Institution: University of Bristol
Unit of Assessment: 1: Clinical Medicine
1. Unit context and structure, research and impact strategy

REF2021 UoA1 highlights

- **Structure:** During this REF cycle, the University of Bristol (UoB) has undertaken a strategic research restructuring in biomedical sciences to focus on excellence in five areas: Cardiovascular Sciences (CVS) and Infection, Immunity and Cancer (II&C) (UoA1); Population Health (UoA2); Neuroscience (UoA4); Fundamental Biosciences (UoA5). This fosters critical intellectual mass, increases funding competitiveness, improves academic output quality, promotes good academic practice, provides a stimulating and supportive environment for early career researchers (ECRs), and maximises the impact of our research.
- **Funding:** Compared with REF2014, research funding during this REF cycle has increased considerably. Total research spend increased 67% to more than £106m, a 50% increase per full-time-equivalent (FTE). Support includes high profile awards such as: Sir Jules Thorn Award (**Caputo**, £1.4m); four British Heart Foundation (BHF) Chairs, (up from two in REF2014); four BHF programme awards; MRC Senior Clinical Fellowship (**Coward**, £1.47m); two MRC Programme awards (**Cannell**, £1.5m; **Avison**, £2.9m); MRC Stratified Medicine Award (**Saleem**, £2.5m); and a Wellcome Trust (WT) Senior Research Fellowship (**Piddini**, £2m) (section 3a).
- **Training:** We have developed a fully integrated 'cradle to consultant' clinical academic training scheme for medical, veterinary and dental professionals linking our undergraduate WT-INSPIRE scheme, through Academic Clinical Fellowships (ACFs) to doctoral training including our £5.1m WT-funded Clinical Academic Training PhD programme. We have established an opportunity for clinicians to re-engage with research careers through a unique research-primer scheme (Elizabeth Blackwell Institute (EBI) Fellowships), with 38 awarded since 2014 supported by £983k funding. For biomedical scientists, a series of large Doctoral Training Programmes (DTPs) have been established (attracting over £53m funding), including a BHF-funded PhD Programme in Integrative Cardiovascular Science (awarded and renewed) together with bespoke career development opportunities provided through the University as Vice Chancellor's Fellowships (41 across UoB, with an average support package of £200k).
- **Equality, Diversity and Inclusion (EDI):** We are committed to continue to improve EDI. For example, three of the four contributing Schools in this UoA have progressed their Athena Swan awards during this REF cycle (two new Silver and one new Bronze award alongside one existing Bronze) and we monitor and have targets for increasing the proportion of BAME staff, particularly at higher grades. We have exceeded the University stretch targets for female appointments to the professoriate – for example, moving from 18% female in medicine in 2014 to 34% in 2020. Key female senior leader appointments include: **Norman** (Dean, Faculty of Health Sciences); **Purdy** (Head of Bristol Medical School (BMS) then PVC Student Experience); and **Ridley** (Head of School, Cellular and Molecular Medicine).

- **Interdisciplinarity:** To support and lend added value to our thematically-based research, and capitalise on an existing culture of interdisciplinarity combined with our strategy, interdisciplinary University Research Institutes (URIs) and Specialist Research Institutes (SRIs) have been established (REF5a). The URIs/SRIs most relevant to UoA1 are: Bristol Heart Institute (BHI, SRI), EBI (Health, URI), Jean Golding Institute (Data, URI), and the Max Planck-Bristol Centre for Minimal Biology (€10m) nested in Bristol BioDesign SRI (Synthetic Biology Engineering, spanning medicine, life sciences and physical sciences). These are complemented by a £21m National Institute of Health Research (NIHR) Biomedical Research Centre (BRC), £9m NIHR Applied Research Collaboration (ARC) and its predecessor CLARHC West (2014-2019, £10m with >£14m matched partnership funding). We have recently been designated as an NIHR-NHSE/I Academic Health Science Centre (AHSC), one of only eight in the UK.
- **Translational and Societal Impact:** Our research has improved clinical practice and health care throughout the world, as evidenced by our Impact Case Studies (ICSs). Economically, we have generated wealth and employment through establishing multiple academic-industrial collaborations and five spin-out companies attracting funding of over £69m. This includes the Purespring start-up (**Saleem**, **Welsh**), launched with £45m Series A investment by Syncona – the largest such UK investment in 2020. Also, KWS BioTest was acquired by Charles River Laboratories in 2018 for £16.7m. The effectiveness of our research structure is evident from our ability to rapidly develop a multidisciplinary approach to major societal and health care issues. This is exemplified by our reaction to the COVID-19 pandemic, when UoA1 staff contributed to a range of endeavours – from defining the structure of the coronavirus spike (**Davidson**-Science-2020) and a coreceptor (**Yamauchi**-Science-2020) to being the largest city region recruiter to the Oxford-AstraZeneca vaccine trial in the UK (REF5a Annex).

1a. Overview of Research Policy and Structure

Research in clinical medicine at UoB is delivered through Schools within the Faculties of Health Sciences (Dean- **Norman**) and Life Sciences (Dean- **Tavaré** [UoA5]) under the overarching leadership of the Pro Vice-Chancellor for Health and Life Sciences (**Iredale**).

Our research mission is to study comprehensively the full translational health pathway spanning from molecules to populations and back again. We do this collaboratively throughout all of our biomedical research activities, which are also returned in UoAs 2, 4, 5 and 6. Our close interdigitation with the NHS and success in translational research is evidenced by our AHSC award in 2020.

Following REF2014, UoB undertook a major strategic review of biomedical research, to charge and catalyse research excellence for the current REF cycle and beyond. Through this process the University further coalesced biomedical research into five areas that cross School and Faculty boundaries. This maximizes leverage from investment, ensures effective and focused capacity building, and capitalizes on and enhances the existing culture of interdisciplinarity to deliver excellence at scale. These comprise: 1. Cardiovascular Sciences (CVS) (Lead- **Angelini**); 2. Infection Immunity and Cancer (II&C) (Lead- **Ridley**); 3. Population Health, including the MRC Integrative Epidemiology Unit (UoA2); 4. Neuroscience (UoA4); 5. Fundamental Biosciences (UoA5). To support and lead these changes the position of PVC Health and Life Sciences (**Iredale**) was established and a series of Faculty re-organisations to bring key groups into juxtaposition took

place. The CVS and II&C groupings interdigitate with the cognate NHS services at multiple layers, but crucially through joint leadership models (from Non-Executive Directorships downwards) where all divisional activity is led by a clinically-active academic (e.g. CVS **Angelini**).

The interdisciplinarity of activity in UoA1 is also reflected by the contributing Schools, which for CVS are: BMS (Head- **Blom** [UoA2]); Physiology, Pharmacology and Neuroscience (PPN) (Head- **Piggins** [UoA4]); and Cellular and Molecular Medicine (CMM) (Head- **Ridley**). For II&C they are: BMS; Biochemistry (Head- **Nobes** [UoA5]); and Bristol Dental School (BDS) (Joint Heads- **Barbour**, **Bain** [NHS]). UoB has conferred SRI status on the cardiovascular science grouping (one of only seven SRIs across the University) to reflect and represent the significant, externally-recognised critical mass in this field – Bristol Heart Institute (BHI) (Director- **Angelini**).

1b. Strategic Research

UoA1 consists of 102 category A researchers (94.6 FTE), 17% of whom are ECRs. These researchers are aligned to either the CVS or II&C themes.

CARDIOVASCULAR SCIENCES

CVS research spans the full translational pathway from fundamental discovery science to the development and execution of large clinical trials, and is a substantial element of the BRC. During this REF cycle the group has supported four successful BHF Chairs (**Angelini**, **Caputo**, **Emanueli**, **Newby**). Since REF2014 proteinuric renal medicine (as a major independent risk factor for cardiovascular disease) together with thrombosis/platelet biology have been integrated into this theme. These complement the established strengths of Cardiac Surgery, Cardiac Imaging and Clinical Trials in addition to fundamental cardiovascular cell biology and physiology performed in this UoA. CVS has eight inter-related sub-themes: A. *Cardiac Surgery*, B. *Cardiac Imaging*, C. *Hypertension*, D. *Thrombosis and Platelet Biology*, E. *Cardiovascular Electrophysiology*, F. *Vascular Cell Biology*, G. *Renal Science*, H. *Clinical Trials.*

A. CARDIAC SURGERY (Angelini, Ascione, Benedetto, Caputo, Ghorbel, Gibbison)

This group of paediatric and adult cardiac surgeons, together with academic cardiac anaesthetists and fundamental scientists, are based at the Bristol Heart institute (BHI) and £6.3m MRC/BHF/UoB-funded Translational Biomedical Research Centre (TBRC) on UoB's Langford campus where large animal surgery/research occurs.

The mission is to improve the outcomes for patients undergoing cardiac surgery through the development of novel therapeutic approaches and by refining current practice. The group pioneered off-pump cardiac surgery in the 1990s, now used world-wide. Research highlights during REF2021 include using stem cells to repair damaged cardiac muscle and arteries (**Angelini**-Circulation Research-2015; **Ghobel**-Biomaterials-2019), developing new techniques to analyse animal-model cardiac pathology (**Ascione**-Nature Protocols-2017) and improving cardiac-surgical patient care globally by leading numerous large multi-centred randomised prospective trials. Trials include assessing if liberal or restricted blood transfusions are perioperatively beneficial in cardiac surgery (**Angelini**-New England Journal of Medicine [NEJM]-2015), defining the best surgical approaches for coronary artery bypass operations (**Benedetto**-NEJM-2016, 2018, 2019) and optimal aortic valve replacement techniques in children and young adults (**Caputo**-Journal of American College of Cardiology [JACC]-2016). High-quality meta-analyses are also undertaken, for example: assessing the use of protease inhibitors in hyperlipidaemic situations (**Benedetto**-

European Heart Journal [EHJ]-2016), defining the benefit of calcium channel blockers on radial artery coronary grafts (**Benedetto**-JACC-2019), optimising the management of antiplatelet therapy in coronary artery surgery (**Ascione**-EHJ-2014) and assessing the mortality risk associated with dual antiplatelet therapy post cardiac-vessel stent insertion (**Benedetto**-Lancet-2015). The group has also interrogated the effects of cardiac surgery on pituitary-adrenal dynamics (**Gibbison**-Critical Care Medicine-2015).

B. CARDIAC IMAGING (Biglino, Bucciarelli-Ducci, Paul, Pufulete, Sammut-[ECR])

This group uses magnetic resonance imaging (MRI) to assesses coronary and myocardial function in health and disease. Through both national and international collaborative studies, they have shown that using cardiac MRI to assess patients with angina results in fewer patients needing to undergo revascularisation surgery compared with those investigated using conventional “invasive” angiography (**Bucciarelli-Ducci**-JAMA-2016; NEJM-2019). They have also optimised imaging methods to assess myocardial infarct oedema (**Pufulete**-Radiology-2015) and predict patients at risk of future infarcts (**Sammut**-JACC:Cardiovascular Imaging-2018). MRI has also been used to guide cardiac prognosis in a variety of other diseases including Amyloidosis (**Bucciarelli-Ducci**-Circulation-2015), primary hypertension (**Bucciarelli-Ducci**-Heart-2016) and post-myocardial infarct (**Bucciarelli-Ducci**-JACC:Cardiovascular Imaging-2019). **Biglino** is a biomedical engineer bringing computational and mathematical expertise to image acquisition and interpretation (**Biglino**-JACC:Cardiovascular Imaging-2019), working closely with **Paul** who uses sophisticated Cryo-Electron Microscopic techniques to model filamentous cardiac fibre function (**Paul**-Journal of Cell Biology [JCB]-2020).

C. HYPERTENSION (Hart, Nightingale, Paton, Teschemacher)

This group investigates the central control of blood pressure using an array of sophisticated *in vitro* and *in vivo* model systems. They have discovered novel drug targets in the carotid body critical in controlling blood pressure (**Paton**-Nature Medicine-2016), that unilateral resection of a carotid body can cure drug-resistant hypertension (**Hart**-JACC Basic to Translational Science-2016) and that hypertension may be protective for neurological status in some settings (**Nightingale**-Circulation Research-2016). Furthermore, they identified key neuronal pathways responsible for heart rate and central blood pressure control (**Teschemacher**-Nature Communications-2014, 2018). Collectively, these researchers are identifying novel therapeutic targets to cure the most difficult to treat hypertensive patients.

D. THROMBOSIS AND PLATELET BIOLOGY (Bradbury, Hers, Kelly, Mumford, Mundell, Poole, Westbury-[ECR])

This group investigates the key mechanisms underlying thrombosis within the circulation. They have described important mechanistic processes that induce platelet adhesion in the pathogenesis of atherothrombosis (**Poole**-Circulation-2015; **Hers**-Journal of Clinical Investigation (JCI) Insight-2018; **Mundell**-Blood-2014) and investigated the roles of G-coupled receptors by working closely with Kelly who has expertise in this field (**Kelly**-Blood-2016; PNAS-2019). They have discovered multiple genes critically important for controlling platelet number, size and function (**Westbury**-Science Translational Medicine [STM]-2016; **Mumford**-Blood 2016, 2017(i), 2017(ii); **Mumford**-JCI-2017) and delineated crucial regulators of thrombosis (**Bradbury**-Blood-2020). Ground-breaking work by the group has improved patient care through a genetics-driven stratified medicine approach (*REF2021-ICS)* including whole genome sequencing of rare patient cohorts (**Mumford**-Nature-2020) that has advanced understanding of multiple haematological conditions.

E. CARDIOVASCULAR ELECTROPHYSIOLOGY (Cannell, Hancox, Harmer, James)

These researchers have developed novel techniques to study the function of ion channels in cardiomyocytes (**Hancox**-Journal of Biochemistry (JBC)-2018; PloS Computational Biology-2016). This has led to the world-wide adoption of these techniques and development of a Comprehensive *in vitro* Proarrhythmia assay (CiPA), which is now used globally in pre-clinical cardiac drug safety (*REF2021-ICS*). They have also developed new techniques to image calcium currents in cardiac tissue (**Hancox**-Circulation Research-2018), which have been used to assess cardiac Calcium signalling abnormalities underpinning arrhythmias in heart failure (**Cannell**-PNAS-2020) and assess solute movement in cardiomyocytes (**Cannell**-PNAS-2018; **James**-Journal of Molecular and Cellular Cardiology-2015). Finally, important pro- and anti-arrhythmic pathways have been elucidated through CRISPR/Cas9 editing of embryonic cardiomyocyte stem cells (**Harmer**-EHJ-2018).

F. VASCULAR CELL BIOLOGY (Bond, George, Johnson, Madeddu, Richardson, Suleiman, Lewis-[ECR], Mascetti-[ECR]).

These researchers explore the mechanisms underpinning atherosclerosis and cardiac cell injury. They have defined the roles of microRNAs and metalloproteinases in the development of cardiovascular disease (**Johnson**-Circulation Research-2017), how cells adapt to hypoxia (**Bond**-EMBO Molecular Medicine-2018), the therapeutic potential of cardiac stem cells in ischaemic and diabetic damaging environments (**Madeddu**-Nature Communications-2015; Circulation Research 2015(i), 2015(ii); **Mascetti**-Development-2015(i), (ii); Cell Stem Cell-2014, 2016; Nature Communications-2018), and the use of gene therapy to halt the progression of atherosclerosis (**Madeddu**-EHJ-2020). Furthermore, the importance of secreted adipose WNT proteins on vascular health have been elucidated (**George**-STM-2019), together with crucial vascular functions of specific long non-coding RNAs (**George**-Circulation Research-2019). Using *in vitro* and *in vivo* models cardiac stress (**Suleiman**-British Journal of Pharmacology-2017) and metabolic (**Lewis**-International Journal of Molecular Sciences-2019) pathways have been defined. Finally, the importance of inflammatory cell signalling for tissue repair in cardiovascular and other disease processes has been interrogated using sophisticated Zebra fish models (**Richardson**-JCI-2014; PLoS Genetics-2014; Immunity-2015; Nature Communications-2019; Cardiovascular Research-2020).

G. RENAL SCIENCES (Coward, Drake, Foster, Fry, McArdle, Saleem, Satchell, Welsh, Butler-[ECR], Ding-[ECR])

Bristol Renal comprises over 50 academic clinicians and fundamental scientists. A major collective research interest is proteinuric glomerular kidney disease with a focus on nephrotic syndrome and diabetic nephropathy. SciVal metrics ranked them world #1 for glomerular proteinuria podocyte biology. Research highlights include developing the gold standard human podocyte cell line used globally both academically (cited >900 times) and in industry for drug development and toxicity testing. They have identified numerous novel genetic drivers of proteinuric disease (**Welsh**-American Journal of Human Genetics-2019; Journal of American Society of Nephrology (JASN)-2017, 2019; **Saleem**-Nature Communications-2016; JCI-2017; Nature Medicine-2017). They also study renal cell biology underpinning diabetic nephropathy (**Coward**-JCI-2017; Kidney International [KI]-2019; Nature Communications-2019; PNAS-2020). This includes developing mathematical models to explore cell signalling pathways (**McArdle**-PNAS-2014; Nature Communications-2018, 2019; JCI-2020). The glomerular endothelial cell and its associated glycocalyx in diabetes is also a

research focus (**Satchell**-JASN-2014, 2015(i), (ii); **Foster**-Diabetes-2019; KI-2018; **Butler**-KI-2019). Bristol Renal have been instrumental in developing a stratified medicine approach to nephrotic syndrome (**Ding**-JASN-2014; **Saleem**-KI-2017; Clinical JASN-2020) (*REF2021-ICS)* and establishing national and international cohorts of nephrotic and chronic kidney disease to study approaches including whole genome sequencing (**Saleem**-Nature-2020). **Drake** and **Fry** study the physiology of the lower urinary tract, focussing on bladder function, performing high-quality randomised clinical trials into pharmacological therapies for incontinence and overactive bladder symptoms (**Drake**-European Urology-2015, 2016, 2020) and understanding fundamental mechanisms of bladder control (**Fry**-eLife-2020).

H. CLINICAL TRIALS (Culliford, Harris, Metcalfe, Norman, Reeves, Qureshi-[ECR])

This group develops, performs and analyses high-quality clinical trials using innovative trial design in cardiovascular disease and other important areas of medicine and surgery, within the team science research culture pertaining across UoA1. Examples include the use of peri-operative blood transfusions in cardiac surgery (**Reeves**-NEJM-2015), airway management in cardiac arrest situations (**Reeves**-JAMA-2018), and the benefit of bariatric surgery (**Reeves**-PLoS Medicine-2016). They have evaluated the use of cheaper anti-VEGF therapies compared with more expensive formulations in age-related choroidal neovascularisation in the eye, resulting in huge cost savings world-wide (*REF2021-ICS)*, and shown no benefit in the use of mineralocorticoid antagonists in chronic chorioretinopathy (**Culliford**-Lancet-2020). The group has developed tools to evaluate bias within clinical trials including the ROBINS-I “Risk of Bias in non-randomised studies of intervention” (**Reeves**-BMJ-2016) and the follow-up tool (RoB-2) (**Reeves**-BMJ-2019). These two papers have been collectively cited more than 4000 times. The group has also developed methodology to improve laboratory-based research (**Harris**-eLife-2015) and performed systematic reviews to define best practice for surgical procedures (**Qureshi**-Neurology-2015).

Metcalfe is a statistician who bridges CVS and II&C and leads on the design, execution and analysis of trials. Key examples are in defining the best treatment and screening modalities for prostate cancer (**Metcalfe**-NEJM-2016(i), (ii); Lancet Oncology-2014; JAMA-2018), and trials to reduce pesticide self-poisoning in rural Asia through lockable devices (**Metcalfe**-Lancet-2017).

Clinical trials leadership and expertise has been further bolstered by the appointment of **Norman**, who leads multi-centre prospective randomised trials in pregnancy. These include clarifying the role of vaginal progesterone in preventing preterm birth (**Norman**-Lancet-2016) and vaginal bleeding early in pregnancy (**Norman**-NEJM-2019). **Norman** has also shown that: closely monitoring reduced foetal movements in pregnancy does not prevent stillbirths (**Norman**-Lancet-2018); and administering morphine analgesia for procedures in premature babies is not beneficial and can cause harm (**Norman**-Lancet-2018).

INFECTION, IMMUNITY & CANCER

II&C (Lead- **Ridley**) has four sub-themes: A. *Virology*, B. *Microbiology including Antimicrobial Resistance (AMR)*, C. *Immune Regulated Disease*, D. *Cancer and Cell Programming*. This theme is formed by researchers from four UoB Schools: CMM; BMS (predominantly from Translational Health Sciences); PPN; and BDS. Other aspects of UoB’s infection and immunity research are submitted elsewhere including aspects of vaccine research (UoA2) and AMR (UoAs 2, 5, 6 and 8).

A. VIROLOGY (Davidson, Looker, Matthews, Rivino, Yamauchi)

Understanding how viruses spread, are modulated by the immune system, invade cells and evoke cellular damage are crucial issues for this theme. These researchers have made a number of seminal discoveries during this REF cycle, particularly those relating to the evolving SARS-CoV-2 pandemic. They have discovered critical free fatty acid binding pockets in the spike protein that are potential therapeutic targets (**Davidson**-Science-2020) and identified that Neuropilin-1 is a crucial host factor for SARS-CoV-2 entry into cells (**Yamauchi**-Science-2020). They have also worked swiftly and collaboratively to help prevent the spread and catastrophic consequences of some of the most potent pathogens in the world. This is evidenced by **Matthews**' involvement in identifying and containing the Ebola viral outbreak in West Africa in the middle of this decade (**Matthews**-Nature-2014, 2015, 2016). **Matthews**' work had major global impact on containing this disease *(REF2021-ICS)*, and defined the molecular pathways underpinning cellular damage in other viral infections including Hendra virus (**Matthews**-Genome Biology-2014).

These researchers have identified key conserved viral peptides that enable Natural Killer (NK) cell receptors to target multiple pathogenic viruses (**Davidson**-Science Immunology-2017). They developed novel methodologies to generate vaccines (**Davidson**-Advanced Functional Materials-2019) against highly virulent viruses such as Zika (**Davidson**-Nature Communications-2018) and dengue (**Davidson**-Scientific Reports-2016). They have used population modelling to predict global and regional incidences of important viral diseases including neonatal Herpes (**Looker**-Lancet Global Health-2017) and its impact on the acquisition of other infections including HIV (**Looker**-Lancet Infectious Diseases-2020). Furthermore, mixed-methods approaches have shown how infection rates have altered over time in relation to deprivation (**Looker**-Lancet-2015).

Mechanistic insight into understanding how viruses interact with cells and cellular proteins to initiate infection and progress disease is important as it can identify novel therapeutic targets. Numerous key mechanisms of cell damage due to Influenza A have been identified (**Yamauchi**-Science-2014; eLife-2016; Nature Microbiology-2019), and tools developed to identify complex extracellular interactomes for this virus (**Yamauchi**-Nature Communications-2018).

As well as the direct cellular effects of viral infection, deciphering how the immune system modulates viral infections is crucial, especially for viruses with no effective pharmacological therapies or vaccines, such as dengue. The group has discovered that T and NK cells proliferate and hone to the skin in patients with dengue fever (**Rivino**-STM-2015; Nature Communications-2019) and that specific T-memory cells are produced in this disease (**Rivino**-Immunity-2019).

B. MICROBIOLOGY AND AMR (Avison, Barbour, Cerajewska, Diezmann, Hill, Ireland, Massey, Nobbs, Spencer, Su, West, Amulic-[ECR], Bandara-[ECR], Correia Carreira-[ECR], Haworth-[ECR], Tyrrell-[ECR])

Microbial infection and an emergence of resistance to current therapies are amongst the most pressing global issues for society and health. In AMR research this group leads collaborative international One Health initiatives and uses molecular genetics, biochemistry and functional genomics to characterise key AMR mechanisms (**Avison**-Nature Chemistry-2014; Nature Communications-2016; eLife-2016; **Spencer**-Lancet Infectious Diseases-2016; PNAS-2016; Nature Communications-2018; **Tyrrell**-Nature Microbiology-2017; Lancet Infectious Diseases-2017). Other groups investigate how pathogens cause disease by identifying virulence factors using pathogen Genome Wide Association Sequencing (GWAS) and mathematical modelling

approaches (**Massey**-PLoS Biology-2015; Genome Research-2014; eLife-2017; Nature Microbiology-2017), molecular recognition mechanisms by which pathogens interact with host epithelial cells (**Nobbs**-PLoS Pathogens-2019; JBC2016, 2017; **Ireland**-Applied and Environmental Microbiology-2014; **Haworth**-Cellular Microbiology-2017) and the role of heat shock proteins in fungal infections (**Diezmann**-PLoS Genetics-2016). Immunological responses to infection are also studied including the role played by the neutrophil (**Amulic**-Blood-2015; Developmental Cell-2017; Science Immunology-2019; Cell Metabolism-2020), how mucosal immunity prevents pathogen invasion (**Hill**-Nature Microbiology-2016) and the effects of infective processes on other pathologies including Alzheimer's disease (**Cerajewska**/**West**-Frontiers in Aging Neuroscience-2017). Cross-disciplinary approaches have also been employed to develop antibacterial biomaterials to prevent pathogen invasion, for example in the oral cavity (**Su**-Nature Communications-2020; **Barbour**-Microbiology-2015; **Bandara**-njp Biofilms & Microbiomes-2018) and post-wound formation (**Correia Carreira**-Nanotoxicology-2015; Biomaterials-2018).

C. IMMUNE REGULATED DISEASE (Dayan, Dick, Gillespie, Hamilton-Shield, Iredale, Jones, Lee, Nicholson, WilliamsAlistair, Wuelfing, Goenka-[ECR], Long-[ECR])

Immune dysregulation is a major driver of many debilitating disease processes that effect millions of people world-wide. Fundamental immunological processes underpinning the development of inflammatory disease including T cell trafficking have been studied (**Dick**-Nature Medicine-2015; **Wuelfing**-STM-2016; Science Signaling-2016, 2019; eLife-2017; **Lee**-PNAS-2015; **Nicholson**-Journal of Immunology-2014). The early autoantibody signature and immunological basis of type-1 diabetes have been explored (**Gillespie**-Diabetes-2014, 2015; Diabetologia-2015,2020; **WilliamsAlistair**-Diabetes-2014, 2015, 2019; Diabetologia-2018; **Hamilton-Shield**-Pediatrics-2015). **Iredale**, working with colleagues in Edinburgh and Bristol, focuses on the innate immune system, molecular drivers of fibrosis and inflammation in the liver and pancreas (**Iredale**-Nature Communications-2019; Nature Medicine-2016; PloS Medicine-2017; ScienceTM-2018). **Jones** and colleagues explore disease mechanisms underlying cytokine-driven chronic disease (**Jones**-Immunity-2014; Journal of Experimental Medicine-2015; PLoS Pathogens-2016; Nature Immunology-2019; Diabetes-2019). This complements work by ECRs in the School (**Goenka**-Clinical Infectious diseases-2014; **Long**-Diabetologia-2020).

These researchers also lead multi-centre randomised clinical trials into immune regulating therapies and their impact on disease severity. This includes the use of the anti-TNF-a monoclonal antibody, Adalimumab, in juvenile idiopathic arthritis associated uveitis (**Dick**-NEJM-2017) as well as active (**Dick**-NEJM-2016) and inactive non-infectious uveitis (**Dick**-Lancet-2016). These studies have revealed Adalimumab to be more effective than current standard of care in treating these eye diseases and have changed clinical practice world-wide (*REF2021-ICS*). Trials in thyroid eye disease have shown that intensification of immunosuppression with radiotherapy is non-superior to current standard of care, improving patient care by reducing radioactive burden (**Dayan**-Lancet Diabetes and Endocrinology-2018), and have assessed the effects of primary Graves' disease therapies on cardiovascular morbidity and mortality (**Dayan**-Lancet Diabetes and Endocrinology-2019). They have led ground-breaking first-in-man studies assessing novel immunotherapies in the treatment and prevention of type-1 diabetes (**Dayan**-STM-2017).

D. CANCER AND CELL PROGRAMMING (Atan, Blair, Brown, Carazo Salas, Dodd, Essafi, Kafienah, Malik, Maskell, Perriman, Piddini, Perks, Ridley, Roberts, Sheppard, WilliamsAnn, Lloyd-Lewis-[ECR], Robinson-[ECR], Vincent-[ECR])

UoB cancer-related research covers the whole translational pathway from fundamental science to high-quality clinical trials. A variety of techniques are used to understand how cells differentiate and de-differentiate during both normal development and in neoplastic situations. This includes employing integrative fundamental cell biology to elucidate how gene and protein networks control processes including cell growth, division and differentiation (**Carazo Salas**-Developmental Cell-2014; Nature Genetics-2015; Nature Communications-2015, 2016; Nature Methods-2017; **Essafi**-eLife 2017), understanding how cell competition is controlled during both normal development and cancerous situations (**Piddini**-Developmental Cell-2014, 2015; Nature Communications-2016, 2017; Current Biology-2016) and understanding the dynamic pathways that regulate stem cell fate in development and cancer (**Lloyd-Lewis**-Nature Cell Biology-2014; Science Signalling-2014; Nature Communications-2016(i), (ii)). Studies have improved understanding of why some stem cells initiate leukaemia, but others produce normal blood cells during hemopoiesis (**Blair**-Blood-2014; Nature Communications-2017).

This group also investigates the transcriptional control of neoplastic cells (**Roberts**-Nature Communications-2014) alongside the environmental drivers of neoplasia. These include epigenetic regulating mechanisms (**Brown**-Molecular Carcinogenesis-2017; **Malik**-European Journal of Immunology-2015), the role of Insulin-like growth factors in cancer (**Perks**-Clinical Cancer Research-2015) and mechanistically how the metabolic environment modulates cancer initiation and progression in bowel cancer (**WilliamsAnn**-Gut-2016; EMBO Molecular Medicine-2018). Metabolomic studies are performed in Insulin-resistant states during the evolution of cancer (**Vincent**-PNAS-2014; Molecular Cell-2015; Cell Metabolism-2015, 2016; Immunity-2015; Nature Communications-2016, 2019), together with the role of actin cell dynamics in malignancy and metastasis (**Ridley**-Nature Communications-2014; Cancer Cell-2017; JCI-2019).

Important human diseases from a developmental cell biology perspective are studied using a variety *of in vivo* and *in vitro* models. These include cystic fibrosis (**Sheppard**-Nature Chemistry-2016; PloS Biology-2017; JBC-2017), blindness and epilepsy (**Atan**-PNAS-2014; BMJ-2018; Human Genetics-2019) and musculoskeletal conditions (**Kafienah**-Stem Cells-2017).

At the other end of the translational pathway, large international multi-centre randomised clinical trials provide evidence on the best therapies for our patients. An exemplar of this is work examining the benefit of radiotherapy in malignant pleural effusion management (**Maskell**-Thorax-2014, 2016; Lancet Oncology-2016; NEJM-2018). It has shown that radiotherapy is not beneficial, which has informed international guidelines, reduced terminally ill patients' unnecessary repeat attendances to hospital, thereby improving their quality of life and saving substantial healthcare costs. Other researchers in this group have developed new technologies for monitoring patients at home with respiratory disease (**Dodd**-Frontiers in Physiology-2017), and defined risk factors for cancer progression in large patient cohorts (**Robinson**-Nature Communications-2020; Clinical Cancer Research-2018).

Finally, cross-disciplinary tissue engineering work complements multiple aspects of research in UoA1, across both themes (CVS & IIC). This has been facilitated by nurturing a talented chemist (**Perriman**). An EPSRC ECR at UoB, **Perriman** progressed into a UK Research and Innovation (UKRI) Future Leaders Fellowship and is now a key PI in the new Max Planck-Bristol Centre for

Minimal Biology. This work has revealed novel ways of growing both stem and differentiated cells on engineered membranes, and generating complex organoid systems (**Perriman**-Nature Chemistry-2014; Journal of the American Chemical Society-2014; Nature Communications-2015, 2019).

1c. REF2021 impact strategy

To translate our research, we have created a central Translational Research Hub (TRH) within UoB's Research and Enterprise Development (RED) Division to consolidate our collective staffing and funding resources to support our health and life sciences research translation across Main Panel A (REF5a). Funded by UoB and a WT Institutional Translational Partnership Award (iTPA), oversight of TRH is provided by a Steering Group chaired by **Iredale** as PVC, and includes the two Faculty Deans (**Norman**, **Tavaré** [UoA5]), our Advisor on Business Development and Royal Society Entrepreneur-in-Residence, Dr Richard **Seabrook** (formerly WT Head of Business Development), and the EBI Director (**Gooberman-Hill** [UoA2]). TRH provides a single entry-point for all researchers interested in translation of their health and life science-related research. It currently comprises 8FTE support staff, an increase of 6FTE during the current REF cycle, and 'hides the wiring' to simplify engagement. It also provides a simplified single-point-of-contact into the University for companies seeking to explore engagement, commercialisation and collaborative research opportunities with academics in the health and life sciences. TRH has overseen £5.7m of devolved portfolio funding received during the current REF cycle (MRC Confidence-in-Concept (CIC) (£2.2m) and Proximity-to-Discovery (£600k), WT iTPA (£800k) and BBSRC Impact Acceleration Account (IAA) and Flexible Talent Mobility Award), all strategically deployed to support the translation of health and life science research.

During the current REF cycle, across Main Panel A we have:

- Developed the local industrial strategy in life sciences and are now an anchor institution within a burgeoning innovation ecosystem. We have a strong digital technology cluster, being part of the renowned University business incubator "SETsquared" (awarded "world's best University business incubator" by leading research and advisory firm, UBI global). This includes the life sciences incubator Unit DX, home to Ziylo (acquired by Novo Nordisk for up to USD800m).
- Secured collaborative industry funding totalling £17m with collaborators including GSK (over 20 projects), AstraZeneca (11), Eli Lilly & Co (11) and Pfizer (9). Other notable collaborators include Abbvie, GE Healthcare, Vertex, UCB Celltech, Vertex, Gilead, Celgene, Takeda, Edwards, Genzyme, Unilever, P&G, Biogen and Sanofi.
- Managed >600 disclosures, filed >160 patents, received £5m in licence income and realised £9m from share sales. The current active patent portfolio is ~140 families with a current licence portfolio of 135.
- Created five spin-out companies attracting funding in excess of £69m, including £45m for the Purespring start-up, the largest such UK investment in 2020.

All UoA1 staff are supported in translating their research to ensure societal impact and benefit. Each School has a dedicated staff member nominated as its Impact Lead. These are academic staff with direct experience in translating research outcomes through licensing, and via spin-out companies. UoB has been awarded IAAs from the MRC, BBSRC and EPSRC, which have enabled UoA1 staff to undertake secondments in Industry and site visits. UoA1 staff have also received funds from UoB's devolved Global Challenges Research Fund budget, which supports international

impact delivery activities. If appropriate, staff time for translational work is protected via allowances in workload models and/or via 'impact sabbaticals'.

1d. Research integrity

UoB is committed to supporting a strong research environment underpinned by a culture of integrity, excellence and continual improvement. Through **Munafò** (see below) and others we are at the vanguard of developing approaches to integrity and reproducibility. We are signatories to DORA and VITAE principles, and train our researchers, managers and support staff according to these directives. UoB has acted as advisor to the UK Research Integrity Office and is a committed and an early adopter of the principles of the Concordat to Support Research Integrity, with clear policies and procedures that all staff are expected to follow. UoB has created an Academic Lead for Research Improvement and Integrity role (**Munafò** [UoA4]), reporting directly to the PVC for Research and Enterprise, and to the University Research Committee. **Munafò** co-founded and co-leads the multi-funder UK Reproducibility Network (UKRN). Through our partnership with ten other UK institutions that are formal members of UKRN we are coordinating a number of institutional statements, including on research transparency and the use of responsible metrics. By working in this way, we ensure greater interoperability across the sector and are able to focus on implementing these statements.

We lead on the following activities to enhance a positive culture of research integrity in UoB by:

- ensuring the availability of an integrated training and development programme for staff and students at all stages of their research career;
- supporting policy framework development, especially linking to national activity in this area, including working closely with the UKRN;
- ensuring dedicated expert academic and research professional support and mentoring at all career stages, including support for UKRN Local Networks;
- assessing issues that lead to academic staff feeling pressured into taking "short cuts" and exploring what wider cultural changes need to be considered;
- research improvement (including research integrity and research culture) being embedded within all of our doctoral training programmes, with ongoing development of a modular series of short courses on topics ranging from data skills to leadership (including more informal postgraduate-led initiatives such as 'ReproducibiliTea' journal clubs);
- UoB supporting PhDs in the study of research integrity and reproducibility.

1e. Research strategy for the next 5 years

We will build on the strengths of our current strategy by:

- Continuing to align our research strategy against the UoB and Faculty-specific research strategies, to ensure complementarity.
- Prioritising investment in existing areas of disciplinary and methodological excellence, capitalising on the recent structural reorganisations.
- Prioritising the renewal and expansion of key infrastructure components, particularly the NIHR BRC.
- Working with and in the URIs to establish new areas of research vibrancy and excellence developing from the interdisciplinary interfaces of our areas of research excellence. For example it is now a strategic priority across the Faculties of Health Sciences, Life Sciences, Science and Engineering to support and cultivate the interface between synthetic biology

and population health, using advanced and quantum computing to drive innovative drug development in collaboration with sector-leading digital companies such as Oracle.
- Extending and deepening our links with the Bristol BioDesign SRI and the Max Planck-Bristol Centre for Minimal Biology.
- Enhancing our strategic links with Health Data Research UK, in addition to strengthening our internal health data science activities, which already see Cardiovascular Science "hard wired" to population health (UoA2).
- During the last year we have secured funding to expand our containment level 3 (CL3) facility and additionally to create a dedicated CL3 aerosol laboratory to support growth in our infection (including COVID-19), immunity and AMR research (£1.7m).
- Developing the UoB-Pfizer UK Vaccine Centre of Excellence (supported by the above facilities and staff across UoAs 1 and 2), led by **Finn** (UoA2) and underpinned by £5m investment from Pfizer.
- Ensuring sustainability of each disciplinary area in relation to staff workload, by continuing our policy of focussed investment and by aligning our infrastructure support with research priorities and excellence.
- Fostering academic and wider stakeholder partnerships to help deliver and translate our research, capitalising on new investments such as our joint UoB/WT-funded TRH.
- Promoting an inclusive, generous and supportive research culture that champions the highest standards of research ethics, transparency and individual wellbeing and rewards and incentivises team science.
- Providing support, the optimal environment and career opportunities for ECRs.
- Promoting the best of our mid-career researchers into established roles and ultimately leadership positions to expand our complement of senior investigators in areas of research strength.
- Ensuring financial stability, particularly in relation to research grant income support for direct and indirect costs.

2. People

Staffing strategy and staff development

The groups comprising UoA1 have a tradition of collaboration, openness, collegiality and a strong "esprit de corps". Many of our current research leaders (e.g. **Coward**, **George**) have been nurtured and mentored from the ECR stage of their careers. We have supplemented this by attracting exceptional research leadership talent (e.g. **Ridley**, **Norman**).

We have established an approach to succession planning over and above new staff and proleptic appointments. Focussed on our key areas of research, we encourage and support our senior professors to identify successors and create succession and strategic plans for our major research groups. The Faculty of Health Sciences has also established a pathway to substantive academic posts that will be in place for the next REF period for research staff with a track record of successful income generation and contribution to education and research training, which further advances our model of supporting career progression. During this REF cycle, within UoA1 we have promoted 17 staff to Reader/Associate Professor (8 female) and 16 to full Professor (6 female).

Our strategy is to enthuse, recruit and develop outstanding established scientists and scientific leaders, promising ECRs and the very best PhD candidates. We encourage our undergraduate students to become research active through a research-inspired curriculum, and we offer bespoke

training opportunities for clinicians and biomedical scientists throughout their undergraduate and postgraduate careers to help them realise their full academic potential.

2a. Clinical Academic Training

We have established the Integrated Clinical Academic Training Pathway (Bristol ICAT) to provide a supported and mentored clinical academic training programme for medical, dental and veterinary graduates. This provides comprehensive 'cradle to consultant/independence' training by aligning a series of complementary training components to develop future clinician scientists – from undergraduate studentships (WT-UoB INSPIRE programme £40k) through predoctoral work (NIHR ACFs and WT-UoB EBI clinical primers), doctoral studies (WT, MRC, NIHR, BHF etc.), post-doctoral studies via clinical lectureships (NIHR- and UoB-funded), and then senior posts/Fellowships.

UoB EBI Clinical Primers were established in 2011 to provide an opportunity for medical, dental and veterinary graduates to engage or re-engage in research early in their careers. These provide six months' full-time research funding (salary and consumables). During the current REF period, 38 primers have been awarded, funded by almost £1m from EBI funds. Encouragingly, nearly 40% of this cohort (17/44) have used this as a springboard to obtain prestigious, externally-funded PhD Fellowships.

In 2017, with our GW4 partners, we established the WT-funded Clinical Academic Doctoral Training Programme for medical, dental and veterinary graduates (GW4-CAT), underpinned by a £5.1m award from the WT (Director/PI- **Iredale**). Uniquely in the UK this offers doctoral training to all three professional groups and combines this with exit to a clinical lectureship after successful completion of a PhD. GW4-CAT PhD Fellows can access the best research environments and supervision across the Universities of Bristol, Cardiff and Exeter. Since 2017, of the 23 appointments, 11 are based at UoB (5 in this UoA). The success of GW4-CAT led to the leveraging of a further 3 clinical PhD fellowships fully-funded by the three Universities. At steady state 15-20 professionally qualified candidates will be undertaking PhDs in Health Sciences at UoB, frequently with a supervisory team crossing REF UoA boundaries. For example, in 2019 there were 5 Vets (3 WT-funded, all working in laboratories and supervised by staff in this UoA), 1 Dentist (WT-funded working in this UoA) and 12 Medics (2 BHF-funded, 2 KRUK-funded, 2 MRC-funded, 3 WT-funded, 1 Industry and 2 NIHR-funded, all working in this UoA). Through the prospective management of doctoral candidates and NIHR- and UoB-funded clinical lectureships, successful PhD Fellows graduate to lectureships to continue mentored postdoctoral development, from where candidates are encouraged to apply for senior Fellowships.

Our NIHR allocations of ACFs and Academic Clinical Lectureships (ACLs) have increased steeply during this REF period. In 2014 we ranked 13th nationally in the NIHR yearly allocation table for these posts; we are now 6th. Since 2014, BMS and BDS have supported a total of 114 ACFs, of whom 44 undertook research in this UoA, together with 58 ACLs, 26 of whom undertook research in UoA1.

At steady state we support 3-4 NIHR ACLs in Dentistry (2 currently in this UoA), 20-25 NIHR ACLs in Medicine and 2 (UoB-funded) in Veterinary Medicine. Through these mechanisms the clinical academic team coordinated a UoB-funded administrator and assistant, who offer advice and support to this key cohort and provide a one-stop-shop for advice and contact for aspiring clinical academics across the Universities of Bristol, Cardiff and Exeter.

2b. Biomedical Scientific Training

Doctorial Training Programmes (DTPs)

UoB's success in open competitions for DTPs, particularly those offering interdisciplinary training opportunities as both a single institution and partner in GW4, offers an outstanding doctoral training environment for biomedical scientists (Table 1). These schemes have supported more than 80 scientists per year during REF2021 and received funding in excess of £53m. Examples include: forming the BHF 4-year PhD programme (Leads- **Poole**, **George**, **Gaunt** [UoA2], £2.5m, renewed in 2020); establishing the GW4-CAT scheme described above; being the only University (of 9) to have their WT Dynamic Cell Biology PhD programme recently renewed; and being awarded the EPSRC-funded Centre for Doctoral Training in Digital Health and Care (one of 12 doctoral centres awarded to UoB in the 2019 round of EPSRC awards).

Support for Early Career Researchers (ECRs)

During REF2021 we have established and funded a structured and mentored scheme for ECRs – the Vice Chancellor's Fellowship (VCF) scheme. Targeted to areas of strategic priority and/or key interdisciplinary interfaces to promote innovation and scientific excellence, these support the career progression of top-flight candidates applying through open competition. Overall, UoB has appointed 41 of these fellows at a cost of £5.7m. Importantly, we provide mentorship and career support for outstanding fundamental scientists at early stages of their careers, whether VCF- or externally-funded, with the aim of positioning them for more Senior Fellowships and proleptic appointments. Integral to this approach are the 38 Clinical Primer awards totalling £983k, and £100k in bridging funds for post-doctoral researchers supported by EBI this cycle in this UoA. During REF2021 the following early and mid-career researchers have been awarded substantive externally-funded prestigious post-doctoral fellowships: WT Senior non-Clinical Fellowship (**Piddini**, £2m); MRC Senior Clinical Fellowship (**Coward**, £1.47m); MRC Career Development Award (**Amulic**, £1.2m); BHF Intermediate Fellowships (**Hart**, £400k; **Richardson**, £810k); Diabetes UK post-doctoral Fellowships (**Vincent**, £610k; **Long**, £541k). To date, all of those who have completed their Fellowships have progressed into established Faculty posts.

Table 1: Major DTPs/academic training schemes UoA1 researchers lead and/or are significant participants.

Scheme	Funder and value	Funding period	PhDs (per year)	UoB role
GW4 Clinical Academic Training	WT £5.1m (£6m including GW4 Universities' contributions)	2017-2023	4-6	Collaborative award with Cardiff and Exeter Universities; **Iredale** is Director
BHF Integrative Cardiovascular Science PhD programme	BHF (£2.5m renewed in 2020)	2017-2023	4	**Poole** and **George**, with **Gaunt** (UoA2) are co-Directors
WT Dynamic Molecular Cell Biology programme.	Wellcome Trust (£5.4m)	2021-2028, with previous awards continuously held since 2008	5	One of only 9 programmes nationally to be renewed in most recent funding round; **Cullen** (UoA5) is Lead
BBSRC – South-West Biosciences doctoral training partnership	BBSRC (£12.7m)	2020-2028, with previous awards continuously held since 2012	18-23	Collaborative award with Bath, Cardiff and Exeter Universities; **Brady** (UoA5) is Director
EPSRC/BBSRC Synthetic Biology Centre for Doctoral Training (SynBio CDT)	ESPRC/BBSRC (£5m)	2013-2019	2	Collaborative award with Oxford University
MRC GW4 BioMed Doctoral Training programme	MRC (£6.5m)	2016-2024	18	Collaborative award with Bath, Cardiff and Exeter Universities; **Dayan** is Director
Medical Research Foundation National Training scheme in Antimicrobial Resistance (AMR)	Medical Research Foundation (£4m)	2018-2022	18	National (and only) scheme; **Avison** is national Director
WT Molecular, Genetic, and Lifecourse Epidemiology programme	Wellcome Trust (£5.1m)	2021-2028, with previous awards continuously held since 2008	5	One of only 9 programmes nationally to be renewed in most recent funding round; **Relton** (UoA2) is Director
EPSRC Centre for Doctoral Training in Digital Health and Care	EPSRC (£6.3m)	2019-2026	10	**Craddock** (UoA12) is Director

2c. Supporting our staff and students

UoA1 highly values family-friendly work arrangements and these are reflected in, for example, scheduling seminars only within core hours, flexible working arrangements, and reduced workload arrangements (e.g. minimal teaching for 6-12 months) for those returning from maternity, paternity or shared parenting entitlements. Staff who wish to attend conferences but have dependants can apply for financial assistance via a Travel Fund. There are also School-specific parental leave booklets describing how individual Schools can support staff during pregnancy and parental leave, above that provided by the University. Options are available for career breaks for up to a year or more for parents and carers (for example, career breaks of up to 24 months have been arranged for staff whose partners have had to attend extended training in the US) and there is a highly-regarded onsite workplace nursery. Flexible working is usually an informal agreement with line managers reflecting positive working relationships, making flexible working the 'norm'. Moreover, flexible working is included in all job adverts as standard.

Staff and student mental health has emerged as an area of priority concern at UoB and has led to the establishment of separate and bespoke mental health policies for both staff and students. These are supported by substantial in-house counselling and health services (additional £1.5m from 2018), an employee assistance programme telephone advisory service, Mental Health Champions within Schools, and a student-support wellbeing service of approximately 30 FTE staff covering both undergraduate and all research students. This is an ongoing priority within UoB, and a specialist group for young person wellbeing has been established supported by a University-funded VC Fellow to research this area. Multiple smaller-scale interventions also take place; for example, there was a focus on the prevention of suicide in men in November 2019, there are bi-annual staff wellbeing fairs, and World Mental Health Day is marked annually with a series of wellbeing activities.

2d. Progression and promotion

We use the University structures for promotion and progression, which applies consistent thresholds in a framework that takes account of diversity and inclusion, and supports all staff to excel. Within the Schools and Faculties comprising UoA1, we provide tailored briefing to different staff groups on how best to apply for promotion/progression. Individual discussion and encouragement is provided at regular formal staff development and review conversations, and informally as required. Leaders within the Schools and Faculties proactively identify staff and invite them to apply. We consciously target support to those from under-represented groups including women at Professor and Associate Professor level, and BAME staff at all levels. Heads of Schools work with all applicants to optimise their applications. Up-to-date training in diversity and inclusion, and unconscious bias, is mandatory for everyone serving on promotion panels, Chairs are asked to highlight issues as they arise, and external (to the Faculty) observers specifically report on this issue at the end of the process. Individual feedback is provided to unsuccessful applicants, with support to improve performance.

Over the course of REF2021, we have been particularly mindful of the challenges that team scientists face; we are careful to recognise all contributions, acknowledging that team scientists may not always perform well in traditional metrics such as first/last author papers and as Chief Investigators on large grants.

To better inform staff on expected performance, and thresholds required for promotion, we have developed a “standard expectations” document, whereby we are more explicit about the performance indicators expected for Senior Lecturer, Associate Professor and Professor.

Mindful of the insecurity of funding that many mid-career research-focussed staff face, we are piloting a policy of “conversion to core funding”, whereby the University will seek to underwrite the salaries of those on externally-funded projects if: (a) there is a likely pipeline of funding, (b) their performance is such that they are likely to be successful independent academic staff, and (c) they are working in a strategically important area. Early career staff are supported between grants with a ‘bridging scheme’, which maintains continuity of funding if further grant funding is anticipated.

2e. Equality, Diversity and Inclusion (EDI)

All UoA1 Schools are highly committed to promoting equality and diversity in the recruitment and support of their staff, as well as our undergraduate and postgraduate students. The largest proportion of staff in this UoA originate from our medical (BMS) and dental (BDS) Schools, both of which progressed from Bronze to Silver Athena Swan status during REF2021. There have also been positive steps in EDI in CMM and PPN. CMM has gained a Bronze award and PPN has maintained its Bronze status during this cycle. We monitor and have targets for improving the proportion of BAME staff, particularly at higher grades. We have exceeded the University’s stretch targets for female appointments (see highlights in 1 above) and reducing the gender pay gap (3% target for the professoriate by 2023); for example, the current pay gap for non-clinical professors in BMS and BDS is 3% and -11% respectively.

Our approach has been supported by a number of initiatives across UoA1:

- **Mentoring:** a variety of schemes ensure mentoring is available widely, including: Bristol Clear mentoring programme; Bristol Women Mentoring Network; Elevate scheme (for women across academic staff and professional services from BAME backgrounds, run across GW4 Universities); Aurora Women’s Leadership Scheme.
- **Increasing access to opportunities for career development and promotion:** an annual ‘staff review and development checklist’ has been adopted to ensure every staff member discusses relevant promotion/progression criteria in their staff review. This is supplemented by regular promotion and progression workshops between academics and HR to ensure all staff members understand the process and to enhance the transparency of promotion/progression processes.
- **EDI representation in leadership and management roles and beyond:** all committees, discussion panels, recruitment panels, symposia programmes and other such events adhere to gender, and wherever possible ethnic, representation. Key female research leaders and role models are invited to deliver lectures and hold Q&As, such as the annual EBI lecture.
- **Intolerance to inappropriate behaviour:** this has improved with 87% (2019 survey) of staff recognising a culture of respect. Initiatives have included regular information on this topic at meetings and in newsletters, posters and videos to improve communication and raise awareness about recognising and reporting inappropriate behaviour.
- **Parental leave:** a buddy system has been adopted, including keeping-in-touch days and shared parenting leave. Paternal role models are presented on internet pages to address diversity and will be supplemented with a series of short videos.

- **Flexible working** is supported, with the implementation of a more transparent application process in 2017/18.

Our emphasis on EDI is integral to our PhD training programmes, and wherever possible we pursue anonymised applications. During the REF2021 period UoA1 staff have supervised 260 students to completion. Female students (56%) are well-represented on our PhD programmes, 8% have a disclosed disability and 34% are from BAME backgrounds. Similarly, in our Master's programmes 58% of candidates were female, 8% with a disclosed disability and 35% BAME.

Alongside UoA2 we have established a BMS Anti-Racism Task force (MART), inspired by the Black Lives Matter movement. This partnership between students and staff aims to design and implement strategies to identify and eliminate all forms of racism within Medicine. The scope encompasses curriculum decolonisation, workforce representation, and improvement of the wellbeing of staff and students who identify as BAME. BMS has signed up to the BMA Racial Harassment Charter and NHS England's Workforce Race Equality Standard, and BMS research staff are prominent in a pan-UoB initiative to 'decolonise research'. Principal Investigator (PI) training being rolled out for all those leading research groups includes a strong focus on the benefits of diversity and practical strategies to improve the attainment and participation of under-represented groups. The BAME representation in our workplace (14.5%) accords with the diversity of our city; 9.9% of economically active working population for the Bristol Travel to Work Area are from BAME groups.

There is also a range of action plans and initiatives in place to monitor progress centrally, and locally each Faculty has a committee with a specific responsibility for EDI, supported by School-level EDI committees, many of which involve PGRs. Progress is also benchmarked through our involvement with a range of external accreditation schemes such as the Athena SWAN Charter, Race Equality Charter, Stonewall Diversity Champions programme, and the Disability Confident Scheme.

In previous REF/RAE submissions our policy has consistently been to submit all eligible staff. In compiling this submission, we have considered all of our independent researchers via our institutional procedure (REF5a). Rather than being selective, our philosophy is to assist staff to achieve their potential, and the development of ECRs in previous exercises to research leads and senior contributors within the current submission attests to the success of this approach.

All staff are protected by an Appropriate Behaviours Policy, which provides proactive routes for dealing with harassment, bullying and other inappropriate behaviours; it includes access to both a 'Report and Support' tool and an in-house mediation service where appropriate. Within our Schools are designated staff champions for EDI generally and for specific minority groups (e.g. BAME), accessible to staff and students. Each School website has well-established pages devoted to equality issues, including links to sources of support. Commensurate with membership of the Stonewall Diversity programme, Schools host regular events to raise awareness of LGBTQ+ issues.

Recruitment and retention policies are also balanced to ensure equality and diversity, including (wherever possible) anonymised applications, mixed-gender shortlists, gender-balanced seminar programmes, and careful support of flexible working for all staff and postgraduate students. All Schools are currently preparing to upgrade their existing Athena Swan awards by bidding for the

next level up at the next renewal (2021). In each School there are targets to ensure there is a better gender balance in seminar speakers and in recruitment generally; excessive imbalances in the latter can result in positions being re-advertised. For seminar programmes, the speaker list is gender-balanced, including at least 40% women.

3. Income, infrastructure and facilities

3a. Research Income

Compared with REF2014, research funding during this REF cycle has increased considerably. Total research spend increased 67% to more than £106m, and at over £1.1m per FTE this represents a 50% increase per FTE from REF2014. Of the total research spend, £23m came from UK Research Councils, £17m from NIHR, £5.8m from WT and £3.7m from European Union funding. In awards metrics (2018/2019), UoB ranked 10th nationally for MRC, 6th for WT and 5th for BBSRC funding, and had the top success rate for competitive UKRI awards amongst the Russell Group (38% award rate by number).

Highlights of awards include:

- MRC programme grants: **Avison** (£2.9m); **Cannell** (£1.5m).
- MRC Stratified Medicine award (£2.5m) and Global Challenges award (£600k): **Saleem**.
- MRC Regenerative Capital Medicine award (£2.2m) and BHF infrastructure grant (£2.1m) to establish the TBRC: **Ascione**.
- MRC Senior Clinical Fellowship: **Coward** (£1.47m).
- MRC CDA Fellowship: **Amulic** (£1.2m).
- British Heart Foundation (BHF) Chairs: **Emanueli** (£1.2m, now at Imperial); **Newby** (£1.1m); **Angelini** (£3.1m); **Caputo** (£1m).
- BHF Programme grants: **Poole** (£1.55m); **Madeddu** (£800k); **Johnson** (£1m); **Paton** (£980k); **Emanueli** (£860k, now at Imperial).
- The prestigious 50th Anniversary (2015) Sir Jules Thorn Charitable Trust Biomedical Research Award for 'Stem Cell Therapy for Treatment of Congenital Heart Disease: Mending the Youngest Heart': **Caputo** (£1.4m).
- Leading the mechanistic work package theme in the Eu29m European Horizon 2020 Innovative Medicines initiative project "Biomarker Enterprise to Attack DKD": **Coward** (£780k awarded to UoB).
- WT Senior Research Fellowship: **Piddini** (£2m).
- WT Investigator awards: **Poole** and Ghevaert (Cambridge) (£1.3m); **Massey** (£788k).
- UoB obtained the most funding of any University through the recent cross-Council Antimicrobial Resistance (AMR) initiative, receiving £15.4m of UKRI funding, with £11.24m from the UKRI "Tackling AMR- A cross-council initiative": much of this work is led by UoA1 researchers, particularly **Avison**.
- Part of a USD4m US Food and Drug Administration study to advance understanding of severe coronavirus infection: **Matthews**/**Davidson**.
- WT-funded GW4-CAT scheme (£5.1m) and BHF-funded PhD programme (£2.5m): **Iredale**, and **Poole**/**George**/**Gaunt** respectively.

UoA1 researchers also lead and contribute to a number of **large NIHR-funded consortia** with the NHS, social care, and local government. These include the £21m **NIHR Biomedical Research Centre (BRC)** led by **Iredale** that was established in 2017. Prior to this, **Angelini** led the £7m

NIHR Biomedical Research Unit (BRU) in Cardiovascular Disease in Bristol from 2008. In 2019 we were awarded a £9m **NIHR Applied Research Collaboration (ARC)** (ARC West), uniting UoB with NHS and care services, local authorities, private companies and charities to help close the translational gap between generating new evidence and getting it into clinical practice. This succeeded the NIHR **Collaboration for Leadership in Applied Health Research and Care (CLAHRC) West** (2014-2019, £10m core funding with a further >£14m from allied partners). Translation has also been supported during this REF cycle via our WT iTPA and MRC CiC award.

3b. Infrastructure- Buildings

UoA1 has benefitted from several major strategic infrastructural investments by UoB during REF2021. These include a new £56m **Life Sciences building**, which provides bespoke research and teaching laboratories for biosciences. More than £2.4m has been invested in our **Biomedical Sciences building** to refurbish laboratories, update imaging facilities (£600k) and create new communal and social space for staff and students (£1.8m). New laboratory and imaging facilities have also been constructed at our **Southmead Hospital campus** (£9m) and in construction of the **TBRC** (£6.3m, details in section 3d).

3c. Infrastructure- Developing a healthy working environment and world

The University was integral to Bristol becoming the European Green Capital in 2015 and was the first UK University to declare a Climate Emergency. There is a Climate Action Plan formulating a rapid reduction in carbon footprint towards net zero. It includes LEAF accreditation for laboratories, only travelling internationally when fully justified and then offsetting any environmental costs, optimising waste management and incorporating sustainability-related issues into our teaching and postgraduate training programmes.

3d. Core Facilities

UoB invests in high-quality facilities to support translational research for all UoA1 researchers, including:

- **Proteomics and Functional Genomics Facilities**, which have benefitted from updating equipment for quantitative mass spectrometry (~£1m), high-throughput capillary DNA sequencing, high-density-microarray facilities, and next generation sequencers (~£1m) with Illumina, Ion Proton, and Ion PGS enhancing capability in these key areas.
- **Wolfson Imaging Facility**, including over £2.5m of investment in the Bioimaging Facility, involving extensive redevelopment, acquisition of new technology, and full physical and functional integration of existing light and electron microscopy facilities. This includes acquisition of a new cryo-EM facility (£1.5m) which was partly funded by contributions from our GW4 partners together with WT funds to establish this as a regional facility. We have always been at the forefront of implementing new imaging technologies. As a result, the Bioimaging Facility is now a node within Euro-Bio-Imaging and the host of a prestigious European Molecular Biology Organization (EMBO) course in correlative light/electron microscopy.
- **Establishment of the BrisSynBio Centre** (£17m UoB/BBSRC/EPSRC), which has been accompanied by substantial investment (£800k) in automated expression, purification and crystallization facilities (£600k), primarily to support structural biology studies although the automated expression facilities have far wider application. These facilities have been

supplemented by further investments in large-scale insect cell expression facilities and additional crystallization robotics (~£1m).

- Nested within the **Bristol BioDesign SRI**, the **Max Planck-Bristol Centre for Minimal Biology** (Eu10m) delivers technical solutions and synthetic biology support to key staff (including **Perriman**).
- **Animal Services Unit**, which provides outstanding facilities and support for maintaining model organisms, including rodents. Furthermore, UoB has invested in a newly equipped zebrafish (£1.5m) and aquarium facility for other species and in upgrading the rodent facility during the pandemic (£1m).
- **Bristol Translational Biomedical Research Centre (TBRC)**. This national facility for large animal research was opened in 2016 as a partnership between UoB, MRC and BHF (£6.3m total investment). It is located on our Langford campus and is effectively a large animal research hospital operating to NHS, Good Laboratory Practice Monitoring Authority (GLPMA) and Home Office standards. It comprises a fully functional surgical theatre inclusive of a catheterisation laboratory, together with an intensive care unit, preclinical bio-banking with NHS-type cryo-storage, together with state-of-the-art imaging including a 3-Tesla MRI scanner and multi-photon microscope. The current pipeline of ongoing research projects has a factored value of >£20m.
- **Clinical Trials Unit (CTU)**. In 2019 UoB formed the Bristol Trials Centre (BTC) following the merger of the Bristol Randomised Trials Collaboration and the Clinical Trials and Evaluation Unit, both of which are UKCRC-accredited. This has extensive expertise in trials methodology, study design, study management, statistical analysis and data management, including bespoke database design. It included the MRC **Co**llaboration and I**n**novation in **D**ifficu**l**t **C**omplex randomised controlled **T**rials (ConDuCT-II), which was designated one of five national MRC Networks of Hubs for Trials Methodology. BTC comprises members from UoA1 and UoA2, including experts in statistics, health economics and social science, as well as a high level of patient and public involvement. Its research income during this REF has increased more than 200% from £0.84m per annum in 2013/12 to £1.8m in 2019/20, largely from NIHR, from which BTC received about £1m in NIHR CTU Support Funding.
- **Advanced Computing Research Centre** provides access to high performance computing for all researchers, along with full training and support. As detailed in REF5a, the Centre includes a highly-parallelized super-computer facility called BlueCrystal, which is now operating both Phase 3 (serial-optimised) and Phase 4 (parallel-optimised) nodes supporting more than 800 researchers across the University. With ~£12m investment to date, UoB has committed £2m every year to meet the increasing demands of AI, big data and simulation resources across the University. Supporting the research interface of advanced and quantum computing with biomedical science is a key strategic goal of the next five years.
- **The Research Data Storage Facility** provides integrated resilient, long-term petascale storage to all researchers ensuring best practice in data management and sharing, including through allocation of a permanent digital object identifier for data sets.
- **University of Bristol Research Tissue Banks**, with full ethical approval operating within Human Tissue Act governance these receive, process and (where appropriate) release samples from a range of clinical studies and trials both within Bristol and externally. There is also a biobank resource for (healthy and diseased) human cardiovascular tissue within the BHI.

- **Research and Enterprise Development (RED)**, the central UoB Division including staff with specialist skills and training who work with academics to help sustain and grow research activity and impact (REF5a).

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

4a. National, International and Industrial collaborations

UoA1 researchers lead and contribute to many national and international projects and programmes. Overall, 67% of publications from this UoA involved co-authors from other UK institutions, and 64% involved international co-authors. Industry co-authors were included on 9% of publications.

4b. Interdisciplinary collaborations

A key aspect of our ongoing research strategy is to ensure we are fully engaged beyond our own disciplines to maximise the impact and reach of our research. This has been facilitated in UoB by the formation of **five strategic cross-disciplinary collaborative University-wide Research Institutes** (REF5a) and forming the **GW4 Alliance** between Bristol, Bath, Cardiff and Exeter Universities that was launched during this REF cycle.

Elizabeth Blackwell Institute for Health Research (EBI)
EBI is the major URI linked to UoA1. It aims to identify and nurture new opportunities for interdisciplinary research, in particular by exploiting expertise in the non-medical faculties and translating that research into effective health outcomes. EBI includes key partnerships with bio-pharmaceutical companies, local hospitals and health groups. This helps develop collaborative links between bioscience research and patient-facing clinical research. Supported by WT strategic support funding (£3.75m WT ISSF, matched with £3.75m UoB funds) and latterly £800k WT iTPA and the MRC CIC (£2.2m) funding, EBI offers pump-priming funds to develop interdisciplinary and translational research plans, has driven the development of the TRH (section 1c) and provides routes for ongoing recruitment and development of new researchers, initiating partnership activities and outreach events. In the assessment period it has also funded a series of fellowship schemes for our best young non-clinical and clinical talent and created an environment for effective collaboration with external partners within Bristol, other Universities and industry. EBI has also established the unique clinical primer scheme (section 2) and the Bristol Antimicrobial Resistance (AMR) interdisciplinary research strand, to build on an EPSRC-funded Bristol Bridge network that helped to 'bridge the gaps' between the physical sciences, engineering and biomedical science communities to find new solutions for tackling AMR. Finally, EBI was instrumental in rapidly help establish the Bristol COVID Emergency Research Group to understand and combat the many health and societal challenges raised by COVID-19 (UNCOVER; section 4f and REF5a Annex).

4c. National Interdisciplinary collaborations – The GW4 Alliance

The GW4 Alliance was launched in 2014 as a consortium between Bristol, Bath, Cardiff and Exeter Universities, and is the only research alliance across England and a devolved nation. It has been highly successful in facilitating high-quality, impactful health research. Overall, the total grant income leveraged by GW4 has exceeded £123m; this is from initial seed funding of £4.6m, illustrating the success of this collaboration. Notable successes related to UoA1 include the formation of the GW4-CAT programme, driving better animal research through the GW4-National Centre for the replacement, refinement and reduction of animals in research (NC3R) collaboration,

and forming a consortium to tackle the global issue of antimicrobial resistance. This scheme continues to establish innovative cross-University and cross-disciplinary projects, to bring experts and complementary skills together to address major societal issues.

4d. Academic-Industrial collaborations

RED enables our researchers to forge collaborations with industry to facilitate the translation our science into improved health outcomes, wealth generation, and job creation (REF5a). During this REF cycle we have established five spin-out companies generating income in excess of £69m.

Exemplars of our successes include:

- **Purespring Therapeutics** was founded by **Saleem** in 2020 in collaboration with Syncona Ltd to develop adenoviral genetic technology to treat kidney diseases. This has been backed by a £45m Series A investment.
- **KWS Biotest** (**WilliamsNeil** [Category B]), which produces novel immunotherapies. This company has grown significantly during the current REF cycle, now employing more than 60 people, exporting across the world and culminating in it being acquired by Charles River Laboratories in 2018 for >£16m.
- **Pertinax** is a company established in 2015 by **Barbour**. It produces novel antimicrobial materials for dental and other medical procedures and has generated >£2.7m income to date.
- **Ceryx Medical Ltd** was founded in 2016 by **Paton** in collaboration with experimental physicists. This company engineers microchip technology to make novel cardiac pacemakers (£1.76m).
- **CytoSeek** is a biotechnology spin-out company that engineers proteins to be membrane-bound, so as to facilitate cell therapies to be targeted to cancerous organs. Led by **Perriman**, CytoSeek raised £1.1m in 2019 to establish the company.
- **Chondrogenix Ltd** is a cell therapy company that was co-founded by **Kafienah**, and is a subsidiary of Mogrify Ltd. It is developing cell-therapy techniques to produce functional mature human chondrocytes to be used for arthritic conditions.

4e. Communicating our research

In UoB, dissemination of findings is enhanced by the UoB Centre for Public Engagement. Activities include a broad array of media support including social, press and broadcast media, interactive exhibitions and public lectures as well as production of literature and web-based information specifically geared to study participants and lay audiences. The relationship with our city region is excellent; Bristol is engaged with biomedical research and has a strong tradition of recruitment to studies. For example, the region was the biggest recruiter to the Oxford-Astra Zeneca vaccine trial and per capita is the largest contributor to UK Biobank. Examples of the communication and reach of our research include:

- Work on restricted ‘junk-food’ diet and poor vision in teenagers (**Atan**-Annals of Internal Medicine-2019). By December 2019 this paper had an altmetric score of nearly 3000. It had been reported by more than 1200 news agencies and had a global reach of more than 4.2 billion people, more than half the world’s population. In 2019 it was the 54th most impactful paper in the world across all disciplines according to altmetric.
- Bioengineer **Biglino**’s WT co-funded work with artist Sofie Layton to create “The Heart of the Matter” collection. This explores the complexity of the heart and congenital heart

disease, through 3D printing, digital animation, printed textiles, sound installation and sculpture. It resulted in exhibitions in Newcastle, Bristol and London attracting over 100,000 visitors with 1.2 million digital reach. It was defined by the Lancet as "A beautiful, thoughtful, evocative representation of what it means to be a patient, a parent, a doctor, or scientist involved in treating people with heart disease".

- **Avison** acted as an advisor to the highly successful post-antibiotic dystopian comic book series "Surgeon X" (Kenny and Watkiss, Image Ltd), co-funded by WT.
- Face-to-face communication of our research to local and national audiences through patient information days, local school visits and engaging in national science communication schemes such as "pint of science". During this REF cycle over 20 UoA1 researchers have participated in this scheme.

4f. Research response agility- COVID-19

A strength of our interdisciplinary URIs is that they allow us to rapidly bring researchers from different disciplines together, fund them and tackle major health care issues, as illustrated by our scientific response to the current COVID-19 pandemic. Facilitated and pump-primed by EBI, we assembled the Bristol COVID Emergency Research Group (UNCOVER). This is a collection of researchers united in their efforts to understand and combat the many health and societal challenges raised by COVID-19. It includes clinicians, immunologists, virologists, synthetic biologists, aerosol scientists, epidemiologists and mathematical modellers, with links to behavioural and social scientists, ethicists and lawyers.

Notable successes of UoA1 researchers originating from this initiative include:

- Defining the Linoleic Free Fatty Acid binding pocket in the spike protein of SARS-CoV-2 (**Davidson**-Science-2020) and the therapeutic potential of this target to block viral pharyngeal transmission from infected cases to contacts. This is currently being developed as a therapeutic approach.
- Demonstrating that the VEGF-A receptor Neuropilin-1 is a critical host factor for SARS-CoV-2 entry into cells (**Yamauchi**-Science-2020).
- The **Matthews**/**Davidson** teams used integrative RNA sequencing, proteomics and phospho-proteomics to profile virally infected cells and showed a propensity for mutation in the SARS-CoV-2 spike glycoprotein when producing the virus from cells. (**Davidson**/**Matthews**-Genome Medicine-2020).
- **Matthews**/**Davidson** helping progress the Oxford-AstraZeneca vaccine by showing collaboratively that human cell lines exposed to the ChAdOx1 vaccine cause very high levels of SARS-CoV-2 S glycoprotein but low-range expression of the adenoviral backbone.
- Collaborative work between UoA1 Category C intensivist **Cook**, aerosol expert **Reid** (UoA8) and anaesthetist **Pickering** (UoA4) used high-resolution environmental monitoring of ultraclean operating theatres to show that the risk of aerosol generation in airway procedures commonly undertaken by anaesthetists was very low. This suggests that this is not a high-risk procedure for SARS-CoV-2 transmission, with potential implications in reducing the amount of PPE needing to be worn by anaesthetists and hence reducing major delays in inpatients arriving and leaving operating theatres.

4g. Collaborations with the NHS, public health and social care services – Category C staff

- We have over 1600 research active staff working in the NHS or local services in our region. In 2012 through a strategic alignment led by the UoB, **Bristol Health Partners** (BHP) was

established. This involved the local acute and mental health NHS trusts, public health and social care. During this REF cycle, BHP has grown to cover: three acute and mental health NHS Trusts (University Hospitals Bristol and Western (UHBW) Trust, North Bristol Trust (NBT), Avon and Wiltshire Mental Health Partnership); three Clinical Commissioning Groups (Bristol, North Somerset and South Gloucestershire); the two Bristol Universities (UoB and UWE Bristol); the three local Councils; Sirona, the provider of adult community health services in our region; and the Bristol-based NHS Blood and Transplant (NHSBT). BHP is directed by a UoB academic (**Wynick** [UoA4]) and its mission is to maximise our excellence in research and healthcare provision, education and training to deliver world-class health, clinical and economic outcomes. We also conduct applied health research more widely in the South West region with local providers of NHS services and commissioners, local authorities, voluntary sector and patient organisations through **ARC West.** The strength of these NHS-University collaborations resulted in us being designated as an NIHR-NHSE/I **Academic Health Science Centre (AHSC)**, one of only eight in the UK. These structures and interfaces enable our NHS research active category C staff to flourish.

In terms of UoA1 Category C staff, during this REF period UHBW and NBT have had:

- 107 NHS-employed staff who have been PIs or Co-applicants on studies attracting grant funding (>£62m in total). Of these approximately 20% of PIs are non-medical members of the multidisciplinary team.
- On 31 July 2020, 358 Category C NHS staff had dedicated research time in their job plans. These comprised 79 NHS consultants and 279 nursing/AHP/pharmacy/R&I staff.
- Over 1650 NHS-employed staff support research per year (using E-dge metrics).
- The success of our NHS-University partnerships is further evidenced by the fact that Bristol had the fourth highest aggregated NIHR Research Capability Funding (RCF, a measure of total NIHR grant income) in the country, consistent with our current total awarded NIHR grants of >£135m.

Exemplars of the reach and success of UoA1 Category C staff include:

- Three NHS consultants achieving MRC Clinical Academic Research Partnership (CARP) awards to fund research time and consumables, one of whom (**Dodd**) has already progressed to an established UoB position.
- Being **lead applicants** on large clinical studies including: **Moppett** (£2.1m CRUK-funded study into newly diagnosed acute lymphoblastic leukaemia); **Bahl** (£1.1m Sanofi-funded study examining role of Cemiplimab in penile carcinoma); **Pieles** (£500k NIHR EME-funded study into the treatment of Barth syndrome; **Young** (£530k NIHR DRF funding to explore decision-making in young people with burns).
- **Co-applicants: Ramanan** (£4m MRC Stratified Medicine award to Investigate childhood arthritis and associated uveitis in the CLUSTER consortium); **Sparrow** (£1.8m NIHR HTA-funded Treatment of Advanced Glaucoma Study (TAGS)); **Vohra** (£1.3m NIHR EME-funded Carbon Dioxide Insufflation and Brain Protection During Open Heart Surgery; **Carlton** (£2.4m NIHR PGfAR-funded Multicentre research programme to enhance return to work after trauma).

4h. Contribution to the discipline

Data in this section are from a comprehensive survey completed by UoA1 staff in 2020.

Fellowships
Notable achievements include Fellow of the: Royal Society (**Ridley**); Royal Society of Edinburgh (**Norman**, **Iredale**); Academy of Medical Sciences (**Angelini**, **Dick**, **Iredale**, **Norman**, **Ridley**); Royal Society NZ (**Cannell**); Royal Society of Biology (**Paton**, **Ridley**, **Suleiman**, **Norman**); British Pharmacological Society (**Paton**, **Poole**); European Respiratory Society (**Maskell**). Furthermore, most of our clinically qualified academics are also Fellows of their respective professional colleges and organisations.

Journal Editorships
Over half (54%) of our non-ECR researchers have served on scientific journal editorial boards during this REF cycle. This includes 11 editorial positions on journals including Hypertension (**Paton**), Current Opinions in Cell Biology (**Ridley**), NIHR Journals Editor (**Norman**), Methods in Molecular Biology (**Yamauchi**) and Biology (**Davidson**). Furthermore, 26 researchers have held Associate/Deputy editorships, and 31 have been editorial board members on 69 journals. Notable journals served include Cell, Developmental Cell, EMBO Journal, EMBO Reports, Circulation Research, F1000, Scientific Reports and Arteriosclerosis, Thrombosis and Vascular Biology.

Participation/Chairing of National and International scientific grant and initiative committees
Nearly half (46%) of our academics have chaired and/or been members of grant committees/panels serving over 90 funding initiatives, for example:

Chairs – **UKRI:** Main Panel A, REF2021 (**Iredale**); MRC Genetic Engineering Mice for Medicine (GEMM) (**Coward**); MRC Molecular & Cellular Medicine Board (**Poole**). **Wellcome Trust:** Science Interview panel (**Norman**). **NIHR:** Global Health Group (**Norman**); UKCRC Trial Management Operations Group (**Culliford**). **Academy of Medical Sciences:** Team Science Project (**Ridley**); Starter Grants Committee for Clinical Lecturers (**Iredale**). **International:** Academy of Finland Research Council for Health (**Norman**); ANR French commission monitoring activities of INSERM centres (**Madeddu**).

Co-Chairs – **AMS:** Careers Committee (**Ridley**). **Genomic England:** Clinical Interpretation Partnership for Haematology (**Mumford**). **International Society of Thrombosis and Haemostasis:** Scientific Subcommittee for Platelet Biology (**Mumford**).

Notable Panel Memberships – **UKRI:** MRC Council member (**Iredale**); MRC Consortium award grant panel (**Saleem**); MRC-DBT-DFID-ESRC GRP Newton Bhabha award panel (**Norman**); MRC Regenerative Medicine Committee (**Madeddu**); MRC Molecular and Cellular Medicine (**Ridley**); MRC Doctoral Training Programmes Panel (**Ridley**), MRC Population & Systems Medicine Board (PSMB) (**Coward**); MRC Stratified Medicine Panel (**Coward**); MRC Training and Careers Committee (**Coward**, **George**); MRC CARP awards (**Coward**, **George**); MRC Neglected Infectious Diseases Panel (**Davidson**); MRC Zika Virus Rapid Response Panel (**Davidson**); MRC UK-Indonesia Infectious Diseases Panel (**Davidson**); UKRI-BBSRC COVID-19 Expert Working Group (**Davidson**); MRC COVID-19 genotype-phenotype steering group (**Davidson**); EPSRC Project Grant Committee (**Ascione**); BBSRC Funding Committee (**Avison**, **Diezmann**, **Spencer**); BBSRC Panel of Experts (**Jenkinson**). **NIHR:** Health Technology Assessment (HTA) programmes: Maternal, Neonatal and Child Health Panel (**Norman**); Funding Committee (**Pufulete**, **Maskell**);

Intervention Prioritisation Panel Methods Group (**Reeves**); Oral & Dental Speciality Group (**Ireland**); Senior Fellowships Panel (**Dayan**); Genomic Medicine Clinical Reference Group (**Mumford**). **Wellcome Trust:** Expert Review Group (**Massey**, **Norman**, **Piddini**); Science Panel (**Norman**); Clinical Interview Committee (**Iredale**); Senior Investigator awards panel (**Saleem**); Clinical Research Career Panel (**WilliamsAnn**). **BHF:** Fellowships Committee (**Hancox**); Project Grant Committee (**Johnson**, **Poole**); Programme and Chairs Committee (**George**). **Royal Society:** Wolfson Fellowships Panel (**Ridley**); **Academy of Medical Sciences:** Springboard Award Panel (**Ridley**). **Cancer Research:** UK Insights panel (**Lloyd-Lewis**). **International Juvenile Diabetes Research Foundation:** Funding Committee (**Gillespie**). **Diabetes UK:** Clinical studies group (**WilliamsAlistair**). **Fight for Sight:** Grants committee (**Atan**, **Dick**). **Kidney Research UK:** Fellowships and project grants committee (**Coward**, **Saleem**, **Satchell**, **Welsh**). **Cystic Fibrosis Trust:** Strategy Implementation Board (**Sheppard**). **British Society for Antimicrobial Chemotherapy:** Grants Panel (**Spencer**). **NHS Bowel Cancer Screening Programme:** Prioritisation Exercise (**WilliamsAnn**). **UK Therapeutic Cancer Prevention Network:** Committee (**WilliamsAnn**). **Royal Society of Edinburgh:** Clinical Science Sectional Committee (**Iredale**).

Invited Keynote Lectures/Prizes

Two-thirds (67%) of our academics have received prestigious research prizes or delivered keynote plenary lectures at major scientific meetings, including:

Prizes: Eardley Holland medal for outstanding work in the field or sciences of obstetrics and gynaecology (awarded every 5 years) 2020 (**Norman**); Public Health England Antibiotic Guardian Award 2018 (**Avison**); Hooke Medal, British Society for Cell Biology 2019 (**Piddini**); Sir Jules Thorn Award for Biochemical Research 2015 (**Caputo**); F1000 Award, ETH Zurich 2014 (**Yamauchi**); British Medical Association John Moulton prize 2017 (**Bradbury**); Sir Derrick Melville Dunlop Medal, Royal College of Physicians of Edinburgh – Immunotherapy of Type 1 Diabetes (**Dayan**); Queen's Anniversary Prize to Edinburgh University 2018 for "Clinical innovations to respond to major unmet needs in women's health" (**Norman**); British Biophysical Society Young Investigator's Award and Medal 2016 (**Perriman**).

Invited Keynote lectures: De Wardener Prize named lecture UK Renal Association 2018 (**Saleem**); Royal College of Surgeons London invited lecture 2019 (**Benedetto**); World Diabetes Congress invited lecture 2018 (**Gillespie**), American Society for Nutrition plenary session 2014 (**Hamilton-Shield**); Keynote, Experimental Biology, San Diego 2014 (**Paton**); keynote OPTIONS IX for the control of Influenza 2016 (**Yamauchi**); American Society of Nephrology invited plenary speakers 2016 (**Coward**), 2018 (**Satchell**), 2019 (**Saleem**); Symposium on Emerging Viral Diseases, Wuhan, China 2018 (**Davidson**); The Peter Lauberg Prize, Rachmiel Levine-Arthur Riggs Diabetes Research Symposium, Pasadena, California 2019 (**Dayan**); Doyne Lecture, Oxford Ophthalmological Congress 2016 (**Dick**); Dame Shelia Sherlock lecture British Society of Gastroenterology 2017 (**Iredale**); American Thoracic Society Keynote speaker 2016 and 2019 (**Maskell**); EMBO Keynote Speaker 2015 and 2016 (**Ridley**).

Leading positions and Trusteeships in Professional Societies and Charities

Our academics undertake a variety of leadership roles in many professional societies and charities. Some exemplars are: President of British Society of Cell Biology (**Ridley**); President of UK Eye Genetics Group (**Atan**); Vice-President of Association for Research in Vision and Ophthalmology (**Dick**); President of European Vision and Eye Research (**Dick**); Chair of British Atherosclerosis

Society (**George**); Research Lead, Congenital Heart Disease for the UK and Ireland Society of Cardio-Thoracic Surgery (**Caputo**); Scientific Advisory Lead, British Maternal and Fetal Medicine Society (**Norman**); Trustee and member of Board, British Heart Foundation (**Iredale**); Trustee for Mesothelioma UK (**Maskell**).

NHS leadership roles

Chair, British Committee of Standards in Haematology Rare Disorders Working Party (**Mumford**); non-Executive Director: NHS Lothian Board 2014-2016; North Bristol NHS Trust 2017-present (**Iredale**).