and contributed to the NICE and Royal Osteoporosis Society guidelines on Vitamin D.
- **Lee Hooper** is a member of the National Hydration Network; member of the World Health Organization Nutrition Guidance Expert Advisory Group (NUGAG), which develops world nutrition guidance; member of the advisory board of the Cochrane Nutrition group; editor of the Cochrane Heart Group.
- **Lindsay Hall** is a member of Microbiology Society Policy Committee 2018-2019; member of the WHO-Wellcome Trust Expert Advisory Group for nutrition; member of the Wellcome Trust-Royal Society Sir Henry Dale Fellowship Committee (2018); member of the Wellcome Trust Henry Wellcome Basic Science Fellowship Committee (2014-2019).
- **Matthew Moscou** is Co-Vice Chair for the French ANR CES20 panel (scientific grant panel).

Our UoA6 staff and their projects were recognised through Honours, Awards and Prizes:

- **Inez Schoenmakers** won the Academy of Medical Sciences Springboard award in 2016 for her work on Vitamin D.
- **Susan Fairweather-Tait** was elected Fellow of the American Society for Nutrition.
- **Michael Müller** is a member of the editorial board of AJCN and has a visiting professorship for Nutrigenomics at Nanjing Agricultural University, China.
- **Yongping Bao** has a visiting professorship at Harbin Medical University, China.
- **David Vauzour** received the United Arab Emirates Prize for best research department (2018).
- **Alison Mather** was named by BioBeat one of 50 female leaders in healthcare business in the UK (2018) and was recognised with a runner-up prize from the Medical Research Foundation for her work on antimicrobial resistance (2019).
- **Lindsay Hall** received the Society for Applied Microbiology's WH Pierce Prize in 2019, won the Wain Medal (2019), and won the Microbiology Society's Public Engagement Achievement Award (2019).

4.4 Contribution to the Economy and Society. The unit has five active Impact Case Studies, exemplifying the unit's wider contribution to the economy and society. Two of these were selected for submission. Highlights of Impact Case Studies not submitted include:

- educational impact of the importance of the microbiota on early development of the gut (**Lindsay Hall**).
- the spin-out company Vinescapes (vinescapes.com), supplying services since 2016 in support of a climate-resilient wine sector in England and Wales (**Stephen Dorling**).
- the introduction of a new model for calculating dietary iron bioavailability and estimates of country-specific values for dietary iron bioavailability (**Susan Fairweather Tait**).
- During the **COVID-19 pandemic**, we have been engaged in relevant research. FMH has a portfolio of 119 COVID-19 projects, many of which benefitted involvement UoA6 academics:

- The CLIMB infrastructure, which **was pivotal to UK efforts to sequence coronavirus genomes**, was developed from a project led by **Mark Pallen** (Section 4.2).
- **Ailsa Welch** participated in a review of Vitamin D and SARS-CoV-2 virus/ COVID-19 http://dx.doi.org/10.1136/bmjnph-2020-000089.
- **Lee Hooper** participated in a review on "community use of face masks and similar barriers to prevent respiratory illness such as COVID-19" https://doi.org/10.2807/1560-7917.ES.2020.25.49.2000725.
- Links between **Simon Carding** and **Martin Warren** and the University of Kent underpin a project using **new approaches for COVID-19 vaccine delivery**, engineering the ability of gut bacteria to generate nanoparticle sized outer membrane vesicles.
- **Simon Carding** is also **member of WHO's COVID-19 Expert Advisory Group on vaccine prioritisation** (2020-present).

Unit members have numerous academic commercial partnerships:

- **Anne-Marie Minihane** has commercial collaborations with Abbott Health Care (CANN) and Unilever on n-3 fatty acids/flavonoid and cognitive health.
- **David Vauzour** is Co-PI on a grant to Florida Citrus and has collaborations with the Activ'Inside, France and BioActor, Netherlands.
- **Lindsay Hall** is PI on Unilever/ BBSRC Development and evolution of the infant human skin microbiome.
- **Matthew Moscou** has a grant from 2Blades Foundation to facilitate interaction with JT (Japan Tobacco) and an iCASE studentship in partnership with KWS SAAT SE & Co (GE) focusing on barley improvement.
- **Peter van Esse** is PI on two grants with Bayer and a collaboration with the crop science division of JT on wheat. Corteva and Bayer plan to produce products based on **Van Esse's** research. **Moscou** and **Van Esse** receive income through 2Blades from a range of companies including Corteva/Bayer, Monsanto/Bayer and JT.
- **Ian Charles** is a board member of Anglia Innovation Partnership LLP (2015-present); Board member of QIB Extra Ltd (2015-present); Non-Executive Director, Genus plc (2018-present). He was a Board member of the Ramaciotti Centre, UNSW, Sydney (2011–2015); member of the Investment Review Committee of the MRCF Venture Fund (2011–2015); SAB member, Oxford Gene Technology PATHSEEK project (2012–2015).
- **Stephen Dorling** is currently Chief Executive of Weatherquest Ltd. The company, which he co-founded in 2000, is headquartered at UEA and supplies weather and climate services to the Food, Energy, Water, Transport and Media sectors. Weatherquest works strategically with Vinescapes, supplying services to the viticulture sector (ICS). He is the UEA lead on the UKRI-funded Climate Resilience in the English Wine Sector (CREWS-UK) project, in collaboration with Wines of Great Britain. Weatherquest was partner on two completed and two ongoing Innovate UK/DfiD funded Agri-Tech R&D projects on UK soft fruit and Kenya vegetable production. Weatherquest provides strategic advice on climatic suitability of crop production.

Through our numerous engagement events over this assessment period, we offered sustained support to science engagement events in our local community. These include annual participation (posters, exhibits) in the Norwich Science Festival and "Pint of Science" Festival, the Dragon Hall Debates and the Norwich Science Café.

Lindsay Hall has been recognised by a UEA Engagement Award 2019 for her "Guardians of the Gut" that represents a microscopic microbial ecosystem hidden inside our bodies as an immersive, interactive walk-through model. The exhibit attracted funding from a Wellcome Trust 'Engagement Fellowship'; a Microbiology Society 'Microbiology in Society' Award 2018; the BBSRC, who provide strategic support to QIB; a QIB 'Impact Accelerator Award'; and the Arts Council England. It was one of only 22 competitively selected stands at the Royal Society Summer Exhibition in 2018, a prestigious event attracting over 11,000 visitors, predominantly UK school groups. It was voted the second most popular exhibit in a survey of children at the event. The exhibit has toured to The Norwich Science Festival and the Latitude Music Festival. **Lindsay Hall** engages the public via many media outlets: she has been interviewed by **BBC Breakfast, BBC2 Horizon, ITV, BBC4 and Radio 4 and 5 live**, as well as the Times, Irish Times and the Eastern Daily Press (EDP). **Lee Hooper** also won the UEA Engagement Award 2019 for her work on the Hydration topic 'DrinKit', a four-part guide developed collaboratively by her team with care home staff from homes in Norfolk and Suffolk. **Lee Hooper** also has a strong media presence, highlighting the limited role of Fish Oil and Omega-3 supplements in supporting human health (BBC news and website, EDP, Irish News, Irish Telegraph and the Sun).

Some other highlights of our engagement activities over the assessment period include

- **Alison Mather** was a specialist lecturer and facilitator at the London International Youth Science Forum in 2015 and 2018.
- **Ailsa Welch** acted as editor for the second edition of the bestselling title from the acclaimed Nutrition Society Textbook series, *Public Health Nutrition* (2017) and has recently written for *The Conversation* Vitamin C could help older adults retain muscle mass (2020).
- **Mark Pallen**, author of *The Rough Guide to Evolution*, has written and published *The Last Days of Smallpox: Tragedy in Birmingham* (2018) and was celebrated in the Microbiology Society's 75th anniversary, 'Why Microbiologists Matter: a digital celebration of the journeys of our members' in 2020.
- **Simon Carding's** talk "Gut bacteria and mind control: to fix your brain, fix your gut!", (Norwich, 2015) received 1 million views and 13,000+ likes on YouTube.