Institution: University of Bath

Unit of assessment: Allied Health (UoA3)

1. Unit context and structure, research and impact strategy

1.1 Unit Context

The UoA has reinforced and further enhanced its position as a leading world-class research unit in drug discovery, delivery and development that translates early-stage discoveries into clinical impact. The UoA expertise includes *in vivo* and *in vitro* pharmacology, cell biology, immunology, biophysics, medicinal chemistry, medicines design and development, drug delivery, regulatory science, pharmacy practice, health services research, pharmacoepidemiology and clinical rheumatology. Since REF2014, research in the UoA has been re-focused into three overlapping research themes (Figure 1) with the overall aim of increasing collaborative research, enhancing the clinical links of the UoA and achieving translational impact from our fundamental discoveries. This strategy has resulted in the launch of the a new interdisciplinary research centre. The UoA has recruited clinical and non-clinical expertise including Clinical Lectureships and Fellowships, strengthened links with clinical partners including the Royal United Hospital (RUH), established specialized research facilities, and tissue biobanks. An external Research Advisory Group, with industry, academic and clinical representation to advise on research, academic and impact strategy, has been created. We are strongly committed to equality and diversity, through a supportive and inclusive environment for all staff and students, with opportunities for support and progression based on merit, rather than background, identity, beliefs, characteristics, or circumstances.

1.2 Research Strategy

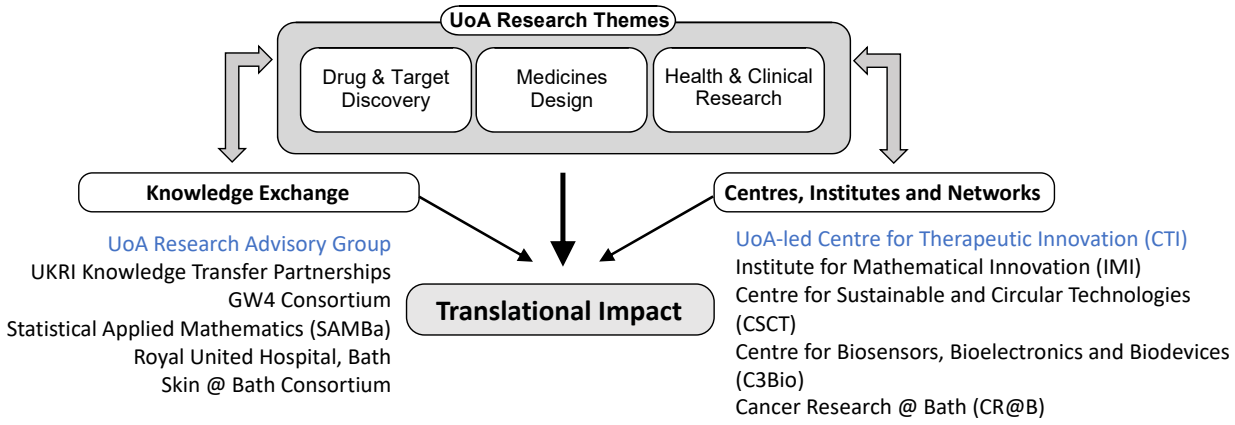

Figure 1. UoA Research Structure

Our **vision** over the REF period has been to drive the translation of our strong fundamental science into clinical impact, inspire and train early-career researchers, and to bring together inter-disciplinary teams to pioneer new approaches in therapeutic innovation. These were captured in the REF2014 future strategic aims that relate to the UoA, upon which we have delivered in this REF period:

- Partnership and knowledge exchange with industry, government and health partners was a major planned initiative to address real-world problems in the discovery, design, formulation and delivery of drugs.
- Build our clinical research programme from the use of medicines and drug safety through to the early diagnosis and treatment of auto-immune disease.
- Create a research centre to promote interdisciplinary collaboration and partnership in the area of drug design and delivery.

To meet the aims outlined in REF2014, the scientific strategy of the UoA has been refocused during this REF period, with our research restructured into three interdisciplinary and collaborative research themes to improve human health through the timely prognosis, diagnosis and treatment of disease. The research themes, (1) **Drug and Target Discovery (DTD)**, (2) **Medicines Design (MD)**, and (3) **Health and Clinical Research (HCR)**, have forged partnerships with healthcare providers, the pharmaceutical industry and government agencies to address significant unmet medical needs. The research has been underpinned and supported by academic secondments with key partners, collaborative national and international consortium funding, and funded knowledge transfer partnerships. The success of this approach is clearly demonstrated by the translational impact cases achieved in the current REF period and >85 peer-reviewed associated publications with industrial co-authors (SciVal).

An external **UoA Research Advisory Group** launched in 2017 to advise on research and impact strategy is chaired by Prof. John Westwick (formerly Global Director of Respiratory Research Novartis); current membership includes Prof. Christine Bond (emeritus Professor of Primary Care (Pharmacy), University of Aberdeen), Prof. Christopher Jones (previously Vice-President & Global Head of Pharmaceutical Development at AstraZeneca), Prof. Tom MacDonald (Blizzard Institute, London), Prof. Mandy MacLean (University of Strathclyde), and Prof. Martyn Davies (former head of the Nottingham School of Pharmacy, co-founder and Chairman of Molecular Profiles, Ltd.).

Our **clinical research programme** has expanded with a major focus on autoimmune rheumatic disease, initially through the appointment of Professor McHugh (2013) and subsequently through strategic use of GSK-endowment funding to appoint two Senior Academic Clinical Lectureships as shared posts with the Royal United Hospitals Bath NHS Foundation Trust. Three NIHR academic clinical fellowships and one academic clinical lecturer in rheumatology have been based in the department in conjunction with the Severn Deanery. Together with major MRC, NIHR and industrial support, this has allowed the establishment of a strong rheumatology research group, complementing existing and new pharmacy practice strengths within the **HCR** research theme (see below). Notably, the growth of clinical expertise in auto-immune disease in this REF cycle and the translational impact is evidenced in the McHugh impact case. The UoA is now in a strong position to expand translational research in collaboration with the RUH built on the successful model in rheumatology.

The REF2014 goal to establish a new centre of excellence in drug design and delivery has been achieved with the creation of the **Centre for Therapeutic Innovation (CTI)** in 2017. The CTI is focused on translation of research into clinical applications and exploitation of associated commercial opportunities. The CTI interdisciplinary membership includes medical, pharmaceutical, health and life scientists, chemists, mathematicians, physicists, engineers, psychologists and experts in data science. Following the award of an MRC Proximity-to-Discovery grant (2018) to support collaborative research ventures in therapeutic innovation, Larijani was recruited (2019) as the full-time Director, importing new biophysical expertise to the UoA, specifically in advanced imaging techniques and precision medicine. The CTI's 5-year research plan informed by its scientific advisory board chaired by Peter Parker FRS (Crick Institute), is focused on: (a) translational biophysics, (b) mechanisms of disease and regeneration, (c) medicines development and (d) advanced bio-imaging and medical devices. Launch of the CTI has included a number of stakeholder events: MRC-funded showcases (2018-2020), innovation events (2018/2020) and a high-profile seminar series; during the Covid-19 outbreak, the CTI has led, and continues to lead, the coordination of pan-campus grant application activity. Funding success includes a bid for a Light Sheet Microscope (BBSRC, (£310k; BB/S019820/1; Co-Is Mrsny, DeBank).

1.3 Achievement of Strategic Aims for Research

The principal strategic aims for research laid out for Pharmacy & Pharmacology in the current REF period have been delivered with respect to our enhanced research integration into the drug development process, the creation of a Centre for Therapeutic Innovation, and further clinical translation in pharmacoepidemiology, drug use and adherence. These objectives have been achieved despite an overall reduction in the critical mass of this UoA (in particular, due to the

significant growth of Psychology in Bath resulting in its separate REF2021 submission to UoA4), with a concomitant impact on research income.

Drug & Target Discovery. This theme brings together medicinal chemistry with biophysics, immunology, neuropharmacology and bioinformatics to address questions in inflammatory disease, neuropsychological disorders, and oncology. The UoA has always had expertise in the science of early-stage drug discovery and this theme was created to integrate academics working across different disciplines. Success in promoting interdisciplinary research has been realized, for example, by the discovery of new anti-platelet agents without bleeding side-effects (Caggiano, Pula, FASEB J.), novel approaches to the development of antidepressants (Husbands, Bailey S, Br. J. Pharmacol.), and insights into ketamine regulation of neural progenitor cells (Lindsay, Bailey S, Cells). The goal to build external collaborations and ultimately enhance translational impact has been achieved. Significant, NIH-funded collaborations with Wake Forest School of Medicine and the University of Michigan have accelerated the 'Opioid Receptor Drug Discovery Programme' with the preclinical testing of compounds for opioid use disorder and low abuse liability analgesics, and new structural insights into agonist-bound activated μ-opioid receptors (Husbands, Nature, PNAS, J. Pharmacol. Exp Ther.; Bailey C, Husbands, Br. J. Pharmacol.). NIH-Funded work with Harvard Medical School has led to new insights into the role of endogenous cannabinoids in intestinal inflammation (Mrsny, J. Clin. Invest.). Furthermore, the importance of long-noncoding RNA in the innate immune system has been unravelled (Lindsay, Nat. Commun.) and characterization of GRIN1 *de novo* mutations in polymicrogyria (MacKenzie, Brain). De Bank and Pula (Sci. Rep.) identified an innovative approach to improve vascularization of engineered tissues in the absence of animal products and, in collaboration with Novartis, Ward and Watson (PloS One) identified the role of PI3Kinase in lung branching morphogenesis using an embryonic lung explant model. New appointments have enhanced capability in cancer and inflammation with the identification of metabolic factors associated with increased risk of distant metastatic relapse (Jungwirth, Nat. Commun.), the phosphorylation-independence of ligand discrimination for protein kinases (Dodson, Chem. Sci.), pathways that regulate microglia inflammation (Niklison-Chirou, Cell Rep.) and the application of amplified FRET-based prognostic tools in cancer (Larijani, Ward, Cancer Res.).

Medicines Design. UoA contributors to this theme have expertise in chemistry, formulation, drug delivery, microbiology, regenerative medicine, bioengineering and regulatory science. The principal focus is to direct the rational design and optimisation of high-performance pharmaceutical formulations and thereby improve drug bioavailability and delivery via the oral, pulmonary, (trans)dermal, trans-ungual and subcutaneous routes of administration. Research has been funded by US FDA and NIH, EU Horizon 2020, Innovate UK, MRC, charities (e.g., Leo Foundation) and by the pharmaceutical, biotech and cosmetic industries in the UK, Europe and globally. Major achievements include: Discovery that the non-destructive epithelial transcytosis of cholix protein domain 1 is a potential carrier for biopharmaceuticals in the gastrointestinal tract that has already underpinned two first-in-human phase 1 clinical trials (Mrsny impact case, Applied Molecular Transport; Tissue Barriers, J. Immunol.). Identification of the mechanism by which a novel peptide enhances myosin light chain phosphorylation in polarized intestinal epithelia and the transient opening of intestinal tight junctions (Eggleston, Mrsny, J. Control. Release). New approaches to measure drug bioavailability from complex drug products (e.g., topical, inhalation) including applications of Raman spectroscopy (Guy, Delgado-Charro, PNAS) and determination of the cohesive-adhesive balance of interparticulate forces (Price impact case), and the identification of key *in vivo-in vitro* correlations in oral drug administration (Fotaki, Int. J. Pharm.). A powerful mitochondria-targeted iron chelator developed for therapy of solar UVA radiation (Pourzand, J. Invest. Dermatol.). Invention of a path-selective, non-invasive, transdermal glucose monitoring system based on a miniaturized pixel array platform (Guy, Tyrrell, Nat. Nanotech.).

Health and Clinical Research. UoA expertise in pharmacy practice, health services research, pharmacoepidemiology and clinical medicine comprise this theme with the aim to improve patient outcomes and safety through early diagnosis, targeted interventions and the optimization of the use of medicines. A REF2014 goal was to enhance the understanding of auto-immune disease and notable advancements in early diagnosis and assessment of rheumatic disease have been made. McHugh has built a research consortium in this area supported by MRC and NIHR

programme grants with national and international collaborations. This has led to ground-breaking work in biomarker identification in autoimmune disease that has now been commercialised (e.g., McHugh impact case), and new guidelines for the early detection and assessment of arthritis in psoriasis have been developed. Over this REF period, this theme has established several tissue banks that contribute to the UK infrastructure in auto-immune disease research (*see section 3.3*). The growth in clinical rheumatology expertise has catalysed new collaborative clinical projects across the UoA to unravel molecular mechanisms of systemic sclerosis, spondyloarthritis, and myositis (e.g., Sci. Rep., Ann. Rheum. Dis.). The treatment of vulnerable patient groups is a second key area that has grown substantially over the REF period in medicine safety in epilepsy and pregnancy, elderly patients and drug misusers in partnership with the EUROmediSAFE consortium, the University of Otago and London School of Hygiene & Tropical Medicine (e.g., Nishtala, Pharmacoepidemiol. Drug Saf.; Scott, Sci. Rep.). New appointments in medicines use and adherence have contributed to understanding the role of pharmacists in front line patient care, medicines usage, adherence, and the behaviour change of service users (Chapman, Watson M, Jones M). Research in medicines optimization has highlighted how pharmacist interventions can improve patient outcomes (Watson M, Cochrane Database Syst. Rev.) and has provided user-testing guidelines for medicines' administration and medication adherence (Chapman, Clin. Endocrinol.).

1.4 Interdisciplinary Research Approach

Interdisciplinary collaborative research has been an important goal of this REF period and adds to the vitality of our research environment (*Figure 1, REF5a 2.28-2.30*). In addition to the interdisciplinary CTI led by the UoA, our staff have significant involvement in other cross-departmental initiatives:

- *Cancer Research at Bath* (CR@B) was initiated, and is led, by the UoA (co-chaired by Caggiano) and provides networking opportunities across the University and with local clinical partners.
- *Institute for Mathematical Innovation (IMI)* Over the REF period, Delgado-Charro has been a member of the IMI research panel (2016-2020) and three UoA staff have benefitted from mathematical training secondments. Tillett, with research interests in precision medicine to treat psoriatic arthritis, has started an 18-month IMI-fellowship to develop Machine Learning and Computer Vision techniques in medical imaging.

UoA academics have served as PhD co-supervisors in EPSRC-funded CDTs in *Statistical Applied Mathematics at Bath* (SAMBa) and the *Centre for Sustainable and Circular Technologies* (CSCT).

Our academics are members of the *Centre for Biosensors, Bioelectronics and Biodevices* (C3Bio), which holds annual networking events and training workshops, and the *Centre for Mathematical Biology*, which has close links and multiple joint activities with SAMBa and IMI.

The CTI, with CSCT, Centre for Pain Research, C3Bio and IMI, has recently launched the Bath **Interdisciplinary Research Network** to address key healthcare challenges using an interdisciplinary approach with regular 'call for arms' initiatives to foster new research collaborations.

1.5 Enabling Impact

A key driver of the UoA's overall strategy is the ability to identify emerging **impact at an early stage** and to support the translation of high-quality research into clinical, societal and economic impact. Academics with significant experience in impact provide individual advice and mentoring opportunities for potential impact activities (Guy, Watts, Impact 'Champions'; Husbands, MacKenzie, Mrsny, Research Committee Chairs; Larijani, CTI Director). A senior leader from AstraZeneca (Prof. Christopher Jones) advised academic staff during the REF period on UoA impact activities. The University Research & Innovation Services provides pre- and post-award support, commercialization services and a dedicated manager to support Innovate UK Knowledge Transfer Partnerships (KTP). Approaches to maximize the potential for research impact include pump-prime funding of early-stage research (e.g., MRC CiC, EPSRC IAA), protection of Bath-generated IP for commercialization (e.g., glucose sensor, Guy), industrial collaborations (e.g.,

KTP awards, CASE studentships), and secondments to develop strong relationships with key partners (e.g., EMA and industry).

In keeping with the increased UoA focus of translation of research towards impact, the early-stage impact identified in REF2014 has been successfully nurtured by this approach. Watts, with expertise in biopharmaceutical development, has collaborated with Qualasept Ltd through KTP awards, to identify NHS- and MHRA-compliant testing methods that have extended the shelf-life of antibody-based therapeutics. This partnership has resulted in impact throughout the NHS by contributing to creation of new NHS guidelines in *Aseptic Preparations (Biopharmaceutics)*, changing procurement practice, reducing wastage of antibody therapeutics by 80% and resulting in outstanding economic growth of the company leading to the Queen's Award in 2019 (*see section 4.2*). Translation of US Food & Drug Administration (FDA)-funded research has contributed to the success of Nanopharm, a respiratory-drug delivery and formulation company co-founded by Price, and sold to Aptar Pharma in 2019 (Price impact case). Mrsny, supported by two year-long secondments, has served as the Chief Scientific Officer of Applied Molecular Transport, Inc. (AMT), a venture capital-funded company he co-founded. AMT has used proprietary technology to demonstrate in first-in-man, Phase 1a/b clinical studies the oral delivery of a biopharmaceutical drug (IL-10) (Mrsny impact case). Mrsny has also developed new *in vivo* predictive technology to model the subcutaneous injection site that is now commercially available (Pion, Inc.). An example of impact that has matured since REF2014 involves the pre-clinical development of new antibody-drug conjugates by venture capital-funded Iksuda Therapeutics (co-founded by Watts and MacKenzie) who have been awarded two Innovate UK grants (~£1M). Potter's 2014 impact case in novel anti-cancer drug development (initially with Ipsen and now with Preglem and based on the assets of Sterix, a Bath spin-out) has evolved with four CRUK-initiated phase I/II clinical trials.

1.6 Future strategic aims and goals

Our vision is to grow as a collaborative research environment with patient involvement to tackle major challenges in health and disease, train future leaders in interdisciplinary science and accelerate our discoveries into translational impact. This strategy reflects a strong commitment from the University to grow interdisciplinary research programmes and the translational success of collaborative research programmes in this REF period. Major initiatives to deliver our research programme will include future interdisciplinary appointments in the following areas, University interdisciplinary research networks, regular showcases with industrial, healthcare and clinical partners to catalyse new engagement and input from patient research partners. Core to our strategy, is the development of a sustainable, open and inclusive research environment to enable all academic staff to contribute to a thriving shared research culture underpinned by diversity and inclusivity.

Our research strategy, therefore, is to apply our interdisciplinary and collaborative expertise to address and resolve unmet medical needs with the potential for rapid translation and clinical impact, specifically:

- **Early diagnosis, prognosis and improved treatment of non-communicable chronic inflammatory disease**

The UoA will develop a programme of research focused on precision medicine for the early detection, prognosis and treatment of auto-immune disease and the inflammatory basis of cancer that crosses all current research themes building on our expertise in pharmacology and identification of drug targets, molecular pathways underlying inflammatory responses, biomarkers, macromolecular drug development, pharmacoepidemiology and data science. This will be underpinned by strong national and international partnerships that led to two impact cases in chronic inflammatory disease (McHugh, Mrsny), tissue banks in rheumatology, networks through the UKRI/NIHR-funded research consortia, new clinical and non-clinical appointments, the strong links established with the RUH and the evolving China-UK Skin consortium. To achieve this goal, the UoA will grow analytical facilities for high resolution single-cell level analysis (e.g. mass cytometry, single cell transcriptomics) in parallel to advanced imaging approaches developed by

CTI, embed mathematical approaches with support from IMI, and develop improved *in vitro* cell-based models with engineers and physicists in C3Bio.

- **Medicines Development**

The UoA will directly engage with key challenges in the pharmaceutical and biotechnology industries, specifically: (a) development and delivery of macromolecular 'biopharmaceuticals'; (b) novel biomaterials in regenerative medicine and *in vitro* modelling of disease and drug response; (c) pharmaceutical bioengineering of medical devices for drug delivery and/or biosensing; and (d) the need to develop the regulatory science principles required to ensure the safety, efficacy and quality of these new medicines. These fields of research represent the cutting-edge of new science in the development of advanced "medicines" at the intersection of chemistry (both synthetic and biophysical), engineering and biology, where innovation is delivers true impact – evidenced by two impact cases (Price, Mrsny) in the current submission - and ensures translation into clinical practice and improved patient outcomes.

- **Translational research in vulnerable populations**

The UoA will focus on the use and safety of medicines in specific groups of patients in real world settings including vulnerable groups and inclusion health, biopharmaceutical considerations in vulnerable groups and drug misuse research. This research spans all themes as evidenced by recent collaborative research between chemists and pharmacists to develop a saliva test to detect synthetic endocannabinoids receptor agonists ('spice') in unconscious patients (Anayl. Chem. 2020). The programme of research will build on industrial and healthcare partnerships, major established research consortium (SPaeDD-UK*, EuroMediSAFE, ConcePTION*), work with social enterprises and charities (e.g. Exchange Supplies, Relapse), the success of collaborations established through long-term NIH Funding in drug abuse research and new UKRI funding with Nottingham University in the area of mu-opioid receptor signalling. A new academic partnership with NIHR School of Primary Care research (Bristol) starts in 2021 to further enhance the multidisciplinary nature and translation of our research in this area.

The **CTI** is closely affiliated to (and led from) the UoA, with a research focus that aims to translate discoveries in cell biophysics, immune signalling and advanced bioimaging into new precision medicine approaches for the treatment of disease. These cross-cutting methodologies will catalyse regional, national and global interactions and collaborations with academia and industry. Examples of research challenges to be addressed include protein structure-function in inflammation, immune cell activation, lipid signalling, and the molecular pathways responsible for physiological processes, how their dysregulation leads to disease, and how they can be repaired or regenerated.

Collectively, the UoA research strategy will provide a fertile environment for delivery of our goals for developing high quality underpinning research with a view to translation towards clinical and commercial outcomes to contribute to the UK economy. This strategy will provide a rich environment for the training and development of new (i.e., PhD) and early-career interdisciplinary non-clinical and clinical researchers, building on our national and internationally-funded collaborative partnerships.

1.7 Open research environment, integrity and ethics including professional bodies

The University upholds the highest standards of research excellence and integrity with robust and transparent policies regarding ethics, data management and the use of human and animal tissue in research (*REF5a 2.20-2.27*). Written policies online are supported by online training in academic integrity for all research staff and students, with additional support from the UoA Ethics Officer and Doctoral College for students. All staff engaged in research using animals must consider the ethical and 3Rs implications of the work and ensure that it is conducted to the highest welfare standards. All research involving animals, whether licensed under the Animal (Scientific Procedures) Act or not, is reviewed by the University's Animal Welfare and Ethical Review Body. Research in the clinical setting or involving patients/volunteers is independently reviewed by submission to either the National Research Ethics Service (NRES) if NHS-based, or to the

University Research Ethics Approval Committee for Health if outside the NHS. Research utilising human tissue is reviewed by an appropriate ethics committee (NRES).

A UoA open access champion supports researchers to use the University library services *(REF5a 2.25-2.26)* to make research outputs open access. This has been highly successful reflected by the 2019 Leiden Ranking that places the University of Bath 12th in the world and 7th in the UK for the proportion of open access papers reported by Leiden (80.5% of papers).

Compliance with professional frameworks rests with the individual researchers as members of their representative organisations. For example, researchers who are pharmacists must comply with the General Pharmaceutical Council's (GPhC's) Standards of Conduct and comply with GPhC guidance that underpins strong and principled research integrity.

2. People

2.1 Staffing Development Strategy

The UoA's staffing strategy embraces diversity of all backgrounds as a valuable cornerstone of a successful research environment. Over the REF period, the UoA has aimed to strengthen clinical expertise, increase research capability in strategic areas, and attract talented research staff to enhance interdisciplinarity across our research activities. Recruitment and staff development are underpinned by a University approach to Equality, Diversity and Inclusion (EDI) (*REF5a 3.20-25*). The UoA aims to provide equality of opportunity and an inclusive environment that values to diversity that, supported by the UoA EDI committee, ensures that all staff are supported to progress their careers at all stages.

Staffing and Recruitment Policy. Since REF2014, recruitment has targeted both early-career academics plus strategically targeted senior leads for specific initiatives within the UoA. Succession planning has been an important aspect of our staffing policy where appointments that follow retirements have been re-focused to enhance research capability in strategic areas, interdisciplinarity, inclusive working and diversity.

Bath's UoA3 submission in REF2014 included 54.2 FTE. With the growth of Psychology, leading to a separate submission, the UoA3 headcount (34.5 FTE) has become smaller and more focussed in outlook. Our staffing strategy has sought to build capacity around the CTI and Health & Clinical Research. This has been achieved through clinical appointments (Tansley, Tillett, Pauling), non-clinical lecturer appointments (Dodson, Jungwirth, Niklison-Chirou, Chapman, Jones M) and strategic senior staff (Larijani, Watson M, Nishtala) combined with successful internal career progression. As such, this REF cycle has seen primarily the recruitment of early-career clinical and non-clinical appointments, and a small number of key senior appointments.

Overall, within the REF period, there have been 11 appointments in Pharmacy & Pharmacology: 5 Lecturers, 1 Senior Lecturer now Reader, 1 Clinical Lecturer, 2 Clinical Senior Lecturers, and 2 Professors. Over the REF period, departures are Prof. Potter to Oxford University, Prof. Welham to BBSRC, Prof. Weiss to Cardiff University, Prof. Watson to Strathclyde University, Dr Millicent Stone to Guy's and St Thomas' and Dr Pula to Exeter University. Prof. Tyrrell and Threadgill have retired. There have been 7 promotions to Senior Lecturer (3 F) (1 part-time) and 5 promotions to Reader (3 F). Of those promotions, 2 staff were promoted to Senior Lecturer then Reader during the REF period (2 F). Overall, the percentage of female staff across all job categories has grown from 42% in 2013/2014 to 57% in 2018/2019. In 2018/2019, the UoA staff was drawn from 19 nationalities with 8.5 % identified as BAME and 25% identified as non-British; we are working with HR to attract a diverse pool of applicants to advertised posts.

Mentoring, Appraisal, Training and Development. All UoA staff are actively supported through a range of complementary formal processes and training opportunities to facilitate and enable career development and progression:

- All research staff have an annual development and performance review to discuss career aspirations, identify training opportunities and review research goals.

- A mentoring scheme available to all research staff for one-to-one support from an experienced colleague. All new academic staff have an assigned mentor during probation.
- Development of emerging leaders in the UoA via the women-only Aurora leadership initiative and an Academic Leadership Programme run by Berkshire Consultancy.

Development and integration of clinical staff. McHugh had combined academic and clinical roles at the Royal United Hospital Bath until 2018; he is now full-time as Head of Department. Pauling and Tillett are Clinical Senior Lecturers having both obtained their PhDs in the UoA (2013/2014). Tansley is a Clinical Lecturer in the UoA who successfully transitioned from a BIRD/RUH Research fellowship (PhD, 2016/2017) to a NIHR Academic Clinical Lectureship in myositis (2018-2021). These are excellent examples of research career development from clinical PhD training within the UoA to academic appointments and the integration of talented clinical staff, who have already contributed to an impact case (McHugh, Tansley). In addition, Jones M was recruited from hospital pharmacy, Scott retains a part-time clinical appointment, and Chapman is an academic chartered health psychologist with a counselling role in practice.

Support for Early-Career Staff. The support of early-career staff is an important part of the UoA research environment to ensure successful career development. A comprehensive support package is available for early-career appointments on probation that includes guidance and support from an experienced mentor, access to University-funded PhD studentships and enrolment on the accredited Bath Course that leads to an HEA Fellowship on completion. Staff are further supported by the annual appraisal system that sets goals for grant submissions, publications and longer-term career development. For probationary lecturers, research time is protected so that teaching and administrative duties are increased over the probationary period. Probationers' progress on research, teaching and administrative/management duties are reviewed annually by the University Academic Staff Committee. Other support available includes the internal peer review of grants and 'mock panel' interviews run by the Research Committee and writing retreats for research grant proposals provided by the University's Research & Innovation Services.

Support for postdoctoral researchers. The UoA is committed to providing a variety of networking and training opportunities for postdoctoral research staff:

- Postdoctoral staff are fully engaged in decision-making in the UoA, for example, with representatives on Departmental Research, Health & Safety, and Athena SWAN Committees.
- The UoA Early Career Researchers Network, including doctoral students, with monthly meetings to share experience, discuss careers and present science.
- Senior postdocs are encouraged to apply as PIs on grant applications and membership of a PhD supervisory team to catalyse career development to independence.
- Research & Innovation Services offers one-to-one support for grant/fellowship applications
- A Leadership and Fellowship Academy and an Academic Career Academy is also targeted at this cohort.

These efforts are supported by the University which has retained a "HR excellence in Research Award" since 2011 aligned with the *Concordat to Support the Career Development of Research Staff* (*REF5a 3.9-3.13*).

Policy for sabbatical leave and impact secondments. The University sabbatical scheme enables the development of research and translation-to-impact activities; it is available to all academic staff with permanent contracts and at least 3 years of continuous service. In the REF period, 5 UoA staff have taken **University sabbatical periods**; Guy (Oxford), Price (Monash), Bailey C (Bristol), Taylor (New Zealand) and Ward (Edinburgh, Dublin). To make the sabbatical scheme more accessible, the UoA launched a Bath-based **mini-sabbatical scheme** where teaching duties are suspended for one semester to develop research and/or impact activities. The first cohort of this scheme comprised of three mini-sabbaticals taken by 3 mid-career, part-time female academics (Bailey, S, McGrogan, Scott) allowing progress on existing projects, resulting in published papers, the development of new collaborations and grant applications being submitted.

Five academics have benefited from **impact secondments** in industry and government and have enhanced the UoA's impact and research: Mrsny (24 months) and **Price** (12 months) have taken secondments that directly derived from and fed into two impact case stories in this REF period. An MRC-funded secondment in AstraZeneca (Fotaki) supported the development of a universal dissolution strategy tool and guidance for paediatrics and secondments as National Experts at the European Medicines Agency (Guy, Delgado-Charro, 12 months each) led to input into regulatory science policy and draft guidelines.

Support during COVID-19 crisis. The UoA supported graduate students and staff through the COVID-19 crisis with 1-2-1s, virtual meetings through teaching groups, weekly Head of Department updates and virtual social events. The UoA (and University) operated a transparent phased safe return to research activities strongly supported by the technical team identifying safe operational procedures.

Recognizing and rewarding staff for research and impact. The University recognises outstanding contributions to teaching and research, and prizes to UoA staff awarded in the REF period: Outstanding Doctoral Supervision (Blagbrough, Ward), Doctoral Recognition Award (Bailey S), and the John Willis Prize for accomplishment in teaching and research (Caggiano). The University's annual contribution pay award scheme for excellence and outstanding contributions has acknowledged staff in the UoA with >50 awards in the REF cycle.

2.2 Research students

The UoA provides doctoral training opportunities to complement support provided by the University Doctoral College (*REF5a 3.17-3.19*).

Recruitment of doctoral students. All applicants are interviewed by UoA staff that have completed *Unconscious Bias* and *Diversity in the Workplace* training. Candidates are interviewed by a panel comprising the potential supervisor(s) and at least one academic independent of the intended supervisory team. All candidates, independent of background or protected characteristics, are selected based on academic achievement and self-motivation. The strategies and policies underpinning these processes are supported by the University Doctoral College.

Studentships from Major Funding Bodies. In a challenging funding environment, the UoA has been successful in securing PhD studentship funding from competitive UKRI schemes, European training networks and CASE awards/Industry-funded studentships.

Examples include: EPSRC Centre for Doctoral Training in Statistical Applied Mathematics (SAMBa), BBSRC SWBiosciences doctoral training partnership and supervision of students undertaking cross-disciplinary projects within the EPSRC CSCT CDT, the UKRI Accountable, Responsible and Transparent AI (ART-AI) CDT and the GW4 BioMed MRC DTP. Students have also been supported by EPSRC doctoral training grant allocations and industrial CASE funding. The UoA has also attracted students through the EU Horizon 2020 Marie Sklodowska-Curie ITN in Pharmaceutical Education and Research with Regulatory Links (PEARRL). Practicing GPhC-registered pharmacists, including individuals from the NHS, have undertaken PhDs with lead supervisors in the UoA (e.g., Pharmacy Research UK). Five externally-funded clinical rheumatologists have been awarded UoA-supervised PhDs; four now hold UK Academic Clinical Lectureships and two more are currently registered for PhDs.

Monitoring and Support. The doctoral students' supervisory team includes at least two Bath-based supervisors, one of which is an experienced academic. Lead supervisors complete progress reports on their PhD students every 6-months following registration. These reports include a student contribution articulating progress made, goals for the next 6 months, and thesis plans. The reports are reviewed and commented upon by the departmental Director of Studies, before submission to the Doctoral College. Reports submitted from departments are then approved or flagged for action by the Faculty Director of Doctoral Studies in Science.

The Doctoral College works with the University Student Services to support students with additional needs (*REF5a 3.17*). For example, the Student Disability Service which provides ongoing support and works with the UoA to develop a disability access plan; the International Experience Coordinator who provides bespoke advice on life in the UK and a dedicated Wellbeing

team that supports all doctoral students; with students with diagnosed mental health conditions are referred to the Mental Health Team.

For full-time doctoral students, 92% students graduating in 2017/2018 and 93% students graduating in 2018/2019 successfully completed within 4 years.

Skills Development. Doctoral students are strongly integrated into the research culture of the UoA with opportunities to present their work within the seminar programme, and at interdisciplinary symposia, such as the CTI showcases, Skin@Bath conferences, and Cancer Research@Bath network meetings. The UoA seminar programme includes an annual symposium for first-year students. Doctoral students and their supervisors review their training requirements on a 6-monthly basis as part of progress monitoring and are strongly encouraged to engage with interdisciplinary activities and the free, comprehensive skills development programme promoted by the Doctoral College. The latter is aligned to the Vitae Researcher Development Framework and delivered by both internal and external training providers. Success of career progression is evidenced by four of our doctoral students that hold Lectureships/Senior Lectureships in the UoA, many have progressed to positions in the pharmaceutical industry or within the NHS.

2.3 Equality, Diversity and Inclusion (EDI)

The University and UoA are fully committed to an equality of opportunity, promote an inclusive approach to equality, values diversity, and aim for an inclusive culture where everyone can thrive independent of characteristics (*REF5a 3.20-25*).

The **UoA EDI committee** (which includes doctoral students and postdoctoral representatives) is responsible for the delivery of EDI action plans underpinned by an annual culture/EDI staff and postgraduate survey, an annual review of workload model data, monitoring of conference attendance to identify those who may need support in attending events and a series of focused discussion groups (e.g. parental leave experiences). Mandatory online training on '*Diversity in the Workplace*' and '*Unconscious Bias'* is required for all managers involved in staff and doctoral student recruitment, management and supervision; all research staff are strongly encouraged to take this training as well. University staff support includes the LGB&T staff network, the Disabled Staff Support group, the Carers Support group and the Race Equality group.

The UoA's ongoing commitment to gender equality and the significant advances in the workplace environment over the REF period is evidenced by Bronze (2014) and Silver (2017) Athena SWAN Awards.

Support for staff and research students returning from periods of leave and flexible working. The UoA supports staff returning from periods of leave for caring or health reasons with a return-to-work meeting and honours requests to adjust working hours. The University policy for flexible working provides support through different options that include reduced workload, temporary transfer of duties and altered working patterns. The University provides an onsite Nursery with a NurseryPlus salary sacrifice scheme and reduced rates for students. All staff meetings and seminars are scheduled in core hours to support staff with caring responsibilities or other commitments. Staff returning from periods of sick leave are supported through Occupational Health Counselling often with a plan for a phased return to work.

Support for Staff and Students with Protected Characteristics. Staff and students are supported on an individual basis by the University occupational health team with work placement assessments. Reasonable adjustments are made to the workload (e.g., to account for dyslexia) and specific equipment and software are provided as required (e.g., for dictation).

Support for staff and research students' wellbeing. A UoA Wellbeing Champion has been appointed to raise awareness of health and wellbeing activities and to signpost access to associated resources and student services including the #NeverOK campaign (*REF5a 3.17*). The Employee Assistance Programme provides anonymous counselling for staff while students services offer counselling for doctoral students. UoA doctoral students are able to bring forward concerns and suggestions regarding support for training and research support through regular meetings of the UoA Postgraduate-Staff Liaison Committee.

2.4 EDI considerations in the construction of our REF submission

Staff leading the REF process have been trained in equality and diversity (including the Equality Act 2010) within the context of the REF submission (*REF5a 3.26*). A representative gender-balanced team from the UoA contributed to the environment statement and output scoring with appropriate training in output assessment. Inclusion of an individual's output in the REF submission does not contribute to the University probation or promotion processes.

3. Income, infrastructure and facilities

We recognise that the UoA support for the development of research programmes must be tailored to each individual such that annual performance reviews are driven by individual goals and identifying the required support (e.g., sabbaticals or mini-sabbaticals, secondments, changes in workload, access to facilities) for each member of staff. Appreciating diversity and ensuring equality, the University Research Grant Development Manager, together with the UoA Director of Research, provide additional support to staff with any special needs in relation to acquiring research funding or accessing scholarly or operational infrastructure supporting their research and research productivity.

3.1 UoA Research Income

The research strategy of the UoA over the REF period has focussed on engagement (leading and collaborating) in large interdisciplinary projects that deliver translational impact to policy makers, healthcare providers and patients. More than one-third of the direct income of the UoA has been funded by such national and international research consortia active over the REF period (the total value of which is ~£30M) and has involved about third of current UoA academics as lead or co-investigators.

The approach has reinforced and enhanced the UoA's strong track record of translating world-leading research in applied science into tangible impact. The three impact cases submitted to this REF exercise are clear examples of such success: McHugh's MRC-funded consortia in inflammatory myopathies providing new diagnostics and enabling improved therapeutic decision-making; Price's collaboration with FDA and US-based colleagues that has, with Bath spin-out Nanopharm, evolved new methods and tools to facilitate the development and regulation of orally inhaled and nasal drug products; and Mrsny's research with AMT that has enabled the discovery of a mechanism by which biopharmaceuticals may be delivered orally with a lead candidate already in Phase II clinical trials in man.

These specific illustrations of international and interdisciplinary collaboration are a subset of the broad success of the UoA as detailed below. The quality of the science is further evidenced by the high standard of the resulting outputs.

Drug & Target Discovery

- U.S. NIH/NIDA funding to Husbands in opioid receptor drug discovery with US partners (total consortium value ~£3.29M) leading to preclinical testing of compounds developed at Bath, and licensed to industry, for opioid use disorder and as low abuse liability analgesics (PNAS, J. Pharmacol. Exp. Ther., Br. J. Anaesthesia).
- U.S. NIH funding to Mrsny with University of Massachusetts, US (total consortium value ~£2M) for research into the control of neutrophilic inflammation in intestinal health and disease (J. Clin. Invest.).

Medicines Design

- European Training Network 'Pharmaceutical Education and Research with Regulatory Links, PEARRL' funding to Fotaki under the Horizon 2020, Marie Sklodowska-Curie programme (total consortium ~£3.3M) involving academic, industry and government partners in the development of physiologically-based pharmacokinetic models to reduce/replace animal use (Eur. J. Pharm. Sci., AAPS J.).

- Innovate UK funding has supported a number of research programmes (total consortium project cost of ~£2.4M) including projects between Watts and Qualasept (extending the shelf-lives of biopharmaceuticals), Fotaki and Sirius Analytical (Evaluation of *in-vitro* tests to reduce animal testing in drug toxicology) and Fotaki in a consortium of 13 industrial partners (SPaeDD-UK, Smart Paediatric Drug Development network).
- US FDA funding to Guy & Delgado-Charro with the University of Maryland, the Colorado School of Mines, and the National Physical Laboratory (UK) (total ~£3M) to develop new methods to assess drug bioavailability in the skin (Pharm. Res.; Int. J. Pharmaceut.).
- EPSRC Inform 2020 programme (EP/N025075/1, total consortium value £1.9M; Price, co-investigator).

Health & Clinical Research

- NIHR funding (RP-PG-1212-20007) to McHugh with 11 national and international partners for "PROMPT" (Early detection to improve outcome in patients with undiagnosed psoriatic arthritis); total consortium value £1.9M (Ann Rheum Dis; impact on policy and practice – see section 4.2).
- MRC funding (MR/M01665X/1) to McHugh with 21 partner organizations for "MASTERPLANS" (MAximizing Sle ThERapeutic PotentiaL by Application of Novel and Stratified approaches); total £4.1M. (Rheumatology (Oxford)).
- MRC funding (MR/N003322/1) to McHugh for "MICA", a UK-wide networking partnership to facilitate collaborative research in idiopathic inflammatory myopathies; value £0.8M (Ann. Rheum. Dis., J. Autoimmun.; see McHugh impact case).
- NIHR funding to Taylor (09/3000/03) for "FRIENDS" (A randomised controlled cluster trial comparing the effectiveness and cost-effectiveness of a school-based cognitive behaviour therapy programme in the reduction of anxiety and improvement in mood in children aged 9/10); total consortium £1.28M (Lancet Psychiatry).

Industry Funding

- Industry-funded projects have been undertaken with, *inter alia*, AstraZeneca, GlaxoSmithKline, Mylan Pharma UK, Pfizer, Qualasept, AMT, Orexigen Therapeutics Inc., and Genetech. Notable examples of outputs and impact include:
  - US funding from AMT to Mrsny contributing to one of the UoA's impact cases. (Tissue Barriers, J. Immunol.).
  - US funding from Genentech to Mrsny resulting in a patented *in vitro* technology to simulate the subcutaneous injection site; commercialisation of a device now used in ~40 academic and industrial laboratories worldwide (J. Control. Release).

Fellowships

Support for both early-career and senior fellowships has been provided with protected research time and mentoring for early-career fellows.

- Watson M, Improvement Science Fellowship, Health Foundation (2016-2019) (The Cochrane Library).
- Potter, Wellcome Trust Senior Investigator Award (2014-2018) 'Chemical Biology of Cellular Signalling using Polyphosphate Messengers' (Nat. Chem. Biol., PNAS).
- Jones M, NIHR Transitional Research Fellowship (2018-2019) (J. Patient Saf.; BMJ Qual.Saf.) .

3.2 Organisational infrastructure including specialist research facilities

Technical and Support Staff. Research in the UoA is supported by specialist technicians in chemistry, molecular biology, analytical methods and electrical/mechanical engineering. The technical team is represented on the Executive and Safety Committees of Pharmacy & Pharmacology. In 2018, the University signed up to a national commitment to support the visibility, recognition, career development and sustainability of technical staff (*REF5a 4.7*).

Research and Innovation Services (RIS). The University's central RIS supports the securing, management and outcome optimisation of research funding to the UoA. RIS provides support to academic staff to:

- develop funding ideas and identify opportunities and sources of funding
- prepare and submit research proposals
- manage and financially oversee funded projects
- protect and commercialise intellectual property

Within RIS, Research Development Managers communicate and align strategic University and faculty with potential funding schemes, particularly for large interdisciplinary projects, and provide tailored, intensive support for individual fellowships and early-career researchers. Industry Partnership Managers facilitate academic and industrial research collaborations with the potential for Innovate UK and/or UKRI KTP applications (e.g., Watts/Qualasept).

Data Infrastructure. The University Advanced Research Computing (ARC) service is essential for the UoA's research in transcriptomics and pharmacoepidemiology supporting collaborations with national and international clinical partners. ARC manages access to high-performance computer (HPC) systems and provides specialized software support and training, workshops. ARC runs the Balena HPC system that provides 3,072x86 compute cores, a range of accelerator cards, a parallel filesystem and visualisation services.

Specialist Research Facilities. There has been significant strategic investment (EPSRC, BBSRC, plus the University; £7.9M within period) into centralized chemical and material analytical facilities to enhance the research environment (*REF5a 4.4*). The UoA benefits, in particular, from the specialist expertise and equipment available in the Materials and Chemical Characterization facility (MC^2), including: microscopy (confocal with airyscan, SEM, TEM, light-sheet), Aria-III flow cytometry, Raman spectroscopy, extensive NMR spectroscopy facilities (including 300MHz, 400MHz, 500MHz), mass spectroscopy (ESI-TOF, ESI-QTOF, MALDI, GS-MSD), size-exclusion chromatography and an advanced hypoxic facility. The UoA was awarded BBSRC ALERT funding for an advanced hypoxic facility (£280k; BB/M012409/1, PI, MacKenzie, co-Is Lindsay, Ward, Pourzand, Pula) and light-sheet microscopy (£310k; BB/S019820/1; co-Is Mrsny, DeBank) as part of MC^2. Other University start-up investment brought in a 2-photon FLIM microscope to the UoA (Larijani). UoA staff also use the outstanding Biological Services Unit with a team of specialist animal technicians to support rodent models for *in vivo* experimentation.

3.3 Collaborative use and contribution to national and international research infrastructure

The pharmacoepidemiology team use population data from the UK Clinical Practice Research Datalink, Hospital Episode Statistics for England, the New Zealand Ministry of Health datasets, the New Zealand interRAI database and the Big Data & Better Aging Research initiative. These resources provide patient data for drug utilisation, drug safety and the identification of risk factors for disease progression. McHugh oversees rheumatology tissue biobanks at the Royal United Hospital, Bath, and within the UoA, comprising over 10,000 samples, with linked clinical data and informed consent, and supplied as part of collaborative projects to Columbia University (US), the European Vasculitis Genetics Consortium, and the University of Manchester. The UoA banks myositis sera samples (~4000 samples) as part of the MYOPROSP prospective study in myositis shared with the University of Manchester. The UoA is a designated centre to test sera donated by patients diagnosed with lupus as part of the MRC MASTERPLANS research programme; samples are held within the UoA. Overall, the use of national databases and the biobanks has informed guidelines, led to earlier diagnosis and improved outcome measures.

The University of Bath is a member of the GW4 consortium of Universities with Exeter, Bristol and Cardiff. GW4 hosts the shared high-resolution cryo-microscopy facility (used by Mrsny lab). A collaboration with the University of Exeter and the National Physical Laboratory (Teddington) has applied advanced nonlinear Raman spectroscopic techniques to image and quantify drug penetration across the skin and nail (Guy, Delgado-Charro, output in PNAS).

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

4.1 Research collaborations and networks that enrich the research environment

Our research collaborations and networks contribute to the sustainability of the UoA research environment (*Figure 2*). As a unit we bring together different disciplines to tackle scientific challenges in medicine and healthcare as well as actively encourage leadership and participation in local, national and international networks. Many of our research outputs include international collaborators (57%, up from 44 % in 2014). These collaborators include leading research institutions across the world (e.g. US FDA, Harvard, Otago, Michigan, Wake Forest, Monash, Karolinska). Research in the DTD theme includes NIH-funded collaborative research with US Universities in opioid receptor drug development (Husbands). In the MD theme, Fotaki is a member of the SPAEDD-UK network with UCL, Aston and Birmingham that have developed safe and efficacious paediatric dosage forms while Mrsny is a partner in a network of 17 UK Universities with SMEs and companies to develop new approaches in bioprocessing (BioProNET) leading to a collaboration between Bath and the company Arecor. Pourzand has been instrumental in leading the 'International Skin@Bath Network & the related 'China-UK Skin Consortium' hosting two international networking events. In the HCR theme, membership of international networks has led to the development and incorporation of new outcome measures in the treatment of rheumatic disease. Pauling chairs the Vascular group of the International Scleroderma Clinical Trials Consortium and Tillett is the European Chair of the Psoriatic Arthritis Outcome in Rheumatology (OMERACT) group. McHugh leads an International Myositis study group (IMACS) in biomarker standardisation. Charlton is part of a EuroMediSafe consortium of 11 partner institutions and an EMA-approved partner on the €28.7M Innovative Medicines Initiative *ConcePTION* that brings together 88 organizations from 11 countries and has provided an evidence base for medication use in pregnancy.

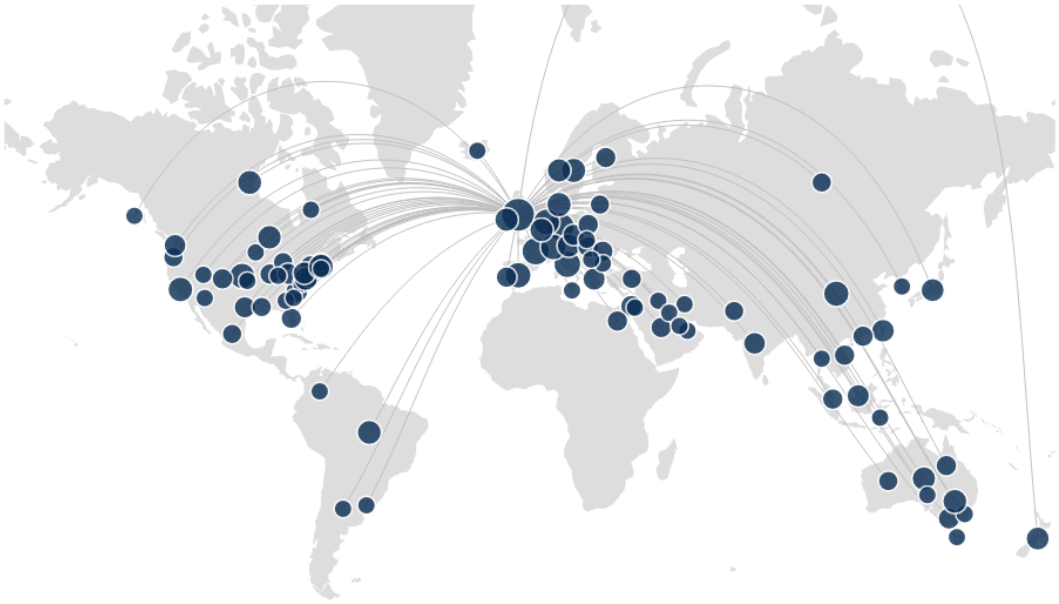

Figure 2. UoA International collaborations between 2015 and 2020, source PURE

Several GW4 funded networks are led by the UoA; Brain Cancer Research (Caggiano), Medicines Optimization (Watson M) and Large-scale Brain Networks (Jones R). Together with other local networks outlined in section 1 (Figure 1), including the Royal United Hospitals, these networks and collaborations help sustain critical mass and funding opportunities in their respective disciplines.

4.2 Wider contributions to the economy and society through response to national priorities, impact and reproducible research

The REF fundamental research strategy has been based on addressing 'real-world' problems to maximize the potential to contribute to society and the economy. In addition to our impact cases, notable examples include:

- Contribution to the Academy of Medical Sciences 'COVID-19: Preparing for a challenging winter 2020/21' (Mid/Early-Career Panel, Tansley**;** reviewed by the Scientific Advisory Group for Emergencies, SAGE); local COVID-19 rheumatology guidance for the Bath area (Tillett) and the LUCID-B Study (Living Under Coronavirus and Injecting Drugs in Bristol) Study (Scott**,** Co-investigator).
- Characterisation of biological therapeutics stability (Watts) contributing to seven-fold increase in Qualasept revenues (GBP 185M).
- Through a NIHR-funded PROMPT programme grant (McHugh) validation of a new Psoriatic Arthritis Impact of Disease Questionnaire to assess psoriatic arthritis (PsA); endorsed by the OMERACT international organization for inclusion in future PsA randomized control trials and clinical practice.
- Development of training on needle and syringe programmes with Exchange Supplies aligned with NICE guidelines and training films for pharmacy professions ('WeAreWithYou') to improve supervised user services (Scott).
- Reproducing findings of the association between obesity and psoriatic arthritis and reporting how reducing weight over time lessons that risk (McHugh).
- Responsiveness to national and international priorities is also evidenced by successful applications to funding calls (Section 3).

4.3 Engagement with diverse communities and the general public is a highly valued activity supported by the University Public Engagement (PE) Unit. UoA-led local events include an 'Art of the Brain' with artist Stephen Magrath (images in the Wellcome Collection), BRLSI Brainwave workshop and events in Pint of Science. Bailey S won the Vice-Chancellor's Award for PE (2015) and the UoA was awarded a Wellcome Trust PE seed fund (Ward; 2015) to develop a strategic approach for PE that was presented at the 2015 Cheltenham Science Festival. Key areas identified for engagement are: (i) local community, (ii) public and patients (iii) NHS and other public bodies involved in healthcare provision, and (iv) industry. UoA Research staff and doctoral students are involved at the local community level via activities such as Bath Taps into Science, Bath Science Cafe, Soapbox Science, and the University Images of Research. Bailey S was an invited speaker at the National Coordinating Centre for Public Engagement 'Research Academy' training (2018-2019). See *section 4.4* for engagement with beneficiaries including patients and key stakeholders. Larger global audiences are reached through a range of media communications including contribution to national television programmes (Guy, Bailey S), The Conversation and press releases to highlight research. Understanding Animal Research named Bath as a 2019-2022 Leader in the Openness around the use of animals in research including work within the UoA.

4.4 Relationships with key research users, beneficiaries or audiences to develop impact from research. Many staff engage with patient groups, healthcare professionals, industry and patients to inform patients, to input into research programmes and to develop impact (e.g. podcasts to patient groups Tansley). Patient partners are embedded in NIHR research programmes of the UoA (e.g. NIHR PROMPT study). McHugh, Pauling and Tillett all participate with patient support groups and events (e.g. Lupus UK, SRUK, Myositis UK). The NIHR fellowship of Jones M included an advisory group of NHS pharmacists, nurses and doctors to advise on research design. Scott works with Exchange Supplies, a social enterprise to improve harm reduction, and the London School of Health & Tropical Medicine to produce evidence-based harm reduction information. Scott has also worked with 'Release', a drugs, human rights and law charity, leading to a draft card to be carried by people on opiate substitution therapy, comparable to 'steroid cards' carried by patients on corticosteroids. Chapman has conducted a survey in

collaboration with the Epilepsy Society leading to publications for scientific and non-scientific audiences. Work with Qualasept and the NHS has led to the development of NHS- and MHRA-compliant testing methodologies for the extended shelf life of antibody-based drugs (Watts). Other examples include partnership with Genetech that lead to the development of new *in vitro* predictive technology (Mrsny), with AstraZeneca to develop new tools and guidelines (Fotaki), with the US FDA to develop and validate methods to assess bioequivalence of complex generic drug products (Guy, Delgado-Charro, Price, Fotaki), and the EMA to develop guidelines for the assessment of topical drug delivery to the skin (Delgado-Charro, Guy). Social workers, homeless charities, healthcare workers and police have been involved in the development of a device for the detection of synthetic cannabinoids (Husbands, Blagbrough, Scott).

4.5 Interdisciplinary research is important for the translation of early-stage research projects into translational impact and sustainability of the discipline. The CTI is leading an interdisciplinary research network across the University with a 2020 MRC-funded networking event with industry and several 'calls to arms' to build interdisciplinary bids to address real world problems. Examples of interdisciplinary research include MRC- and NIHR-funded research consortia (McHugh) bringing together clinical rheumatology with heath economists, geneticists and statisticians to improve earlier diagnosis and treatment of autoimmune disease. Other outstanding examples include the development of a glucose-sensor technology in collaboration with Physics (Guy) and work with Electronic & Electrical Engineering to develop new platforms to detect protein phosphorylation and miRNA (Lindsay, Pula). The need to improve diagnosis, assessment of disease severity and treatment of spondyloarthropathies has led to the formation of the Bath Spondyloarthritis Research Consortium (SPARC) that brings together clinical expertise with pharmacoepidemiologists (McGrogan), computer scientists and mathematicians.

4.6 Contribution to the Research Base

Fellowships, Prizes and Awards evidence the excellence of research and impact activities within the UoA. Guy was the first recipient of the 'Transdermal Delivery Kydonieus Foundation Award' in 2018 and the Maurice-Marie Janot Award 2016 from the Association de Pharmacie Galénique Industrielle for original and innovative research in pharmaceutics, biopharmaceutics and pharmaceutical technology. Bailey C was awarded the 2018 Novartis Prize from the British Pharmacological Society for achievements in research. Mrsny was awarded the 2019 Founders Award from the Controlled Release Society to honour contributions to the society and science. Niklison-Chirou awarded British Neuro-oncology Society Young Investigator Award (2019) and Tillett awarded EULAR Clinical Scientist Award (2015). Delgado-Charro was awarded Fellowship of the Academy of Pharmaceutical Sciences of Great Britain.

Researchers from the UoA have made contributions to society through national and international **advisory roles** in areas that range from the use of medicines to animal welfare. Examples include expert advisor for the NICE Centre for Guidelines (2016-), Chair of British Society Rheumatology Treatment Guidelines for psoriatic arthritis (2004-2016), Chair of the ARUK clinical study group for spondyloarthropathy (2012-2016) and Current Chair of International Myositis Assessment and Clinical Studies Group (McHugh). Advisor for the Framework 7 Trans-int consortium (2014-2015; Mrsny) and Member of the United States Pharmacopeia Expert Panel (2019-2025; Fotaki). Delgado-Charro (2016) and Guy (2018) were seconded as National Experts at the European Medicines Agency. Member of the BPS Animal Welfare and *In Vivo* Pharmacology Group (2015-2020) and the BPS Deputy Vice-President of engagement (2020) (Bailey S) and membership of the Biochemical Policy Committee (2014-2019; Dodson). Membership of the Expert Advisory panel for Pharmaceutical Science, the Pharmaceutical Society (2014-2017) and the Science and Research Board of the Royal Pharmaceutical Society of Great Britain (2017-2019) (Guy).

Contribution to the **peer-review process** includes membership of grant committees and editorial boards. Examples include the MRC non-clinical training and career development panel (Ward), the BBSRC committee E (personal awards), the UKRI Future Leaders Fellowship Panel College (Eggleston) and the NC3Rs CRACK-IT Challenge Review Panel (Guy). Guest membership of the Versus Arthritis Disease Subcommittee (Ward), The Myositis Association, Lupus UK, Medical Research Foundation (McHugh) and NIHR Health Services and Delivery Research Prioritisation

Committee (Jones M). Membership of the Irish Research Council (STEM) postgraduate and postdoctoral fellowship outer-board (Ward), the Science Foundation Ireland Virtual Review Panel for Technology Development Innovation Awards and the Frontiers for the Future Programme (Eggleston). BHF 2020 quinquennial review panel for BHF chair at QMUL (Ward). Membership of the Innovative Medicines Initiative, H2020 grant panel, KU Leuven grant panel and the Slovenian Research Agency (Fotaki), evaluation panels of the Agence National de France and the Finnish Academy of Science (Larijani). In the US, Guy was a member of the International Life Sciences Research Announcement (ILSRA) Physiology, Monitoring and Pharmacology, NASA (Washington, D.C., USA). Locally, membership of the Bath Institute for Rheumatic Disease Grant Award Panel (McHugh, MacKenzie, Pauling).

Examples of Editorial board membership include Scientific Reports, Experimental Lung Research, (Lindsay), Journal of Biological Chemistry, American J Clinical and Exp Immunology (Ward), Pharmacology Research & Perspectives, British Journal Pharmacology (Bailey S, Bailey C), PLOS ONE (Larijani), The Biochemist (Lloyd), Journal of Rheumatology (Tillett), BMC Rheumatology (Pauling) and RMD open (McHugh). Pharmaceutics, Cosmetics (Delgado-Charro), Journal of Pharmacy and Pharmacology, Die Pharmazie, AAPS open and Dissolution Technologies (Fotaki) and BMC Microbiology (Bolhuis).

Invited keynotes, lectures or conference chairs: Our academics have organised/chaired sessions in 35 conferences including Gordon Conferences, FASEB summer conferences, the Bill and Melinda Gates Foundation and the Royal Society. Over the REF period we have delivered >200 invited seminars at national and international conferences and institutions (including Universities of Edinburgh, Oxford, Parma, Southern Denmark, California, Tulane, Zhejiang). Notable highlights include the Maurice-Marie Janot Award Lecture 2016 (Guy), the US Controlled Release Society Founders Award Lecture 2019 (Mrsny) and the prestigious Royal Society of Chemistry's Biological and Medicinal Chemistry Lectureship in 2014 (Potter).

Contribution to PGR training has included membership of the MRC GW4 BioMed leadership team (MacKenzie) and the BBSRC SWBio implementation team (Bailey C, Eggleston). Eggleston is the Faculty Director of Doctoral Studies for the Faculty of Science.