Institution: University of East Anglia

Unit of Assessment: UoA3: Allied Health Professions, Dentistry, Nursing and Pharmacy

1. Unit Context and Structure, Research and Impact Strategy

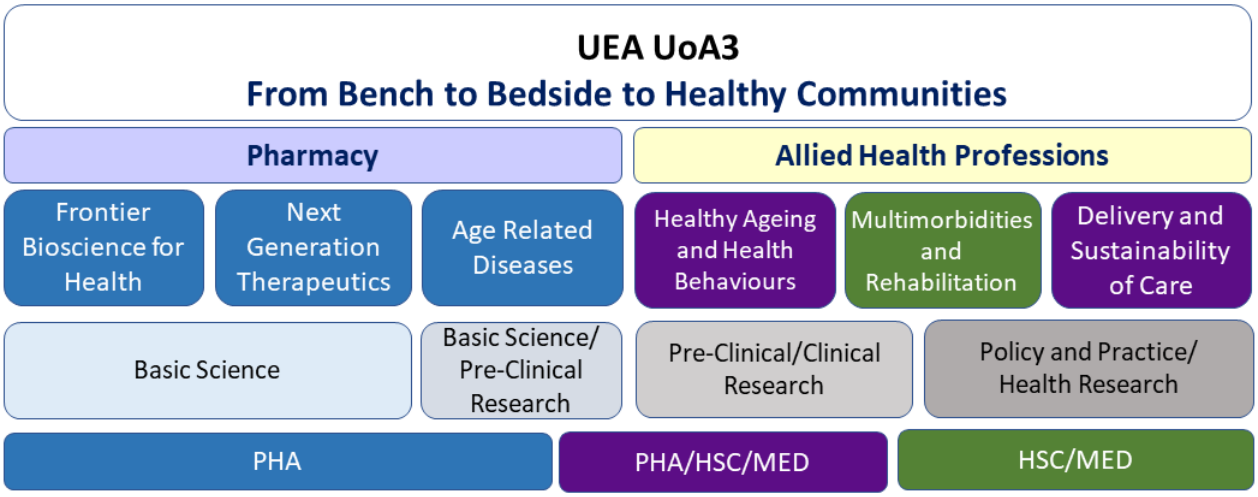
1.1. Context and Structure of the Unit

This submission reports on research and impact activities by 51 staff (47.4 FTE) from the Schools of **Health Sciences** (**HSC**, 27 staff), **Pharmacy** (**PHA**, 22 staff) and **Medicine** (**MED**, 2 staff). The Schools contributing to this Unit of Assessment are in the Faculty of Medicine and Health Sciences (FMH: **HSC** and **MED**) and the Faculty of Science (SCI: **PHA**). We are part of the **Norwich Research Park** (**NRP**); a partnership between UEA, the **Norfolk and Norwich University Hospital** (**NNUH**) and independent research institutes – the **John Innes Centre** (**JIC**), the **Quadram Institute Bioscience** (**QIB**), the **Earlham Institute** (**EI**) (all supported in part by the BBSRC). These partners form an extended campus containing one of Europe's largest concentrations of life science researchers and the Unit plays an integral role in its activities in developing core science and applied health research.

Our research spans **From Bench to Bedside to Healthy Communities** in terms of influence and reach. The activities in **PHA** focus on the fundamental science of developing new medicines (molecules, materials, formulations), understanding the mechanisms of drug action, developing underpinning scientific methods, and medicines management. **HSC** and **MED** focus on understanding the determinants of health and well-being, developing and evaluating interventions to optimise health and well-being and improving and sustaining models for the delivery of care. Together our research addresses global health challenges along the pre-clinical, applied clinical and implementation continuum, with areas of strong collaboration between **PHA**, **HSC** and **MED**.

The unit structures its research into **six overarching themes** across the *Pharmacy* and *Allied Health Professions* spectrum:

- *Frontier Bioscience for Health;*
- *Next Generation Therapeutics;*
- *Age Related Diseases;*
- *Healthy Ageing and Health Behaviours;*
- *Multimorbidities and Rehabilitation*;
- *Delivery and Sustainability of Care*.



Scheme 1. Structure of UoA3 at UEA

Our research community strategy pursues excellence based on synergies between chemical, biological, medical and applied health research, with a focus on particular areas of strength and collaboration across the Unit and beyond.

The unit has grown substantially in size, income, international reach and collaboration with non-academic stakeholders since REF2014 when two submissions were made to UoA3. We have increased our research power over this period through investment in new staff and increased income-generating success. During REF2021 period we have been awarded £45.5M research funding (up from £20.1M, combining the UoA3a and UoA3b submissions for REF2014). Our current UoA3 submission is based on the return of 47.4FTE instead of 28.2FTE in REF2014. Research discoveries across different themes have been published in leading interdisciplinary journals (*Angewandte Chemie*, *BMJ*, *JACS*, *Nature Chemistry*, *Nature Communications*, *PNAS*, *The Lancet*) and subject-specific journals (*Advanced Materials*, *Journal of Immunology*, *Molecular Pharmaceutics*, *Nucleic Acids Research*, *The Lancet Psychiatry*, *The Lancet Respiratory Medicine*).

1.2. Research Strategy, with Review of Past and Future Objectives

1.2.1. Overview and strategy

Our strategic aim is to deliver innovative research that contributes to real world challenges across a wide range of areas in science and health, which has translational capacity for improved human health and welfare. Our research has developed considerably over the assessment period, in line with the plans from REF2014 and aided by a University-wide strategic *root-and-branch review* of our research and impact strategy led by the Pro-Vice Chancellor for Research and Innovation in 2015.

Our research and impact strategy are to:

- Pursue world-leading excellence in research and impact across the **Six Themes**.
- Build upon areas of strength, while remaining flexible to rapidly respond to regional, national and international research priorities.
- Strengthen local collaborations and capitalise on our position working across the NRP and UEA Health and Social Care Partnership.
- Deliver a strategy that recruits outstanding staff and fosters ambition amongst new and existing staff groups.
- Foster the next generation of researchers as contributors to a vibrant academic community.
- Deliver improvements in health and care systems that benefit patients and their carers.

We have a culture of solution-orientated research, creating forums for interdisciplinary discussions, forging external partnerships, and providing leadership. Since REF2014 we established *multi-organisational research networks* to enhance collaboration and develop translational impact:

- **UEA Health and Social Care Partners** (**UEAHSCP**) established in 2019, is a formal partnership of 12 health and social care organisations with 45,000 staff across East Anglia. **UEAHSCP** facilitates early-stage research, innovation and collaboration to improve health and social care in the region, by focussing on healthy ageing, young people's mental health and living with chronic conditions.

• **The Norwich Institute of Healthy Ageing (NIHA**) provides research links across the **NRP**, including Schools in this UoA, the Norwich Medical School, the Norwich Business School and groups from the **QIB** and **JIC**. Partners include **NNUH**, Public Health Norfolk, Local Government and community groups (including **UEAHSCP**). It targets the complex social, economic, geographical, and environmental determinants of health behaviour with the ultimate goal to increase healthy life expectancy and reduce health inequities.

Norwich Cancer Research Network

• The **Norwich Cancer Research Network** (**NCRN**) includes 140 researchers from all NRP organisations and encompasses research from identification of novel therapeutic targets and molecules through to clinical trials and on to public health policy for the prevention and treatment of cancer.

- The **NIHR Applied Research Collaboration** (**ARC**) **East of England** (**EoE**) is a five-year consortium between Cambridgeshire and Peterborough NHS Foundation Trusts, and the Universities of Cambridge, East Anglia, Hertfordshire and Essex along with other regional Trusts, Local Authorities, Regional Sustainability and Transformation Partnerships, patient-led organisations, charities, and industry partners across the region (Section 3.2.2).

Research strengths and successes by themes:

Frontier Bioscience for Health

The unit's research is underpinned by our novel methodologies to probe structure and mechanisms spanning length-scales from molecules and materials to cells and tissues. These extend beyond the remits of biological- and health-focussed research and include:

- Thermal and Imaging methods (**Fabian**, **Qi**, **Round**);
- NMR tools for soft matter and protein-ligand interactions (**Beekman**, **Fabian**, **Khimyak**, **Wallace**);
- Computational and modelling methods (**Fabian**, **Hamilton**, **Khimyak**);
- Nutrition models (**O'Connell**, **Sobolewski**);
- Primary (**Morris**, **Sobolewski**, **Stokes**, **Warren**) and *ex-vivo* 3D (**J Sanderson**) cell models.

BOX 1. Highlights**: Frontier Bioscience for Health**

- **Wallace** developed a novel NMR-based method to determine pKa (*Anal. Chem*. 2018);
- **Round** used innovative single molecule imaging methods to study alginate gelation (*Carbohydrate Polymers* 2016);
- **Khimyak** and **Fabian** used NMR crystallography to understand structure of porous solids (*Chem. Mater*. 2020) and order-disorder transitions in pharmaceuticals (*Angew. Chem.* 2016, *Mol. Pharm.* 2016).

Next Generation Therapeutics

In this interdisciplinary theme we design and develop new molecules, materials (**Fabian**, **Khimyak**, **Round**), formulation approaches and healthcare technologies (**Qi**, **Saeed**, **J Sanderson**) for treatment of complex diseases. Other areas of expertise include:

- Anticancer, Antimalarial and Antimicrobial Agents (**Morris**, **Ganesan**, **Hamilton**, **Searcey**, **O'Connell**);
- Protein-protein and -nucleic acid interactions (**Beekman**, **Searcey**);
- Biologically active natural products (**Gibbons**, **O'Connell**, **Sobolewski**, **Stokes**);
- Epigenetics (**Ganesan**);
- Advances in 3D-printing (**Qi**, **Saeed**).

BOX 2. Highlights: **Next Generation Therapeutics**

- **Beekman** and **Searcey** discovered a highly efficient approach to develop inhibitors of the p53/hDMX or hDM2 interactions (*Chem. Sci*. 2019);
- We developed novel nano-formulations (**Morris**, *Nanoscale* 2018; **Qi**, *Biomaterials* 2019) and graphitic carbon-nitride nanomaterials (**Khimyak**, *Angew. Chem.* 2014);
- **Matthews** *et al*. demonstrated that novel calix[4]arene-based glycoclusters functionalised with galactosides or fucosides protected against *Pseudomonas aeruginosa* infection *in vivo* (*J. Med. Chem*. 2014);
- **O'Connell** *et al*. introduced a novel plant transient transfection technology for rapid preparative access to plant-derived molecules (*Metabolic Engineering* 2017).

Age-Related Diseases

Our activity spans from the identification and validation of new targets, drug discovery and nutrition to new formulations and improvements in patient welfare, with expertise in:

- Cancer (**Ganesan**, **Morris**, **O'Connell**, **Qi**, **Searcey**);
- Inflammation (**O'Connell**, **J Sanderson**, **Sobolewski**);
- Eye-Degenerative Conditions (**Bhattacharya**, **Qi**, **Saeed**, **J Sanderson**);
- Cardiovascular Conditions (**Warren**);
- Patient Adherence (**Bhattacharya**, **Scott**, **Twigg**, **Wright**).

BOX 3. Highlights: **Age-Related Diseases**

- **Warren** demonstrated therapeutic potential of stem cell migration for development of new drugs for vascular diseases (*Aging Cell* 2016, *Cell Death and Differentiation* 2015);
- **Ganesan** showed that NAADP signalling plays a major role in reperfusion-induced cell death and represents a potent pathway for protection against reperfusion injury (*Cardiovascular Research* 2015);
- **Sobolewski** showed that monocytes modulate crypt stem cell number and promote crypt cell proliferation to maintain gut homeostasis (*J. Immunol.* 2017).

Healthy Ageing and Health Behaviours

This theme demonstrates the overlap in research of **PHA** and **HSC** and focuses on developing, evaluating and implementing behaviour change interventions to improve population health and health service delivery. This includes:

- Diet and Physical Activity (**Atkin**, **Deane**, **Hardeman**, **Hanson**, **Sach**);
- Smoking and Alcohol (**Naughton**, **Khadjesari**);
- Medication Usage (**Bhattacharya**, **Wright**, **Twigg**).

BOX 4. Highlights**: Healthy Ageing and Health Behaviours**

- **Hardeman** developed a method to specify behaviour change interventions in terms of component behaviour change techniques (*HTA* 2015);
- **Sach** showed daily emollient use during the first year of life does not prevent eczema in high-risk children and reported an increased risk of skin infections (*Lancet* 2020);
- **Naughton** developed toolboxes to analyse behaviour change in N-of-1 RCT and used it in smoking/tobacco use (MiQuit) (*Addiction* 2017);
- **Twigg** identified patterns of medications use in pregnancy from a multinational perspective (*BMJ Open* 2014).

Multi-morbidities and Rehabilitation

This theme draws together pre-clinical and applied research to understand the complex health and care needs of populations across the life span and find effective treatments, including:

- People with dementia and their carers (**Arthur**, **Cross**, **Kishita**, **Mioshi**, **Poland**, **Richardson**);
- People in residential, palliative and end of life care (**Buck**, **Bunn**, **Farquhar**, **Killett**, **Peryer**, **Poland**);
- Acquired brain injury (**Mares**, **Northcott**, **Pomeroy**, **Sach**);
- Musculoskeletal disorders (**Chester**, **Jerosch-Herold**, **Smith**).

BOX 5. Highlights: **Multi-morbidities and Rehabilitation**

- **Arthur** published the first multi-area direct evidence of a 20% drop in incidence of dementia, mostly observed in men (*Nat. Commun.* 2016);
- **Richardson** and **Arthur** demonstrated a strong association between some classes of anticholinergic drugs and future dementia incidence (*BMJ* 2018);
- **Peryer** evaluated the clinical efficacy of occupational health intervention for care home residents with stroke-related disabilities (*BMJ* 2015).

Delivery and Sustainability of Care

This theme investigates how health and social care can be better organised and delivered (**Buck**, **Killett**, **Murdoch**) to facilitate positive experiences for both service-users and staff, including:

- The informal (carer and volunteer) workforce (**Bunning**, **Farquhar**, **Kamble**, **Kishita**, **Poland**);
- Promotion of staff wellbeing (**Bunn**, **Khadjesari**, **K Sanderson**);
- Innovations in who delivers care (**Bhattacharya**, **Hardeman**, **Scott**, **Wright**).

BOX 6. Highlights**: Delivery and Sustainability of Care**

- **Bhattacharya** and **Scott** developed a hospital Deprescribing Implementation Framework (hDIF) (*Age and Ageing* 2019);
- **Bunn** demonstrated that routine clinical signs and symptoms of dehydration are ineffective in older people living in care homes (*Amer. J. Clin. Nutr.* 2016);
- **Murdoch** identified problems affecting care quality in nurses' use of computer decision support software for telephone triage (*Social Science & Medicine* 2015).

1.2.2. Implementation of Unit's research plans from REF2014

The UoA3 submission is based on the cross-faculty activities of **PHA** and **HSC/MED**. **HSC** was established in 2014, in line with strategic objectives highlighted in the UoA3b submission from UEA. Table 1 describes progress made in achieving the strategic objectives from our UoA3(a/b) REF2014 submissions:

Table 1: REF 2014 strategic objectives

REF2014 objective	Fulfilment
1. *"Pharmacy strategy over the next five years will be to support and nurture internationally leading research in the focused areas". (**PHA**)*	Based on the external and UEA funding we have invested £5.3M into our underpinning research infrastructure (Section 3.2).
2. *"To continue to develop links with local (UEA, NRP) and more distant (UK and International) collaborators." (**PHA**)*	Considerable increase in research funding from international bodies during REF2021 to £3.1M from £1.3M.
3. *"increase research programme grant income and expenditure" (**HSC**)*	Research awards across the whole UoA3 increased from £20.1M to £45.5M (Section 3).
4. *"Expand further our NHS research partnerships." (**HSC**)*	Successful activity in the CLARHC East of England led to the recently awarded **ARC EoE** (Section 3.2.2). **UEAHSCP** has been instrumental in expanding our regional NHS research partnerships.
*5. " Increase substantially the number of successfully completed doctorates." (**HSC/PHA**)*	The number of completed doctorates increased from 66 to 113 across the whole UoA3.
*6. "New Building for Pharmacy…" (**PHA**)*	UEA invested £2.8M into the substantial upgrade of research facilities directly benefiting **PHA** staff (Section 3.2). A new SCI Laboratories Building with dedicated space for **PHA** opened in 2019.
*7. "Develop … international centre of excellence in Acquired Brain Injury" (**HSC**)*	The vision for our brain research became more interdisciplinary. We secured large infrastructure grants to support discovery and clinical application leading to UEA Wellcome-Wolfson Brain Imaging Centre (£3.4M, Section 3.2.1).
*8. "Lead patient and public involvement in research activity" (**HSC**)*	The new **ARC EoE** has a focus theme on PPI and inclusive research.
*9. "Expand our research career pathway activity…" (**HSC**)*	The new **CLACEast** (Section 2.2.3) and **ARC** have significantly expanded the research career pathways for Nursing, Midwifery and Allied Health Professionals in the region.

1.2.3. Research objectives for next 5 years

Building on the Unit's interdisciplinary activities, we have a strong framework for progress in the next REF period. We aim to develop further synergies between fundamental science and applied health research and address global challenges through activities that align with **NRP** and UKRI/NIHR strategies. We are well placed to continue to attract funding from alternative sources including charities, industry and international organisations.

Central to the Unit's sustainability is forging new collaborations within **NRP** and developing our pivotal position within **UEAHSCP** (also Sections 3.2.2 and 4.1). We will continue to make full use of the complementary expertise, facilities and critical mass these provide to succeed in attracting large-scale partnerships (e.g. DTPs, infrastructure) to take integrated approaches to challenges across the bench-to-bedside-to-healthy communities continuum.

Over the next five years we aim to:

- Expand our research footprint via our newly established research centres including the **NIHA**, **Institute for Volunteering Research** (Section 4.3), **Norwich Epidemiology Centre** (Section 4.1) and **NCRN**;
- Grow our activity in addressing pressing global health challenges, including:
  - fundamental causes of disease (inflammation, cancer, cardiovascular and gastrointestinal diseases);
  - development and evaluation of interventions to improve health;
  - developing new tools to combat antimicrobial resistance;
  - promoting healthy wellbeing initiatives for sustainable health;
- Continue to tackle new emerging health and social care priorities, for example, addressing healthcare needs for long-COVID and evaluate service innovations as a result of COVID;
- Consolidate our expertise in advanced computational methods, including machine-learning tools, to facilitate the design of new drugs and materials, to predict their properties and mechanisms of action;
- Innovate in developing experimental methodologies based on our strengths (NMR spectroscopy, MRI, thermal and imaging methods) and recent institutional investment in advanced research facilities;
- Integrate tools such as *in silico* screening, phenotypic assays, artificial intelligence and 'omics approaches to facilitate the discovery of biologically active molecules with new modalities of action including antibody-drug conjugates, allosteric modulators, protein-protein interaction disruptors, multitargeting drugs, protease targeting chimeras and synergistic combination therapy;
- Grow our ICS portfolio through increased breadth and depth of end-user engagement;
- Build upon our current success in Athena SWAN [Bronze (**PHA**), Bronze (**HSC**), Silver (**MED**)] and continue to strive for best practice in Equality, Diversity and Inclusion;
- Facilitate leadership in bidding for large research consortia and interdisciplinary grants.

1.3 Impact: Strategic Goals, Mechanisms and Achievements

The REF2021 period saw a complete culture change to ensure that impact generation became recognised as an integral component of our core activities. We introduced a variety of mechanisms to foster an environment that supports the development of relationships with non-academic end-users, including:

- Identification and development of new Impact Case Studies (**ICS**) facilitated by impact leads in **PHA** (**Morris**) and **HSC** (**K Sanderson**).
- We are supported by six specialist relationship managers within UEA's Research and Innovation team to facilitate translational research.
- Staff are encouraged to pursue translational funding; with multiple staff members having won Industrial Partnerships, Innovation Grants [>10 staff including **Hamilton** (ICS2), **Qi** (ICS3), **Wright** (ICS4)], or consultancies (Section 3.1.2).
- Facilitating developing impact *via* i-CASE studentships and industry-funded PhD awards, we have partnered grants with 12 different businesses including AstraZeneca, Novartis, Ecospray [**Hamilton** (ICS2)], Unilever and Janssen.
- Staff are actively encouraged to pursue impact funding from various *Innovation Development Funds*. UoA3 staff won **£861K** of UEA/NRP funds to develop our impact portfolio (Section 3.1.2).

Box 7. **UoA3 Impact Case Studies**

ICS1: **Bunning** designed a community-based inclusive development project empowering caregivers of children with developmental disabilities in rural Kenya;

ICS2: **Hamilton** established the mode of action of garlic-derived polysulfide compounds underpinning international regulatory approval of polysulfide-containing biopesticides;

ICS3: **Qi** determined the underpinning mechanism of formulation stability for the anti-HIV drug etravirine;

ICS4: **Wright** determined the high risk of medication error in patients with enteral tubes, leading to industrial collaboration and licencing of new liquid drug formulations.

- Our strategy has been to encourage researchers working in clinical practice and policy to contribute expertise to translational activities by accepting invitations, e.g. **Smith** (NICE committees), **Killett** (CQC standards for care homes) and **English** (WHO and industry standards for the diagnosis and monitoring of diabetes via HbA1c measurement).
- Internal training sessions open to all researchers (including PGRs) to build impact capacity, including: stakeholder identification and involvement strategies; impact pathway development; identification of external partners to co-produce and fund research; and impact evidencing.
- An annual review of each registered ICS at both the Faculty and Pro-Vice Chancellor level. As a result, the unit's number of ICSs grew from six in 2014 to >25 in 2020.
- Support and recognition of impact success through workload adjustments, promotion, buy-out of teaching responsibilities and/or leave periods for impact activities. **Bunning**, **Hamilton**, **Saeed** and **Qi** were granted study leave for impact activities.
- Encouragement to enter UEA's annual Innovation and Impact Awards contest. **Bunning**, **Saeed** and **Qi** were recipients of UEA Impact and Innovation Awards.

1.4. UNIT'S APPROACH TO INTERDISCIPLINARY RESEARCH

The unit's strategy embraces interdisciplinary research best suited to deal with complex research questions across our bench-to-bedside-to-healthy communities environment. Our interdisciplinary research themes foster synergies between our subject specific areas in fundamental science (*pharmaceutical materials*; *molecular and cellular pharmacology*; *medicinal chemistry and chemical biology*) and applied health research (*behavioural science, biomechanics, complex intervention development, digital health, implementation science, linguistics, clinical neurophysiology, trial methodology*).

We have extensive links across the **NRP** and with other Schools in UEA [Chemistry, Biology, Engineering, Computing Sciences (i.e. for smartphone app development (**Mares**, Health Foundation, £55K), Law (ASSENT **Bunning**, £378K, Nuffield) and Norwich Business School (**K Sanderson**, ESRC, £659K)]. Examples of interdisciplinary and collaborative research are listed in Section 4.

Specific mechanisms facilitating interdisciplinary research include:

- The establishment of the **UEAHSCP**, **NIHA** and **NCRN** linking us across **NRP** and with regional NHS, public health bodies and local government.
- We share laboratory space and facilities with other Schools (Chemistry, Biological Sciences and Engineering) and across the **NRP**. Our teams also work in the Biomedical Research Centre, which promotes open-plan collaborative workspace for fundamental biomedical research and, via links with **QIB** and **NNUH**, clinical translation into patients.

- The opening of **QIB** in 2018 provided the unit with another research partner focussing on nutrition and health with active collaborations illustrated by several research outputs (*Nature Commun.* 2017, 2018, *PNAS* 2018, 2019, *Nature Food* 2020). Current collaboration in applied health research is focussed on the efficacy and safety of faecal microbiome transplantation [**Atkin** and Carding (**QIB**), RESTORE-ME (Invest in ME, £610K, total)];
- The competitions for BBSRC-funded bioDTP and SCI Studentships encourage supervisory teams from more than one organisation on the **NRP** or from different Schools respectively, thereby actively promoting interdisciplinary PhD projects (examples include collaborations between **UEA**, **QIB** and **JIC**). These are strengthened by recent successful applications to the Wellcome Trust [EDESIA, Plant Food and Health programme (QIB, BIO, **MED** and **PHA**)] and MRC Doctoral Antimicrobial Research Training Studentships (DART) (**NRP** institutes, **MED** and **PHA**).

1.5. Progress towards an Open Research Environment

The unit pursues open research and reproducibility through both University-level processes and unit-level activities e.g. presentations at annual research strategy days and regular staff meetings. All accepted manuscripts are uploaded to the *PURE research information system* and become externally accessible in compliance with REF requirements. A new University-level initiative extends open access to underpinning datasets using *PURE*, facilitating reproducibility. The University also administers UKRI/NIHR and charity funds for open access publication in accordance with funders' requirements.

1.6. Research Integrity and Ethics

The unit strives for exemplary standards of research integrity through a combination of University-level processes and the unit's own activities. 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*. The University recently revised its Research Ethics Policy and all staff adhere to its requirements. At unit level, we instil automatic compliance with the highest research integrity and ethical standards via several mechanisms:

- A proactive Animal Welfare and Ethical Review Board, which reviews all animal research applications for the University.
- A strong emphasis on the paramount importance of research integrity and ethics in all PGR student inductions.
- Research involving the use of human tissues is overseen by the FMH Human Tissue Committee with relevant ethics consideration (**O'Connell**);
- Research ethics requirements are a vital part of patient-facing research in UoA3 [FMH ethics committee: **Buck** (Chair), **Twigg** (Former Deputy Chair), **Scott** (Member)]. For research involving human participants, the University combines our existing high standards with those additionally required by the UK Policy Framework for Health and Social Care Research. The University has Joint Office arrangements with **NNUH** to manage our research governance responsibilities for this group of studies. The University is also a supporting organisation of the AllTrials Campaign.

In addition to promoting best practice in research ethics, we are leading research on how to make research participation more equitable, through a project to develop an ethically sound, legally robust strategy for including adults in research who have impairment of capacity and/or communication (**Bunning**, Nuffield Foundation).

2. PEOPLE

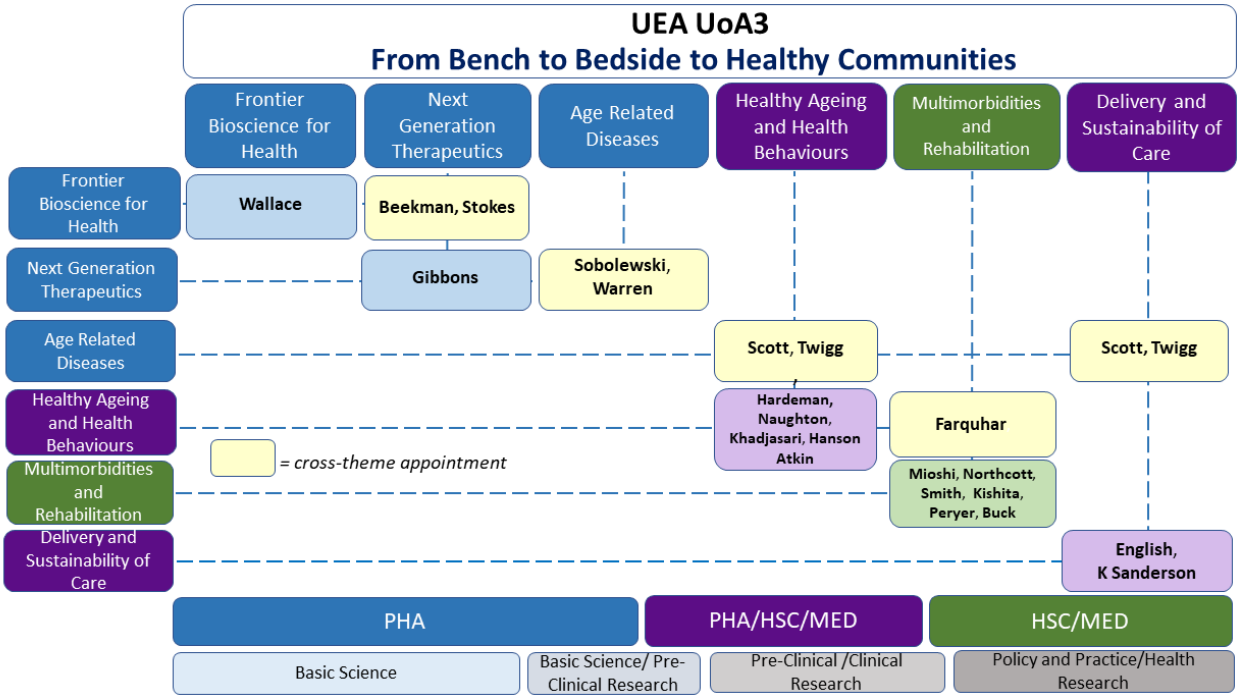
2.1. STAFFING STRATEGY AND STAFF DEVELOPMENT

The Unit's overall strategy for *People* is to facilitate career development of existing research staff at every level and recruit outstanding new staff in open, fair competition and support their career development. This includes mentoring internal and external candidates as they apply for fellowships to be hosted by the Unit. We aim to provide excellent career development for our PGR students and to ensure a research environment with the highest standards of equality, diversity and inclusion. This vision is shared across the three Schools in the Unit.

2.1.1. Staffing and Recruitment Policy

Effectiveness and fairness in recruitment are ensured by mandatory training of all staff in *Recruitment and Selection Processes, Diversity in the Workplace* and *Unconscious Bias*, refreshed every two years.

In the REF2021 period, **22 new faculty research appointments** (12F/10M) were made **to strengthen all Six Themes** across the *Pharmacy* and *Allied Health Professions* spectrum and **develop new areas of excellence**.



Scheme 2. Staffing strategy across UoA3

New Senior Posts include Chairs in:

- Applied Health Research (**K Sanderson**);
- Dementia (**Mioshi**);
- Natural Products (**Gibbons**).

Appointments on Senior Lecturer/Associate Professor (AP) level were made to develop:

- Behavioural Science (**Hardeman** now Professor, **Naughton**);
- Health Promotion (**Khadjesari**);
- Palliative Care (**Farquhar** now Professor);
- Speech and Language Therapy (**Northcott**);
- Physiotherapy (**Smith**).

and at Lecturer level to study:

- Protein-protein Interactions (**Beekman**);
- Behavioural Medicine (**Scott**);
- Gut Immunology (**Sobolewski**);
- Purinergic Pharmacology (**Stokes** now AP);
- Primary Care Pharmacy (**Twigg** now AP);
- Cardiovascular Mechanobiology (**Warren**);
- Dementia (**Kishita** now AP);
- Palliative Pare (**Peryer**);
- Behavioural Epidemiology (**Atkin** now AP);
- Nursing and Clinical Sciences (**English** now AP, **Hanson**, **Buck**).

Wallace joined **PHA** in 2017 as a Research Fellow of the Royal Commission of the 1851 Exhibition and won a prestigious UKRI Future Leaders Fellowship in 2020 to develop novel NMR chemical shift imaging methods to facilitate accelerated drug discovery.

These appointments enhanced our research capability contributing to a high-quality diverse research environment. Researchers who left the Unit since 2014 left academia or retired (7), repatriated (2) or joined other UK HEI (6) and **QIB** (1). Very few staff will reach traditional retirement age before 2027/2028. Whilst the number choosing to retire cannot be predicted, our plan, based on the continued success of UoA3, will be to replace these posts as they arise.

2.1.2. Staff Development and Support

To implement our staff development strategy, we use a suite of mechanisms at University (see REF5a), Faculty and School levels:

- **Annual appraisal** for staff in all categories involved in research:
  - For **academic staff,** including **research fellows**, an annual appraisal is combined with the **Research Activity Planning (RAP) meeting** (covering research and impact) led by the Head of School and Director of Research. The approach is *supportive*: achievements and readiness for career advancement are **celebrated**, and opportunities for support, training and career advancement are identified. Past record (data on outputs, grants, PhD supervision, impact and innovation) and future plans are discussed and agreed for the coming year, encouraging individuals to set realistic targets considering workload commitments. **RAP** meetings inform an **Annual Research Review** overseen by the Associate Deans for Research and the PVC-Research;
  - For **contract research staff**, annual appraisal is typically by the project's PI, but this can be changed on request. Appraisals celebrate achievements and include career development and training needs analysis. For staff on short-term contracts there is a focus on **optimising career development** for further employment. RAs are encouraged to advance to fellowships or faculty positions (within the Schools and elsewhere), exemplified by **Beekman**, **Chester**, **Peryer**, **Scott**, **Twigg** and **Wallace**.

- Training and continuing professional development needs are provided by the Centre for Staff and Educational Development, which offers >200 courses. Since 2014 this includes an **individual development funding scheme** for off-site specialised training requirements.
- The Unit fully supports *UEA's Code of Practice for the Management of Research Staff*, including management guidelines for PIs, which was revised to comply with the new *Concordat to Support the Career Development of Researchers*. UEA now offers financial relocation assistance to new contract research staff. It has also introduced a merit-based promotions process for contract research staff that accords with the revised Concordat,

such that UEA will fund any funding shortfall for merit-based promotions and salary progression awards.

- **Promotions Committees** consider cases for confirmation of appointment and promotion of academic and contract research staff by implementing UEA's processes according to standards of academic excellence in **PHA**, **HSC** and **MED**. Supportive feedback on all applications, with guidance for career advancement, is provided by the Head of School. We reward all staff for outstanding performance and collegiate activities. Timely promotion applications are encouraged by a prompt to discuss promotion in the *Appraiser Checklist* that all staff receive. The effectiveness of our approaches is evidenced by the success of 17 (12F/5M) (of 29) applications for promotion and all 14 (7F/7M) applications for confirmation of appointment. Seven senior internal promotions were made to Chair (6) and Reader (1), all female staff.

- All staff may apply for a semester of study leave to enhance research productivity, every six semesters (out of five study leaves, three were awarded for development of **ICS**).

- During 2020, in response to governmental restrictions arising from **COVID-19**, UEA was quick to enable staff to take home any office equipment. The UEA updates staff regularly on how to access financial support and to maximise safe working practices. All labs underwent stringent risk assessment and staff workload realigned to ensure that government guidance was adhered to. UEA was one of the first few Universities to safely resume laboratory research in May 2020.

- The University launched a new *24/7 Employee Assistance Programme*, providing a confidential service to staff (their spouse/partner and dependants) to help with personal and professional issues that could be affecting home or work life, health, finances, family issues, child or care support. **Naughton** co-founded the *UEA-wide Wellbeing Interest Network* which facilitates uptake of our own wellbeing expertise by the broader UEA community, fosters collaborations and informs the *University's Mental Health Strategic Vision*.

2.1.3. Support for Individuals at the Beginning of their Research Career

Those at the beginning of their research careers are integral to the strategy and success of the Unit (ten UoA3 staff are ECR). On starting at UEA, our staff are supported through multiple common mechanisms:

- **New faculty appointments** receive a formal **induction** led by the Head of School. They are assigned a mentor, who guides them through UEA processes, including probation. New staff benefit from the MA in Higher Education Practice.
- **Newly-appointed contract research staff** receive a formal School induction led by their project PI. A follow-up meeting at 3-6 months ensures 'all is well'. Mentorship by the PI continues throughout the individual's employment, reinforced by the annual appraisal. All contract research staff may request mentorship by a person other than their line manager. Mentorship and training include advice on preparing manuscripts, grant writing, project management and career advancement, student supervisory responsibilities including co-supervision of PhD students.
- Indicative research job descriptions ensure that RA posts are costed at the correct level and that appointments are made on a salary grade commensurate with knowledge and expertise.
- **Contract Research Staff Coordinators** act as points of contact and extra mentors for research staff and report to their School's Executives.
- The Unit supports contract research staff in presenting their work during the **PHA Annual Research Day** and **HSC Festival** attracting staff across SCI and FMH, the **University-**

wide Annual Researcher Summit, and many opportunities to give research talks within the Unit, across the NRP and at national and international events.

- The Unit also runs an **Early Career Researchers Club** and **Buddy** Scheme.
- **Staff are encouraged to apply for externally funded fellowships**. Applicants work with assigned mentors and are guided through the process from grant outline to preparation for the final interview. In addition to success of **Wallace** (Section 2.1.1), Backhouse became Alzheimer's Society Research Fellow in July 2018. We also hosted one Marie-Curie Fellow (Casal until 2020), Delso was awarded a Marie Curie Fellowship in 2020.

These activities complement the support provided to all staff.

- In addition, in **PHA** new faculty appointments receive support through a research start-up fund; priority in Faculty-led PhD studentships competitions and access to DTP competitions; and a lighter teaching load in the first two years of appointment (i.e. 1/3 and 2/3 of full load respectively). This helped our staff to establish their research, demonstrated by their successful New Investigator Awards from EPSRC (**Saeed**) and BBSRC (**Stokes, Warren**).

2.2. RESEARCH STUDENTS

Postgraduate research (PGR) students underpin the research in the Unit and make significant contributions to the Unit's sustainability and vibrancy. The Unit is well represented in doctoral training programs (BBSRC bioDTP, MRC DART i-case DTP), MSc programs (NIHR MSc Clinical Research, HEE CLACEast), networks (NIHR Applied Research Collaboration, formerly Collaboration for Leadership in Applied Health Research & Care). We also recruit students via annual internal competitions (SCI Studentships including those in support of ECR and EPSRC DTA), industrial funding and charities (BHF, Big C). We have successfully adhered to a strategy aimed to increase recruitment, providing 50% matching funding for externally funded students (examples include studentships co-funded by Centre for Pharmacy Postgraduate Education, Boots, Rosemont, Public Health England, Academy of Medical Sciences Springboard and NNUH).

During the REF2021 period **113** PGR students defended their doctorates across UoA3, up from **66** across UoA3(a/b) in REF2014. The size of UoA3 PhD cohort during the REF2021 is 277 students.

2.2.1. Recruitment policy

The recruitment of PGR students adheres to UEA's policies on recruitment and Equality and Diversity (E&D) including its Codes of Practice with respect to Protected Characteristics. We aim to recruit excellent students from as wide and diverse a pool of candidates as possible. Recruitment is via open calls followed by a formal selection process involving, as well as the proposed supervisory team, independent interview panels, Head of School, PGR Director and the PGR Service. The recruitment of PGR students is merit-based with full awareness of the requirement to guarantee equality of opportunity to all. Evidencing the outcomes of this approach, within the Unit there is a good gender balance among PGR students [50%F in **PHA** (sector average (58%F) and 77%F in **HSC** (sector average 62%F)].

2.2.2. Professional Doctorate in Health and Social Care (ProfDHASC)

Building on the career frameworks and applied focus of research training provision in collaboration with local NHS partners, **HSC** introduced (in 2019) a Professional Doctorate option for local capacity building in clinical academic careers, with input and supervision provided by **HSC**/**PHA** staff across the Unit (currently 13 students are following this pathway).

2.2.3. Clinical Academic Careers

UoA3 staff led a £1.6M NIHR Masters Clinical Research programme (2015-2019) (**Arthur**, **Mares**) to build research capacity in nursing, midwifery, allied health professions and Pharmacy with 53 completing, including nine that have secured HEE pre-doctoral bridging awards and four that have secured NIHR doctoral fellowships.

In 2018, the **Clinical Academic Careers East Hub** (CLACEast.net, **Jerosch-Herold**) was developed to host funded internships (HEE £219K p.a.) as part of the NIHR Integrated Clinical Academic (ICA) Pathway. It supported 37 clinical academics in the East of England through Pre-Masters, Pre-Doctoral and Post-Doctoral Bridging awards. Its strategic focus is to continue to build research capacity and capability among the healthcare workforce in collaboration with regional NHS partners, NIHR ARC and academic institutions. These initiatives have resulted in greatly increased application and success rates for prestigious NIHR ICA doctoral awards (four awarded to the UEA).

2.2.4. Support for PGR students

Development of PGR students in UoA3 is overseen by the SCI or FMH Graduate Schools and the **UEA Doctoral College**. In addition to frequent informal meetings, mandatory formal progress meetings occur every 4 months and include an Initial Meeting and a Probationary Meeting within 12 months of starting. The Probationary Meeting has an independent chair and permits formal progression to the PhD programme.

To support them, PGR students have access to a multi-member supervisory team and to the relevant School PGR Director (**Ganesan** (**PHA**) and **English** (**HSC**)). Where the primary supervisor is an ECR, the secondary supervisor must be experienced. All PGR supervisors are required to undertake training in *Best Practice in Research Supervision* every three years. This course focuses on the staff-student relationship and student wellbeing. PGR students have access to the Senior Adviser and Disability Officer, the 'embedded' wellbeing team, which offers drop-in advice and support, and the University's Student Support Services.

PGR students are encouraged to present research findings as part of the **Research Seminar series**, at **PHA annual research day** and **FMH PGR annual conference**, where students participate in a research poster competition and final year students participate in a 3-minute thesis competition. All are encouraged to give oral presentations in the main programme (Best Talk & Poster supported by a Prize). Faculty and School level funding is available via application to enable students to attend external courses and national/international conferences (£5K p.a.). More than 30 students benefitted from this, as well as external conference funds.

2.2.5. Skills and Career Development for PGR Students

The *UEA Code of Practice for Research Degrees* commits to providing transferable skills and employability training, following Roberts “SET for Success” report. All PGR students follow a Training Pathway. This is linked to the *Vitae Researcher Development Framework* and provides a minimum of 10 days full-time training per year, including mandatory training, and offers proposals for broader professional and personal development. These are tailored to individual needs via a *Training Needs Analysis* completed by each student at the start and updated annually as a *Personal and Professional Development Plan*. Training is delivered by a variety of qualified staff, including dedicated Training Coordinators and external providers. It ranges from advanced quantitative and/or technical skills to broader professional skills, responding to the needs of our cross-faculty cohort. It is evidence-based, responsive to students' needs (e.g. via feedback surveys) and inclusive. Specific support for impact and employability is also provided.

Originating from a PGR student survey called the *Honesty Project* in 2015, UEA Student Services developed a **mental health strategy**, the **COURAGE wellbeing project**, which received £300K in external funding matched by UEA. This project, led by UEA, piloted new approaches to prevention, intervention and cultural change around **mental health and wellbeing among PGRs**.

BOX 8. **PGR successes**

- Since 2014 >22 our graduates secured academic posts (in UK and internationally), >20 are in senior research posts in industry and >20 are pursuing research careers as PDRA;
- UoA3 PhD researchers' team won the national BiotechYes2017 competition;
- Bibic (**PHA**, supervised by **Stokes**) was named an American Chemical Society CAS Future Leader;
- Porter (**HSC**) led the student support package for the Catalyst-funded *Courage Project to support PGR mental health* and is now an SRA working on workforce wellbeing;
- Zile (**HSC**, supervised by Porter) works nationally with the SMaRteN network and co-authored a 2020 report on the Vitae/SMaRteN national survey of PGR and ECR wellbeing;
- Bibic, Hlaskova (**PHA**, supervised by **Qi**), Lariviere (**HSC**, supervised by **Poland**) won UEA engagement awards (in 2018, 2020 and 2017 respectively).

2.3. Equality and Diversity (E&D)

The Unit's Schools currently hold Athena SWAN Bronze (**PHA**), Bronze (**HSC**) and Silver (**MED**) awards. **Promoting E&D among all staff is a UEA priority**. Practices and processes are designed to counteract obstacles that may prevent under-represented staff from achieving their full potential. E&D training is mandatory for all staff. Care is taken to ensure all committees – including Research, Promotion, Ethics and recruitment panels – and key School roles are monitored to ensure gender diversity and our recruitment material for all staff demonstrates awareness of E&D issues. These activities are overseen by E&D Committees composed of representatives at all levels, including Heads of School and Directors of Research. The E&D chairs work with the Athena SWAN E&D Project Coordinators in SCI and FMH to ensure sharing of best practice.

UoA3 comprises 59% female staff. The proportion of female staff across *Allied Health Professions* (79%) and *Pharmacy* (32%) is broadly representative of their respective sectors. Women are well represented across all grades.

E&D considerations form an important part of **workload models** in place in the Unit. These models allocate time for research which is transparent to all and accounts for part-time working. Since 2019, **PHA** uses the Faculty of Science Model, which replaced the School-based model. Taking a strategic approach, the model allocates at least 30% of staff time to core research activities as well as nurturing funding success by ensuring all awarded Investigator time is included as workload. **HSC** uses the FMH Academic Activity Model in which all research active staff are given a minimum of 50% of their time for research.

UEA is very attentive to gender issues when considering staff rewards or the submission of cases for increments, regrading or promotion. All staff, including line managers, are required to be aware of the legal obligations concerning maternity/paternity and adoption leave. All staff are regularly signposted to relevant information provided by the Human Resource's Department, including policies on family-friendly and flexible-working guidelines. Staff returning from maternity/adoption leave have a reduced teaching and administration load. Three research staff benefited from the

Return to Work/Family Support Fund designed to assist with their circumstances (i.e. help with care costs while attending conferences).

All staff have access to **ResNet**, a UEA-supported network promoting equality and fairness across the **NRP**. **Qi** and **J Sanderson** were supported to attend *Aurora*, a women-only leadership development programme run by the Leadership Foundation for Higher Education.

UEA has led on Universities UK racial harassment guidance, following up with a BAME Differential Attainment event in June 2019. A working group was established that has since run several projects; a second BAME event took place in June 2020. Three BAME ambassadors are in place across UoA3, with a further two posts due to come across FMH.

2.3.1. E&D in the Construction of the Unit's Submission

The Unit's REF2021 submission has been constructed in compliance with E&D requirements as set out in *UEA's REF2021 Code of Practice*. REF unit decision-makers received *Unconscious Bias training*. Outputs for submission were solicited via open calls and/or discussion with staff. Output quality was assessed at least twice per output in a series of assessments involving internal and/or external assessors and a cross-unit, gender-balanced selection panel. All assessors received instructions according to REF2021 criteria. The external assessment panel was balanced (4F/4M). Anonymous assessment scores were fed back to staff, giving them opportunity for reflection and discussion. Final output selection was overseen by the cross-faculty panel (4F/6M). Four **ICS** and all outputs submitted by the Unit are attributed evenly between male and female staff.

3. Income, Infrastructure and Facilities

3.1. Research Funding

During REF2021 the Unit secured **£45.5M** of research funding across 473 projects, a significant increase compared to **£20.1M** (212 projects) during REF2014. We increased income from all major funding streams: NIHR (£20.4M from £11.5M), UKRI (£8.7M from £2.4M), UK charities (£8.0M from £2.3M), UK industry (£1.6M in from £400K), UK Government (£3.4M from £1.9M) and from international bodies (£3.1M from £1.3M).

3.1.1. Major Research Awards

Our diverse grant portfolio facilitates all research themes supporting fundamental science (UKRI: *EPSRC*, *BBSRC*), EU funding, industry and research charities: (*Diabetes UK, British Heart Foundation, Big C*) and for applied health research (NIHR, UKRI (*MRC*, *ESRC*), research charities: *Cancer Research UK, Alzheimer Research UK, Stroke Association;* NHS trusts). This includes *NIHR senior fellowships* for **Jerosch-Herold** and **Sach**.

BOX 9. **Income Highlights across our Research Themes**

Frontier Bioscience for Health

- **Khimyak** (EPSRC/Innovate UK **GelEnz** consortium (Bristol, Bath, JIC, UEA); £2.6M total, UEA £610K) and **Wallace** (1851 Commission Fellowship, £176K) developed an NMR-based tool kit for soft-matter and biomaterials (*ACS Appl. Mater. Interface* 2018; *ChemComm* 2020).

Next Generation Therapeutics

- From the **DNA-TRAP project** (CEC FP7, €2.4M total, UEA €640K, UEA & Florence and four industrial partners), **Morris** developed DNA-based nanoparticles for antibiotic-resistant bacteria and studied their disposition in the body (*Sci. Rep*. 2017; *Nanoscale* 2018).

Age Related Diseases

- Work by **Searcey** and **O'Connell** on targeted ultrapotent cytotoxics (*J. Org. Chem.* 2015) with potential for targeted cancer therapy is being further developed as part of an EPSRC grant (£450K).

Healthy Ageing and Health Behaviours

- **Wright** led the CHIPPS consortium (with **Arthur**, **Poland** and **Scott**) to study medicines management in care homes in Norfolk, Yorkshire, the Grampians and Northern Ireland (NIHR £1.98M, with NHS Norfolk and Waveney CCG).

Multi-morbidities & Rehabilitation

- **Sach** led health economics assessment on FinCH trial (NIHR, £2M, UEA £1M) that evaluated the Guide to Action Care Home fall prevention programme. She showed that rehabilitation intervention did not increase outdoor mobility following stroke (*HTA* 2014).

Delivery and Sustainability of Care

- **Farquhar** leads SNAP (thesnap.org.uk), a collaborative project (with Cambridge, £261K) that developed person-centred healthcare interventions to help patients identify and address their support needs (*Palliative Medicine* 2019).

3.1.2. Funding for Impact

We pursued several avenues to support our current and future impact activities (see also section 4.2):

- Multiple staff won industrial awards. Notable partnerships include collaboration with Janssen on injectable product development (**Qi**, £300K, partly supporting an ICS3); projects with Rosemont (**Bhattacharya**, **Wright**, £23K, partly supporting ICS4), **Searcey**'s work with Novartis (35K) led to a global patent (WO2016193709A1) that also underpins EPSRC funding (£450K). **Hamilton**'s work on garlic-derived polysulfides supported by BBSRC and Ecospray (£197K) facilitated ICS2.
- The unit's **consultancy income** has grown to **£1.32M** (84 projects) over REF2021 from £248K (9 projects, REF2014). This includes major partnerships with Calpain Therapeutics (**J Sanderson**, £159K), Rosemont Pharmaceuticals (**Wright**, £43K (supporting ICS4)), VisusNano (**Saeed**, £250K), Norwich Consolidated Charities (**Mioshi**, **Kishita**, £43K), Roche Diagnostics & WHO (**English**, £32K), and Pharmaceutical Services Negotiating Committee (**Wright** & **Twigg**, £69K).
- Our Annual Impact Review, with Impact Team support and PVC-Research oversight, provides a gateway to access institutional impact funding. We received £195K from the *Innovation Proof of Concept Fund* (14 projects, including **Hamilton** (ICS2)), £272K from the *Innovation Development Fund* (including **Pomeroy**, **Qi**, **Saeed**), £73.5K from the *ESRC Impact Acceleration Account fund* (including **Bunning** (ICS1)), £117K from *NRP translational fund* (including **Qi**, **Searcey**) and £77K from *HEIF Impact Fund* (including commissioning health economic analysis for ICS3 and ICS4); total **£861K**.
- Support from industry, business and NGOs through their contributions PhD studentships (including CASE awards) was >£125K over the assessment period.

3.1.3. Mechanisms for Generating Research Funding

Our strategy is to generate a **sustainable** income stream for research and impact activities by **mentoring and supporting staff to bid for funding** and enabling an interdisciplinary approach to income generation.

- We help our staff identify funding opportunities across UKRI, NIHR and beyond and promote collaborations (NRP seed-link calls, DTP studentships).
- All our grant proposals >£50k are subject to rigorous and supportive peer-review and sift panels for BBSRC, MRC and NIHR applications that draw upon pan-NRP researcher expertise.
- We collaborate on annual research strategy days and writing workshops to develop strategic goals, highlight existing research opportunities and develop multi-institutional bids and new grant proposals (e.g. EPSRC theme day in 2018). These are organised thematically reflecting strategic research priorities across our six research themes.
- UEA support all projects via the Research and Innovation Services, from inception of the awards to their support, translation and impact.
- We access the **East of England Research Design Service**, located on the UEA campus, which provides free advice and support for the development of applied health and social care research proposals.

3.2. Infrastructure Supporting Research and Impact

The unit's research and impact activities in all themes are undertaken within modern facilities enabling new science and creating theme synergies.

3.2.1. Infrastructure for Fundamental Science and Pre-Clinical Research

Our laboratory-based research is underpinned by core and specialist facilities, indicative of a highly research-intensive unit. Space used by the Unit in SCI has been maintained to a high standard (£2.8M was invested during REF2021 to create new labs, upgrade and maintain essential infrastructure).

We received significant investment (>£2.5M in REF2021) into our Faculty of Science *Instrument Platforms* via applications to Research Councils, UKRI capital equipment funding and co-investment from UEA. *Six Platforms* are of particular significance to UoA3: *X-Ray*, *NMR*, *Mass Spectrometry*, *Elemental Analysis*, *Bio-Imaging* and *Structural Imaging*. Each has an academic lead and dedicated technical staff, providing a direct link for researchers and a lead for instrument development and upgrade. All instruments are available to researchers of the Unit and are utilised for translational research.

- **UEA high-performance computing cluster** is regularly used by the Unit's researchers. Highlights include studies on DNA folding into i-motifs (**Fabian,** *Nucleic Acids Res.* 2018) and phase transitions of pharmaceuticals (**Khimyak**, *Mol. Pharm.* 2016). It has received £520K p.a. continuous investment since 2014 and provides 8312 CPU cores and 10 GPU nodes. Funds for its upgrade with a GPU farm have been secured (UKRI, 2020, £300K) to develop and apply machine learning protocols.
- The **NMR platform** (led by **Khimyak,** also part of *ConnectNMR UK* network) comprises a suite of 6 spectrometers, including a solid-state 400MHz instrument upgraded with fast magic angle spinning probe (EPSRC, 2016, £75K), as well as 800 and 500MHz spectrometers. We secured funds for solid-state NMR capability at 800MHz (UKRI, 2020, £107K), and multinuclear capability for the 500MHz instrument (UKRI, 2020, £82K). The platform enables cutting edge science of soft materials and carbohydrate hydrogels (Section 3.1.1), carbohydrate-protein interactions (Angulo *JACS* 2015), protein-protein interactions and NMR methods development (**Box 1** and Angulo, *Angew. Chem*. 2017).
- The **X-Ray Diffraction platform** benefited from an EPSRC strategic equipment grant (2018, £616K, **Fabian**, **Khimyak**) and follow-on acquisition of a powder X-diffractometer (UKRI, 2019, £140K). This enhanced our capability for research on pharmaceuticals using NMR crystallography (**Box 1**).
- The **Bio-Imaging Platform** benefitted from new confocal and widefield microscopes (UKRI/UEA, £500K in 2019). This facilitates research using image analysis to determine cell morphology (**Sobolewski**, **Warren**) and transforms studies of cell migration and traction force (**Morris**, **Warren**).
- The **Mass Spectrometry platform** was enhanced with an Inductively-Coupled Plasma Mass Spectrometer (BBSRC, £349K, 2017) and a high resolution hybrid MS/MS instrument (BBSRC/UEA, £690K, 2020). Funds for a new MALDI-TOF instrument (EPSRC, £328K, 2020) have been secured, enhancing our research in medicinal chemistry and molecular pharmacology.
- The **Structural Imaging platform** was boosted through a new **Scanning Electron Microscope** (£700K, UKRI, 2019), and upgraded **Transmission Electron Microscope** (UEA, 2015); these facilitated development of nanomaterials and formulations (**Qi** *Biomaterials* 2019).

Alongside our platforms, specific facilities benefit clusters of researchers.

- Medicinal chemists benefit from **GC-MS** (EPSRC/UEA, £50K, 2019); **preparative-HPLC** (UKRI, £80K, 2020); We secured funding for Raman Microscope (EPSRC, 2020, £250K) for pharmaceutical materials and a **Flow Cytometer** for research in pharmacology and chemical biology (UKRI, 2020, £30K).
- **NRP Biorepository** [£2.1M (BBSRC), *part of a new £16.9M Bob Champion Research and Education Building*] facilitates isolation and culture of primary tissues and cells. These include cells from vascular smooth muscle and endothelia (**Warren**), immune cells (**Sobolewski**, **Stokes**), lung epithelia (**Morris**, **Sobolewski**), primary melanocyte/melanoma (**Morris**) and retinas (**J Sanderson**, *Stem Cells* 2018). We have leading expertise in 3D *ex-vivo* models.
- Funds were secured for the **UEA Wellcome-Wolfson Brain Imaging Centre** (UoA4), including a new research-dedicated **3T Magnetic Resonance Imaging Scanner** (£3.4M, UEA, Wellcome Trust, Wolfson Foundation; **Pomeroy**). This expands unit capability to study human cognitive function in early life, adulthood, and in ageing and opens synergies with the NMR cluster.
- The **Movement and Exercise Laboratory** has three cohesive areas for neurophysiology, biomechanics and exercise physiology, and facilitates research on functional and emotional outcomes after transient ischaemic attack (**Mares** *J. Stroke* 2019) and stroke recovery (**Pomeroy** *Neurorehabil. Neural Repair* 2016).

We are supported by **skilful technicians** (11.6 FTE) who provide a wide variety of specialist services. SCI have a 'well-found laboratory' fund, spending £200-£300K p.a. on maintaining or replacing workhorse equipment. UEA's Institutional strategy for replacement of ageing equipment includes the PVC-Research Capital Fund, with a budget of £500K p.a. for co-funding with external bids.

3.2.2. Infrastructure for Applied Health Research

- **UEAHSCP** (Sections 1.2.1 and 4.1) was established to strengthen collaborations with 12 NHS Trusts (including **NNUH**), CCGs, and local government to achieve research income growth through tackling shared priorities. Within two years, **UEAHSCP** invested £200K and attracted over £5M in research funding including NIHR grants CHARMER (£2.4M co-led by **Bhattacharya** and **Wright**) and CARECOACH (£1.92M co-led by Fox (UoA4) and **Cross**).
- The **Norwich Clinical Trials Unit (NCTU)** provides training and methodological advancement in trial design, conduct and analysis. Since 2013 NCTU has grown from five to over 30 staff, with the total value of the NIHR grants to NCTU has increased to >£2.5M (2019/20, the 5th largest income for a clinical trials unit within the NIHR system). **NCTU** facilitated NIHR-funded projects in the Unit: Perfected (**Cross**), CHIPPS (**Poland** and **Wright**), HipHelper (**Smith**), IMPacts and PALMS projects/NIHR fellowship (**Jerosch-Herold**), QUITSense (**Naughton**).
- The **NIHR ARC EoE** (£2.1M to UEA) facilitates applied research addressing specific health or social care needs in our region. This benefited career development of junior research staff across the region including three co-funded PhD scholarships (2 in UoA3) and facilitated a **GCRF** funded workshop for 27 early career dementia researchers in Brazil. **HSC** has very strong links with NIHR/HEE capacity building strategic activity (**Mioshi**, **Jerosch-Herold**) which translates in interlinked opportunities to enhance the research development of students and staff. ARC is supporting RF/SRAs developing their own research programmes: Birt, Beresford and Grotz (**Poland**), **Peryer** (**Farquhar**), and Porter (**K Sanderson**).

- We promote high quality patient, public and stakeholder involvement in our research activity through our partnership with the local Patient and Public Involvement in Research (**PPIRes**) hosted by Norfolk & Waveney CCG. Several UoA3 staff lead in national efforts to set standards for inclusive involvement in research (**Poland**, ARC).

3.2.3. Collaborative Use of Research Infrastructure

Unit researchers are both providers and users of facilities across HEIs. We host research visits from our partners (IMODE (section 4.1.1), GelEnz), and provide expertise for industrial collaborations (DNA-TRAP, **Morris**; **Qi**/Janssen (ICS4)). UoA3 researchers benefit from external facilities; examples include work on the National High-Field Solid-State NMR facility (Warwick) (**Fabian** and **Khimyak** *Angew. Chem.* 2016), using national crystallography and Mass Spec facilities, and Cambridge Crystallographic Data Centre (**Fabian** *Cryst. Growth Des.* 2016).

3.3. E&D Considerations in Supporting Funding Bids and Infrastructure Access

Access to internal research and impact funding, infrastructure and equipment is open to all staff and is based on need and merit. Researchers without grant funding can apply for **subsidised access** to the *Instrument Platforms* to generate 'pilot' data. In line with our overall approach to E&D, we are mindful of avoiding unconscious bias in all decision-making for resource allocation. Our targeted assistance to early career researchers encompasses the whole Unit and covers grant preparation and facilities access.

4. Collaboration and Contribution to the Research Base, Economy and Society

4.1. Research Collaboration

Enabling and expanding research collaboration is central to UoA3 research strategy. Collaboration occurs at all levels, within and across the **Six Themes**, with partners on the **NRP** or local health trusts and externally. The effectiveness of our approach is evidenced by the unit having co-authored 43% of the outputs submitted to REF2021 with international (29 countries) and 65% outputs with UK (>38 institutions) researchers, 20% outputs have NHS co-authors.

We established *multi-organisational research networks* (see Section 1.2) to facilitate collaboration:

- **UEAHSCP** has 13 multi-institution research groups, 6 led by UoA3 staff: palliative care group (**Peryer**), medicines optimisation group (**Wright**), hospital associated deconditioning group (**Hanson**), workforce sustainability group (**K Sanderson**), frailty (**Cross**) and the centre for behavioural and implementation science (**Hardeman**).

- **NIHA** promotes collaborative approach to develop and implement effective strategies to promote sustained population behaviour change, to improve physical and mental wellbeing (**Hardeman** (Executive Group member), along with 14 UoA3 staff).

- **NCRN** is an inclusive community of over 140 cancer scientists, clinicians and public health researchers to develop multidisciplinary collaborations to combat different cancers and share state-of-the-art resources. **O'Connell** sits on the executive; 12 UoA3 staff are **NCRN** members.

We plan to open the **Norwich Epidemiology Centre,** a new collaboration between **HSC**, **MED** and Computing, to support epidemiological research across the **NRP**, particularly for studies using large scale datasets.

4.1.1. Enabling fundamental science and pre-clinical research

Notable **successful NRP collaborations** include the work of **O'Connell** and Osborne (**JIC**) on triterpene biosynthesis and activity (*Box 2*), collaboration of the NMR cluster with Juge, F Warren and Wilde at **QIB** (Sections 1.4, 3.2.1). In collaboration with NNUH, EI and QIB, **Morris** investigated mitochondrial transfer to stem cells in response to infection (*PNAS* 2019). **O'Connell** and **Searcey** have a long-standing collaboration with Bochmann (UoA8) to study anticancer gold (III) complexes (e.g. *Inorg. Chem*. 2017). Internationally, **Matthews** and Vidal (Lyon) developed antibacterial glycol-clusters (*Chem. Eur. J.* 2016, 2018). EU-funded IMODE network (UEA, UCL, Greenwich, Lille, Gent) facilitated **Qi** and **Fabian**'s work on innovative pharmaceutical technologies leading to >5 outputs. Our training and teaching programmes with Taiwan (**O'Connell**, **Searcey**, BBSRC) and Vietnam (**Matthews**, British Council) enhanced our international research profile.

4.1.2. Collaborations in applied health research

A highly collaborative research culture in UoA3 is further evidenced by our participation in **NIHR projects** and **clinical trials** (>90 NIHR projects, with >40 grants over £150K funding to UoA3). UoA3 staff are involved in NIHR **ARC EoE** (Section 3) and **UEAHSCP**. UoA3 research themes align well with the **ARC**'s research priorities and are led by our staff, i.e. *palliative and end of life care* (**Farquhar**), *mental health over the life course* (**K Sanderson**) and *inclusive involvement of research for practice-led health and social care* (**Poland**). **Mioshi** is **ARC EoE** deputy director.

In addition to those listed in Sections 1 and 3, notable partnerships from health research grants include:

- **Cross**, **Poland** and **Smith** are part of PERFECTED program (NHIR, PfGAR grant, £2M total) aimed to improve hospital care for people with dementia admitted with a fractured hip.
- **Kishita** leads the iACT4CARERS study (NIHR £233K total, with UCL and Uppsala) aimed at supporting carers of people with dementia, who are at high risk of depression and anxiety.
- **Bhattacharya**, **Hardeman** and **Naughton** investigated low-cost interventions to support medication adherence of people prescribed anti-hypertensive treatment in primary care (PAM) (NIHR, £2.1M total).
- **Jerosch-Herold** led development of a new patient-reported outcome measure (I-HaND; *J. Hand Surgery* 2018) used as primary outcome in Digital Nerve Repair trial (NIHR £1.2M total led by Oxford).
- As an OMERACT fellow, **Smith** led a UK/Australia/Canada collaboration in the development of a core outcome set for hip and knee osteoarthritis, agreed for use in clinical trials (*Ann. Rheum. Dis.* 2016).

4.2. IMPACT: RELATIONSHIPS AND CONTRIBUTIONS

Our four submitted ICS (Box 7) are representative of our diverse portfolio of >25 active **ICS** that exemplify our contribution to the economy and society. We are engaging non-academic end-users to develop our research impact pipeline:

- **Smith** identified that people do not increase levels of physical activity following hip or knee replacement and provided recommendations on strategies to improve this (now implemented in regional NHS trusts).
- **Sach** led the CLOTHES trial, showing that prescription of silk garments was not cost-effective (implemented by the majority of NHS CCG).
- **Pomeroy** and **Mares** lead the development of neuroscience-based physiotherapy and service improvements using innovative Apps to translate research findings into clinical practice.
- In the NIHR-funded ResPECT study, **Killett** investigated the causes and impact of abuse and neglect in care homes, informing the CQC on care home inspection processes.
- **Wright** & **Twigg** worked with the Community Pharmacy Futures group (including Boots UK, Lloyds and Well) to develop services in diabetes, COPD and multiple medications.
- **Wright** contributed to The King's Fund "Murray Review" by evaluating the cost-effectiveness of community pharmacy interventions. As a result, a minor ailments service is now recommended for local/national commissioning.

Our industrial links underpin future impact activities. Examples (in addition to those in Section 3.1.2) include:

- Collaborations with leading international manufacturers of contact lenses using 3D printing (**Qi** and **J Sanderson**, £230K industrial funding) and ocular implants (**Saeed**, EPSRC award);
- **O'Connell**'s BBSRC-funded work with food and drinks companies (Unilever and Pepsi Co.) to examine if the beneficial cardiovascular health effects of flavonoids result from synergy at cellular levels**;**
- **Qi**, **J Sanderson** and **Bhattacharya** collaborate with the **NNUH** on development of drug-eluting contact lenses (NIHR, underpinned by *BMC Ophthalmology* 2014 and *Stem Cells* 2017).

The success of our industrial interactions is evidenced by the scale and breadth of grant funding success and output co-authorship. >40 peer-reviewed outputs were co-authored with industrial/other non-academic partners.

4.3. Engagement with Diverse Communities

Through events and social media, we communicate our research and impact achievements to the widest possible audience, including school children, local societies and the national/international public.

- As part of NIHR **ARC EoE** theme "The Inclusive Involvement in Research for Practice Led Health and Social Care" (led by **Poland**), we aim to find the best ways of achieving this. This programme addresses how to be inclusive in research by seeking to understand, embed and evidence inclusive working with and engagement of public and patient groups in health and social care (**Poland**, **Killett**, **Bunn**).
- Our growth plans in this area have recently seen the **Institute for Volunteering Research** re-located to UEA, the only such HEI-based institute worldwide, solely dedicated to interdisciplinary volunteering research and scholarship, evidencing the health, economic social and cultural contribution of volunteering to sustaining societies.
- **Jerosch-Herold** received a UEA Engagement Award 2020 as cofounder of **CLACEast**. This is an information hub and support network for aspiring NHS clinical academic health professionals.
- **Qi** leads the Child Malnutrition sub-project within the UKRI Global Research Translation Award (£296K, of total £1.4M). This project includes partners in Thailand, Malaysia, Jordan and Brazil (including local industries) developing low-cost affordable supplements to tackle child malnutrition.
- **Bunning** led a long-standing project on "Community-based inclusive development: empowering caregivers of children with disabilities in rural Kenya" (ICS1).
- We are active participants of the Norwich Science Festival, Pint of Science Festival and Norfolk Show. Eight UoA3 staff have had dedicated stands at these annual events.
- **Qi**'s pharmaceutical 3D printing research featured in the Cambridge and Norwich Technology Corridor 2020 "Disruptor" Series.

4.4. Responding to COVID-19 Pandemic

The COVID-19 pandemic provided an unexpected stress-test for our infrastructure ensuring it remained not only functional, but also afforded us an opportunity to help NHS and communities. We used our research capability to produce PPE (**Qi**) and to design a new device enabling healthcare staff avoid contaminated surfaces (**Saeed**, BBSRC, NRP). We have developed national guidance for care home staff (**Killett**), producing resources for clinicians on topics that should be considered when caring for very ill patients during COVID-19 (**Farquhar**), and tracking changes in lifestyle habits in the community including keyworkers (**Naughton**).

4.5. Professional Contributions to the Disciplines, Esteem and Recognition

UoA3 staff make multiple professional contributions to the sustainability of their research disciplines. These include membership of, and leadership roles in, professional societies and editorial boards, grant funding panels, manuscript peer review, conference organisation [>10, including Recent Appointees in Polymer Science meeting (UEA 2017, **Saeed**); 25th GP2A Medicinal Chemistry Conference (Liverpool 2017, **Matthews**); "Amorphous" meetings of the Academy of Pharmaceutical Sciences (**Qi** (2017), **Khimyak** (2019)), European Crystallographic

Association Conferences (**Fabian**)], and keynote talks (>10) and the training of PGR students and postdoctoral researchers. **Bhattacharya** was a winner of Pharmacy Research UK award in 2016.

Notable service on **grant committees** (>25) include:

- Grant awarding committees: BBSRC (**Ganesan**, **O'Connell**), EPSRC (**Searcey**), EU Commission (**Khimyak**, **Matthews** and **Searcey**);
- **Arthur**, **Cross**, **Jerosch-Herold**, **Mioshi**, **Pomeroy**, **Sach**, **Wright** and others were members of numerous NIHR panels.
- **Bhattacharya**: Member of the Pharmacy Research UK panel.
- **Farquhar**: Chair of Health Research Charities Ireland/Health Research Board (HRCI/HRB) Joint Funding Scheme 2020.

UoA3 staff take active roles in **UK and international learned societies** (>10) governing the full spectrum of disciplines. Notable examples include:

- **Hardeman**: President-Elect of European Health Psychology Society (since 2020);
- **Khimyak** (until 2017) and **Wallace** (since 2017): Members of Royal Society of Chemistry NMR Discussion Group, coordinating its annual ECR meetings;
- **O'Connell**: Independent Advisory Panel member of Breast Cancer UK (since 2017);
- **Ganesan** led the EU-funded COST action on Epigenetics;
- **Naughton:** Vice Chair of Cancer Research UK's Expert Review Panel for Prevention (PRC) and member of the Population Research Committee**.**

An important feature of UoA3 is **translating our expertise into NHS trusts and health care**. Examples (>15) include:

- **Arthur**: Member of Older People's Mental Health Expert Advisory Group in the Department of Health;
- **Wright:** Member of NHS England Community Pharmacy Clinical Reference Group;
- **Smith:** Member of Implementation Guideline Committee for NICE guidelines;
- **Gibbons:** Co-opted Member of the UK Government Home Office's Advisory Council on the Misuse of Drugs Consumer CBD Products Working Group.

UoA3 staff hold editorial posts in >25 international journals. Some examples of senior posts (Editor in Chief (EC) or Associate Editors) include: *British Journal Sports Medicine (***Atkin**), *Diabetic Medicine* (**English**), *Phytochemistry Letters* (**Gibbons**, EC), *British Journal of Health Psychology* (**Hardeman**), *Hand Therapy* (**Jerosch-Herold,** EC), *Addiction* (**Naughton**), *Quality in Ageing and Older Adults* (**Poland,** EC), *Neurorehabilitation & Neural Repair* (**Pomeroy**), *Physiotherapy* (**Pomeroy**) and *Geriatrics* (**Smith**).