Institution: University of Glasgow
Unit of Assessment:UoA1
1.Unit context and structure, research and impact strategy

1.1:UNIT STRUCTURE.

Formed in 2010, the University of Glasgow's (UofG) College of Medical, Veterinary and Life Sciences brings together expertise, intellectual capacity and state-of-the-art facilities to drive research and improve health and the quality of life for humans and animals, globally. The College is structured into three teaching-centred schools and seven research-intensive Institutes. UoA1 is focused around three key clinical/biomedical institutes: the Institute of Cancer Sciences, the Institute of Cardiovascular and Medical Sciences and the Institute of Infection, Immunity and Inflammation. Since the College's inception, and particularly since 2014, these three institutes have developed a cohesive, cross-disciplinary, integrated research framework that supports both translational (bench-to-bedside) and 'reverse' translational (bedside-to-bench) research, as well as comprehensive approaches to Early Career Researcher (ECR) training.

1.2:OVERALL UNIT STRATEGY.

The UoA's overall strategy is to link strengths in basic, translational and clinical science in a seamless, bidirectional research effort, in part by establishing a 'research pipeline' that is fundamental to this strategic vision. Via this pipeline, support and infrastructure are put in place to ensure that outcomes from discovery science are seamlessly translated into the clinic, with clinical challenges and observations reciprocally fed back to the laboratory. Our success in fulfilling this vision is partly reflected by our substantial research income of £616m, awarded from 2014 to 2020. In addition, 91% of UoA staff currently hold competitively awarded research grants. We rank 3rd in the UK's Russell Group for income per FTE (HESA Cost Centre Clinical Medicine), and peer recognition of our work is illustrated by our ranking as 3rd in the Russell Group for scientific outputs (using average field weighted citation index, FWCI for outputs in subject area Medicine: UofG's is 2.79 compared to 1.61 average for Russell Group).

1.3:OUR INSTITUTES.

Integration between our three institutes is fundamental to achieving our strategic aims, while our Institute-based structure remains central to maintaining excellence and theme-specific expertise.

1.3.1:Institute of Cancer Sciences (ICS).

UofG has key strengths in fundamental cancer biology and oncology-focused precision medicine. Our vision of precision oncology includes investigating genetic mutations, and also cancer subtypes, the immunological landscape, stroma, metabolism and the metastatic niche. ICS researchers share key aspects of the Institute's infrastructure, including a state-of-the-art animal facility, cutting-edge imaging facilities, and expertise in transcriptomics and metabolomics. This approach has fostered the formation and funding of strong collaborative networks of translational and basic researchers, such as the CRUK Accelerator-funded and UofG-led, ACRCelerate, and Predict-Meso networks, the CRUK-funded RadNet network, as well as the Pancreatic Cancer UK-funded Future Leaders' Academy. By combining world-leading preclinical cancer models, cancer cell biology, imaging and metabolism, with the highest quality clinical capabilities (CR-UK programme – funded Clinical Trials Unit and Experimental Cancer Medicine Centre), ICS connects basic research and translational goals, through to experimental medicine and practice-changing clinical trials.

1.3.2:Institute of Cardiovascular and Medical Sciences (ICAMS).

ICAMS focuses on basic, translational, and clinical science associated with vascular pathophysiology, cardiac dysfunction and cardiometabolic disorders. It spans three academic hospitals and three university sites, with the British Heart Foundation (BHF) Glasgow Cardiovascular Research Centre providing a central hub on campus. Cross-disciplinary science at ICAMS investigates cardiovascular diseases (CVDs), specifically hypertension, heart failure, ischaemic

heart disease, stroke and cardiovascular complications of diabetes and kidney disease. Approximately 50% of the institute's staff are clinically qualified, some of whom run significant basic-science research projects, while many of the basic scientists have strong clinical science research interests. Streamlining of our research portfolio has been facilitated by restructuring, in 2016, into three research-themed groups (**Vascular, Cardiac and Metabolic Diseases**), each comprising both basic and clinical researchers.

1.3.3:Institute of Infection, Immunity and Inflammation (III).

III is divided into four main research areas: **Immunology, Parasitology, Virology and Bacteriology,** each with its own academic lead, who reports to Institute management team, develops research strategy within their area and also champions collaborations with other areas within III and the wider UoA. Research in III investigates the basic cellular and molecular biology of immune and inflammatory responses, pathogen function, and extends into translational and clinical research with a focus on the pathogenesis of arthropathies and autoimmune central nervous system disorders. Over the past six years, III has focused on translating its parasitology and virology research for low and middle-income countries (LMICs), an important future strategic direction.

1.4:CENTRES OF EXCELLENCE.

UoA1 includes a number of prestigious national research centres of excellence that underpin much of our research activity.

1.4.1:Wellcome Centre for Integrative Parasitology (WCIP).

Research conducted in WCIP investigates the molecular and cellular biology of parasitic infections using genetic, developmental and immunological approaches. Its key aim is to apply insights gained from WCIP research in LMICs to local training opportunities and to improve healthcare systems. This is exemplified by the ScotGov-funded Blantyre-Blantyre Malawi Clinical Research Facility and the creation of a single-cell RNA sequencing facility in Malawi, the first in sub-Saharan Africa. Strategic academic appointments based both in Glasgow and Malawi have been made to support this initiative. These include **Moxon** and **Crampin**, as well as the redeployment of **Garside** to provide senior academic leadership for this initiative. Since 2014, WCIP has grown from 10 to 18 PIs and has generated a direct infrastructural portfolio worth £10m, leveraging £24.2m in PI grants, as well as funding for a Wellcome PhD School (£5.5M).

1.4.2:MRC-UofG Centre for Virus Research (CVR).

CVR is the leading research institute in the UK focused on viruses that affect human health and those at the human-animal interface. It is located within the £23m Stoker Building (2016), and its research benefits from a multidisciplinary staff, whose research skills include molecular virology, structural and cell biology, bioinformatics, ecology and epidemiology, vector biology, and clinical and veterinary virology. CVR recently extended its expertise into LMICs, aligned with WCIP, to identify how basic insights derived from laboratory studies could be applied in the field. Strategic academic appointments made to support this initiative include **Ho** as a clinical expert in infectious diseases in LMIC settings. CVR hosts the Scottish Centre for Macromolecular Imaging (**Bhella**, Director, section 3.4.1), and has been at the forefront of the national Covid-19 research effort. Within a period of 11 months, CVR staff have published 20 seminal research papers (+13 pre-prints/submitted manuscripts) on Covid-19 and been awarded ~£7m to support this research effort.

1.4.3:Research into Inflammatory Arthritis Centre of Excellence Versus Arthritis (RACE).

Led by UofG (**McInnes**), RACE is a world-leading centre comprising the Universities of Glasgow, Birmingham, Oxford and Newcastle. It aims to identify the molecular mechanisms of pathogenesis and novel therapeutic modalities, including phase-1 tolerized dendritic cell therapeutics and phase-1 stromal cell-targeted inhibitor trials – both global firsts. The first phase of RACE focused on early disease stages, while its recently funded second phase (providing an additional £2m) will also focus on established RA and in particular on *remission, flare and refractory disease*, as informed by patient feedback. Beginning with initial funding of £2.5m, RACE has since leveraged >£14m in additional awards. It has also trained 12 PhD students to successful completion, with a second cohort of 12 now underway. It has also organised 10 scientific, international workshops, developed three new

clinical trials (AutoDeCRA2 [Versus Arthritis], TRAFIC [MRC], BioFLARE [MRC]) and supported the science that underpinned the development of novel immune therapeutics for psoriatic arthritis (Impact case: **McInnes**).

1.4.4:GLAZgo Discovery Centre.
This Centre opened in 2014 and is supported by a £3.2m investment from AstraZeneca (AZ) and undertakes research to support the rapid translation of pathology-relevant research findings to drug target development. AZ scientists and UofG investigators (such as lead investigators **McInnes, Goodyear, G.Graham**), share membership of this Centre, which therefore combines academic and pharma ambitions. The Centre has supported over 18 projects on target identification, mechanisms of disease, and the translation of research findings to the clinic. Results from these collaborative projects have led to numerous publications (>15) and, importantly, to go/no-go decisions within AZ. For instance, data from GLAZgo have led to several AZ internal projects being terminated or licenced out to other companies. In addition to the core projects and staff, the Centre has mentored six AZ postdocs, directly funded seven PhD studentships and supported a further three.

1.4.5:Glasgow/Eli Lilly Alliance.
This new strategic collaboration led by **Goodyear**, with a £4.2m investment from Eli Lilly, facilitates discovery and validation of new drug targets for rheumatoid arthritis, psoriatic arthritis, vasculitis and fibrosis.

1.4.6:BHF Centre of Research Excellence (CoE).
In 2014, UofG was recognised as a BHF Centre of Research Excellence (CoE: **Touyz**, Director) and awarded a five-year grant, which was renewed in 2019 for five more years (£3M). These successes have promoted our cardiovascular research and training agendas by strengthening existing research programmes and supporting ambitious initiatives. CoE research covers the spectrum between mechanistic science and clinical medicine, focusing on two defined areas of world-leading research in UofG: 1) molecular and vascular mechanisms in the aetiology of cardiovascular disease and 2) heart failure. In 2020, a third theme was added: cardiovascular disease and Covid-19. Since 2019, UofG has secured £11m in new funding through CoE research. Collaborations with colleagues throughout UoA1, and with the Institute of Neuroscience and Psychology (UoA4) are also central to CoE's overall strategy.

1.4.7:CRUK Glasgow Centre (CRUKGC).
CRUKGC is a partnership between the UofG, NHS Greater Glasgow & Clyde (NHSGG&C) and the University of Strathclyde and incorporates staff from across UoA1. Supported by £8m from CRUK (2016), the Centre focuses on clinical trials and on turning discoveries into treatments and predictive tools. It has three main areas of focus: 1) discovery science, 2) pre-clinical experimentation, and 3) clinical training and development. Its discovery science efforts in colorectal cancer (CRC) and mesothelioma encompass researchers from across UofG, Europe, industry and the NHS, as exemplified by three projects. 1) INCISE (**Edwards**), a Scottish consortium (NHS, industry, UofG), that harnesses artificial intelligence and machine learning to transform bowel cancer screening, supported by £3.37m. 2) ACRCelerate (**Sansom**), a European CRC stratified medicine network producing robust pre-clinical models to de-risk clinical trials with £5m from CRUK. 3) PredictMeso (**Murphy, Biankin)**, an international consortium (including UofG and NHS) that aims to tackle the predicted global increase in mesothelioma and to provide better predictive tools and preventive treatments with £5m from CRUK.

1.4.8:Glasgow Experimental Cancer Medicine Centre (ECMC) and CRUK Glasgow Clinical Trials Unit (CTU).
The Glasgow ECMC **(Evans)** includes the Translational Pharmacology Group (**Thomson**) which includes the CRUK Biomarkers Centre of Excellence. The CTU (Jones) coordinates national and international clinical trials and practice-changing clinical studies and is part of the International Rare Cancers Initiative (CRUK, EORTC, National Cancer Institute; USA). This approach is exemplified by the SCOT (Short Course Oncology Therapy) study. This study showed that three months is as effective as six months of treatment for post-operative chemotherapy for CRC (New England Journal of Medicine, Impact case: **Paul**). These findings are now enshrined in international clinical

guidelines, changing practice for CRC among all UK clinicians. UofG research has also contributed to inclusion of Lenvatinib in international guidelines for the treatment of advanced renal cell carcinoma (RCC) and unresectable hepatocellular carcinoma **(Evans)**. UofG performed the first-in-human studies and pivotal clinical trials that led to lenvatinib receiving worldwide approval as part of a second-line drug combination for RCC (>50 countries). Lenvatinib has also been approved as a first-line monotherapy for uHCC (>55 countries)—the first new drug for this indication in a decade (and only the second licensed for first-line treatment).

1.4.9:Paul O'Gorman Leukaemia Research Centre (POG).

POG conducts both basic research and clinical trials for haematological malignancies to provide new insights into the pathogenesis of leukaemia and to identify therapeutic targets. Among its aims is to develop novel approaches to targeting leukaemia stem cells in chronic myeloid leukaemia (CML). POG leads the world in these research efforts, as evidenced by high impact publications over the REF period (including in *Leukaemia*, *Nature*, *Nature Medicine* and *Cancer Discovery*), and is involved in several CML clinical trials. These include the TASTER trial (£3M, CRUK), a phase-2 clinical trial into combination therapies (**Copland**, **Vetrie**, 2018), and the MATCHPOINT trial, which combines conventional chemotherapy with the multi-tyrosine kinase inhibitor ponatinib.

1.4.10:Glasgow Precision Oncology Laboratory (GPOL).

Since 2014, GPOL (lead: **Biankin)** has received £19m in funding and is at the core of UofG's precision oncology agenda. Its research has defined and prioritised candidate molecular vulnerabilities and led to the development of new therapeutic strategies. Through sequencing performed at GPOL, pancreatic ductal adenocarcinoma (PDAC) was classified into four types (published in *Nature*). This research also identified several key signatures and mutations, for further investigation (published in *Cell Reports*). Patients' biopsies are now routinely sequenced to diagnose PDAC and to accelerate time to treatment. GPOL also leads the PRECISION-Panc initiative (with ~£10m CRUK funding). The identification of DNA damage response-deficient tumours and high replication stress tumours (*Nature*) has led to the PRECISION-Panc PRIMUS-001, -002 and -004 clinical trials. The PRIMUS trials (£3.2m) aim to improve treatment options for the 10,000 patients diagnosed annually in the UK with this cancer, to test new therapies, and provide patients at over 20 UK hospitals with access to precision medicine. This is the first time in the UK that every pancreatic cancer patient in a trial has been issued with a comprehensive molecular profiling report using next generation sequencing technology.

1.4.11:CRUK RadNet Glasgow Centre.

Led by **Chalmers**, RadNET was established in 2019 (with £3.5m from CRUK) to create a platform for innovative radiation research at UofG. The aim of RadNET's research is to optimise radiotherapy to increase cure rates in patients with five cancers of unmet need: glioblastoma, head and neck, lung, pancreas and rectum. This multi-disciplinary programme encompasses discovery science, preclinical research, imaging, biomarkers, clinical radiotherapy research, clinical trials and the training of future radiation researchers.

1.5:ACHIEVEMENTS IN RELATION TO STATED OBJECTIVES.

As described below, we have achieved all of the stated objectives set out in our 2014 UoA1 return. These efforts have been supported by the recruitment of strategically important research staff, as detailed in section 2.

1.5.1:To focus on analysis of cellular migration in physiological and pathological contexts to capitalise on our expertise in chemokine and cytokine biology and advanced imaging technologies.

Staff, within this UoA, continue to lead international efforts to understand the involvement of chemokines and cytokines in inflammatory disease. Research in this area has attracted grants totalling £17.3m and resulted in high profile outputs and impact. For example, **McInnes** has championed basic studies and numerous clinical trials into cytokine and cytokine receptor signalling in inflammatory pathologies (published in *The Lancet*, *New England Journal of Medicine, Nature Medicine*, and other journals). **McInnes** has also been at the forefront of major international clinical

trials, including the secukinumab trial for psoriatic arthritis (PsA), which is the focus of an impact case study. **G.Graham** and **Nibbs** have both provided international leadership in the chemokine and cell migration field (as reflected by their publications in *Immunity, Cell, Cancer Cell, PLOS Biology, Science Translational Medicine*). This research area has also benefited from **Insall's** recruitment to ICS (UoA5) and been extended (in collaboration with **Sansom** and **Morton**) to explore chemokines in cancer pathogenesis and as potential therapies in clinical trials of pancreas (funded by Astra Zeneca) and liver cancer (£1million, CR-UK) (**Evans**). **Garside, Brewer** and **Maffia** continue to provide international leadership in *in vivo* imaging of the immune response (as reflected by publications in e.g., *ELife, Immunity, Theranostics*, and their securing >£1m in grants).

This UoA also continues to build on its basic and preclinical studies into metastasis mechanisms. Highlights include **Sansom**'s discovery that epithelial Notch signalling is a key driver of CRC metastasis via the rewiring of the microenvironment (as published in *Cancer Cell*). Numerous studies by **Machesky**, **Zanivan** and **Norman** have also elucidated the molecular mechanisms of invasion and metastatic niche formation (as published in *Developmental Cell, Nature Metabolism, Science Signalling, Nature Communications*).

1.5.2:To focus on basic microbial molecular and cellular biology, ontogeny and host interaction extending through to population biology.
Researchers at WCIP and CVR have made substantial contributions to microbial and host interactions research and have increased their capacity to translate research discoveries into therapeutic modalities appropriate for use in LMICs. Targeted recruitments have supported this international focus (section 2), as has the appointment of **Garside** as Dean of Global Engagement within UofG. To meet the REF2014 aim to extend the UofG's bioinformatics capabilities, these centres have also focused on microbial molecular analyses. As an example, **Otto** has been instrumental in developing single-cell RNA (scRNA) sequencing within the UoA (*Nature, Nature Medicine, PNAS*). Finally, two of our submitted impact cases have emerged from our microbial studies: 1) the suppression of dengue transmission in endemic areas of Malaysia through the development of biological control approaches to block transmission (**Sinkins**), and 2) the establishment of HCVRUK (Hepatitis C Virus Research UK) (**McLauchlan, Thomson**). Together, our studies in relation to this objective are supported by funds totalling £53.5m.

1.5.3:To focus on mechanisms for vascular injury and endothelial dysfunction
Non-invasive clinical vascular phenotyping, myography, and clinical trials are the three main platforms (developed at the BHF CoE) that have facilitated studies in this area, supported by investments totalling £19.3m.

Small vessel disease: Research in this area has contributed to two UoA1 impact case studies (**Langhorne**: Interventions that help recovery from stroke; and **Quinn**: Improving the assessment of stroke). Complementary approaches to studying microvascular disease are now being developed in other cardiovascular pathology settings.

*Vascular remodeling and fibrosis***:** The BHF CoE established a clinical, non-invasive, high-fidelity vascular phenotyping facility to advance our understanding of endothelial dysfunction, atherogenesis, vascular inflammation and fibrosis in human cardiovascular disease. This impactful work has helped to secure new grants from the ERC (**Guzik, Touyz, Davies, Delles**), pharma (**Berry, J.Petrie, M.Petrie, Lang**) and a multicentre programme grant (BHF, **McCarron/Strathclyde** and **Touyz/UofG**), and has contributed to the development of new technologies, such as the 'self-reporting vascular graft' (**Mercer**).

Oxidative stress and vascular (patho) biology: Delineating redox signalling pathways and post-translational oxidative modifications is a major research focus in cardiovascular disease. In light of this, a redox toolkit has been developed in collaboration with local chemists (**Hartley,** UoA8) and Glasgow Polyomics (section 3.4.4), and has secured funding to develop a platform to analyse the post-translational oxidative modification of proteins in health and disease (**Leiper, Fuller, Touyz, Delles, Bulleid/UoA5, Hartley/UoA8**). The translation of research discoveries to novel treatments include **Leiper's** Critical Pressure Ltd (www.critical-pressure.com), which has received £3.8m of

funding and a £10m grant for clinical trials (Medixci Partners) to assess its use in patients with sceptic shock.

Hypertension and hypertensive disorders of pregnancy: Significant clinical studies and clinical trials have taken place in this area. Trials include AIM-HY (**Padmanabhan**), InflammaTension (**Guzik**, **Delles)**, SA2LT (**Touyz, Delles, Goodyear)** and ENSAT-HT (**Davies, Delles**). Clinical trial activity has also been increased in response to Covid-19 (OBELIX: **Padmanabhan, Touyz**), as have doctoral training opportunities (EU Horizon 2020 ITN £1.4m of £4.3m grant).

1.5.4:To advance a platform for translational cell therapy for cardiovascular pathologies.
This aim has been primarily driven by **Smith,** who is co-PI of the BHF Heart Regenerative Medicine Centre (which is based at Imperial College London and funded until 2021) and also a co-founder of Clyde Biosciences Ltd (www.clydebio.com), a company that uses stem cell-derived cardiomyocytes for commercial *in vitro* assays (which received a £2m capital investment in 2016). Smith's group has generated >10 outputs in this area, including a multi-lab collaborative study published in the journal *Science Translational Medicine*.

1.5.5:To advance heart disease and cardiometabolic research and clinical trials:
UofG is a world leader in cardiovascular clinical trials. Since 2014, it has carried out over 15 clinical trials, of £2.7m in value, and produced >200 published outputs (many in *The New England Journal of Medicine, Lancet and Journal of the American Medical Association*). Its research has also contributed to the licensing of new medications for heart failure and to numerous clinical guideline recommendations that inform patient care. These trials feature in two impact case studies. 1) Benefits of glucose-lowering drugs in treating heart failure (**McMurray, M.Petrie, Jhund**)**.** 2) A cardiometabolic and diabetes platform (**Petrie**, **Sattar**, **Lean, Gill,** supported by **Welsh**), which has made important contributions to the clinical characterisation and treatment of type-1 and -2 diabetes and obesity. It has received £7.9m in funding since 2014 and has generated >200 papers. Recently this group participated in a nationwide epidemiology project, documenting the risks from Covid-19 in people with diabetes in England (**Sattar**) and Scotland (**Sattar, J.Petrie, Lindsay**). This study, published in *the Lancet*, informed the UK government's strategy for diabetes remission. Diabetes research also features in an impact case study (**Lean, Sattar**).

1.5.6:To develop our expertise in cancer cell metabolism growth and survival.
UoA1's precision oncology research aims to improve our understanding of tumour metabolism and their metabolic dependencies and weaknesses. This research (supported by grants totalling £5m) has provided new insights into tumour metabolic flux and into the genetic and immune landscape of tumours, to provide precision treatment options for multiple cancers. During this REF period, several important discoveries in oncometabolism have been made, including by: **Helgason**, who used autophagy inhibitors to target leukaemic stem cells (published in *Leukemia, J. Natl. Cancer Inst, Nature Medicine*), **Ryan**, who implicated mannose metabolism in fuelling tumour growth (*Nature*), **Machesky** and **Maddocks**, who investigated how mechano-sensing impacts tumour cell metabolism (*Nature Metabolism*), and **Maddocks**, who discovered a new metabolic weakness in polyamine metabolism in tumour cells (*Nature Metabolism*). Furthermore, **Sansom** and **Bushell's** research on tumour initiation and growth (which implicated protein translation downstream of mTORC1 in these processes, published in *Nature, Cancer Discovery*) has underpinned a research technology translation alliance, involving Celegene and Bristol Meyers Squibb (with funding of >$30m). This research also led to further funding (£11.m) to support a drug discovery programme. Additionally, **Lewis** has secured £1.2m from the Beatson Cancer Charity to develop and translate novel metabolic biomarkers discovered at the CRUK Beatson Institute into clinically relevant PET probes for improved cancer diagnosis and patient stratification.

1.5.7:To extend our international lead in the field of leukaemia stem cell biology.
Impactful basic research from POG has highlighted autophagy and metabolism as targets for the treatment of tyrosine kinase inhibitor (TKI)-resistant CML, leading to clinical trials. These trials include CHOICES (published in *Leukaemia*), TASTER (led by **Copland** and **Vetrie,** with £3.1m of CRUK funding) and MATCHPOINT (**Copland**). MATCHPOINT combined conventional chemotherapy with the multi-targeted kinase inhibitor, Ponatinib, in patients with blast phase CML

who have a very poor prognosis. It showed a substantial improvement in patient survival as compared to ponatinib alone (EudraCT 2012-005629; Blood). The TASTER trial combines TKIs with novel small molecules to improve responses in CML patients with TKI resistance. POG researchers are also assessing TKIs used in combination with the EZH2 inhibitor, tazemetostat, in CML patients, following preclinical findings (published in *Cancer Discovery*) that demonstrated that this combination eliminated CML stem/progenitor cells. POG researchers have also identified CD93 as a marker of residual leukaemic stem cells that remain after treatment with standard TKIs (*Leukaemia*).

1.6:DEVELOPING OUR INTEGRATED APPROACH TO RESEARCH WITHIN UOA1.

A specific aim of our REF2014 return was to capitalise on the University's new structure to enhance our cross-institute basic and clinical research base. As our three institutes are multidisciplinary, an integrated and collaborative approach to our research effort is an essential contributor to our current and ongoing success. Integration has been achieved through the following initiatives:

1.6.1:Cancer immunology.

We have developed a strong, strategic research focus on cancer immunology (supported by key appointments, section 2) to unite and capitalise on the expertise across III and ICS. As a result of this initiative, immunology is embedded within UofG cancer studies, as evidenced by publications (in *Cancer Cell* and *Nature*), clinical trials (CXCR2 in collaboration with AstraZeneca) and grant income (e.g. from MRC, CRUK, Wellcome, AstraZeneca, Breast Cancer Now).

1.6.2:Cardiovascular oncology.

UofG has developed the only Cardiovascular-Oncology Clinic of its kind in Scotland (**Lang**), and cardiovascular oncology is a scientific priority of BHF CoE. Cardiac clinical activities are embedded in the Beatson West of Scotland Cancer Centre and are supported by additional NHS clinical and research staff. **Lang** collaborates with ICAMS on basic research (**Montezano**) and with clinical academics across ICAMS and ICS **(Evans, Jones)**. This evolving theme is supported by > £2m of new grant income and by £1m for 2-3 new senior recruitments over the next four years.

1.6.3:Cardiovascular immunology.

Research in this area explores immune inflammatory processes in CVD (**Guzik, Maffia**). For example, InflammaTENSION (**Guzik**), an ERC Consolidator grant, uses human clinical studies, animal models and genetic tools to characterise immunophenotypic signatures of human hypertension, to define key concepts in cytokine biology, and to understand interactions among T cells, antigen presenting cells and double-negative T cells, which are overrepresented in hypertensive vasculature.

1.6.4:Internal collaborations and Covid-19 research.

UofG, in particular CVR, have been at the forefront of national and international Covid-19 research efforts. These efforts have included weekly multidisciplinary staff meetings (involving **McInnes, G.Graham, Touyz, Palmarini, Sansom, Machesky, Biankin**), with other colleagues, particularly from UoA5 and UoA8, leading to new and exciting internal collaborations to develop novel approaches to Covid-19 research, funded by awards totalling £2.3m.

Since 2014, 189 new research projects have been funded that are collaborative across Institutes, to a total value of £93m. These include awards from major funders, including MRC, NIHR, Wellcome Trust, Chief Scientist's Office (CSO) and EU, indicative of their internationally competitive nature. Total outputs across the UoA include 5,906 REF-eligible papers published since 2014, of which 9.8% are collaborative across the UoA, resulting from 65% of UoA staff engaging in internal collaborations. This collaborative strategy is further enhancing publication quality; publications across the UoA have an average FWCI of 4.84 compared to 3.10 for single Institute outputs (compared with 1.61 Russell Group average for papers in subject area "Medicine").

RESEARCH AND IMPACT STRATEGY

1.7:FUTURE STRATEGIC OBJECTIVES.

Our future strategic objectives are to:

- Continue to develop UofG's reputation as a global centre for precision medicine research
- define the molecular basis for the pathogenesis of chronic non-communicable and infectious diseases
- Unravel common mechanisms of multi-morbidity and comorbidity
- Understand the prevalence and clinical impact of these diseases at cohort and population levels
- Deliver optimal diagnostics and therapeutics through disease-specific new medicines, treatment strategies, imaging modalities, diagnostics and predictive biomarkers, and to apply precision medicine principles throughout.

We will achieve these aims by enhancing integrative research across our Institutes and Centres of Excellence, to capitalise on their unique and complementary expertise. To do so, a UoA Strategy Group has been created and charged with developing the physical and intellectual infrastructure to pursue these objectives and to coordinate responses to major national and international funding opportunities of relevance to our strategy. We will also further improve and align our technical infrastructure to ensure continued access to the highest quality, state-of-the-art, technologies to enable our work to meet the highest international standards. Our recruitment processes and priorities are in line with these strategic aims (section 2).

Glasgow offers an outstanding environment to pursue these objectives; it brings together basic and clinical research excellence in partnership with the UK's largest NHS Health Board, with access to substantial new clinical research facilities that embed research at the heart of Europe's largest acute hospital campus (section 3.4), within a region that has a high prevalence of chronic diseases and related co-morbidity.

1.8:ENABLING THE ACHIEVEMENT OF IMPACT.

Since REF2014, our aim has been to provide dedicated translational infrastructure, to enhance the development of in-house discovery, and seek commercial and spin-out opportunities.

In support of this aim, and in addition to infrastructure improvements outlined in section 3, we have initiated several key enterprises to maximise the impact from our research. These include:

1.8.1:Unique bidirectional training opportunities.

To provide basic scientists with the opportunity to set their research in a clinical context, we have implemented a clinical observership programme for post-doctoral fellows, which has obtained NHS certification and is being expanded across the UoA. This 3–4-month structured programme, coordinated with NHS consultants across clinical disciplines, provides early career scientists with real-life insights into the pathologies of relevance to their research. Fifteen postdoctoral researchers have taken part in this programme since 2018, with feedback being overwhelmingly positive.

In addition, NHS Research Scotland supports a three-year fellowship programme that enables NHSGG&C consultants within seven years of their appointment to undertake research in collaboration with senior academics. This programme has awarded 16 such fellowships to date with each having honorary clinical academic status. NHSGG&C has also co-funded twelve further research scholarships for trainee doctors, nurse fellows and clinical research fellows.

1.8.2:Developing a translational pipeline.

The "Translational Research Initiative" (TRI: **Goodyear, G.Graham**) brings together experienced academics, technology transfer and business development expertise alongside UofG's investment partners and provides coordinated access to translational funding of over £4.5M from MRC's Confidence in Concept (CiC) and Proximity to Discovery (P2D), BBSRC Impact Accelerator Award

(IAA), Wellcome Trust Translational Partnership (WT-TPA), with significant matched investment from UofG. The TRI coordinates:

- *Targeted opportunity audits and seed-funding to translate ideas to impact:* Working on a three-year cycle, researchers present their research programme to a visiting panel of industrial and biotechnology consultants and University patent experts. The panel identifies opportunities for commercialisation and provides a roadmap for their development, including advice on additional experiments needed to prepare basic research for translational funding and for formal approaches to industry. The TRI has expanded our translational pipeline, identified key industrial partners, contributed to £10.2m in translational funding, and created eight patent and licensing opportunities.
- *Focused engagement and training for all staff including ECRs:* Via local opportunity audits, tailored training packages (e.g., in regulatory pathways for drug development) are being provided for staff, alongside a programme of translational workshops, which include sessions on IP, Value Proposition & Customer Discovery, Review and Pitch Presentation, and Pitching to a Panel.
- *Developing an expert laboratory team to support translation:* A translational laboratory to bridge the gap between traditional academic research and commercialisation has been created that employs '**Enterprise Associates (EAs)'** – postdoctoral researchers with sufficient breadth of expertise to perform experiments across a broad range of biomedical specialties. EAs are line-managed by the UofG Professor of Translational Immunology (**Goodyear**) on behalf of TRI, which also enables oversight, and control over the development of funded projects. EAs are also provided with training in entrepreneurship, patent law and other subjects of relevance at the academic/commercial interface. Through this initiative, we aim to train a cohort of postdoctoral researchers with unique expertise in translational research management.

Examples of projects supported from early concept to external investment include:

- Following seed-funding from TRI, **Baillie** secured a co-development deal with US Biotech company BioTheryX (~£300k) to explore the potential to develop novel compounds that inhibit and/or degrade a cAMP phosphodiesterase (PDE4) in disease systems, including colon cancer and cardiovascular and CNS diseases.
- With £137k (CiC) to investigate the selective targeting of bacteriocins with a view to engineering a healthy gut microbiome, **Walker** secured a further £2.5m of funding (including MRC DPFS and Wellcome Trust Collaborative Award). With business development support from TRI, this work led to two patented technologies with a total of 10 territorial filings.

We have spun out six companies from UoA1 over the last 10 years, including Clyde Biosciences Ltd, Portage Glasgow Ltd, Sannox Therapeutics Ltd, Kvatchii Ltd, Causeway Therapeutics Ltd (UoA5 Impact Case Study), Pathfinder Cell Therapy and have attracted an investment of ~£11.6m.

1.8.3:Underpinning innovation in partnership with NHS and industry.

Core to our translation initiative is to establish effective strategic partnerships with industry and the NHS to provide a direct route to market/clinical implementation for our research. This strategy is underpinned by long-standing relationships and an exceptional, embedded academic-clinical infrastructure (section 3).

UofG partners with NHSGG&C and a wider NHS West of Scotland Network through the Glasgow Health Sciences Partnership (GHSP), co-chaired by the UofG Principal and Chair of NHSGG&C, to achieve bidirectional strategic development and implementation. GHSP provide access to a patient base of 2.8million (52% of the Scottish population), including in areas of significant health inequalities and with high incidences of premature chronic disease and comorbidities.

Through GHSP, UofG has established integrated state-of-the-art clinical innovation facilities at the Queen Elizabeth University Hospital (QEUH), Europe's largest acute hospital campus. This infrastructure is centred around a UK Science Park Accredited Clinical Innovation Zone, which has attracted 15 companies to relocate to the QEUH campus to benefit from facilitated access to imaging, NHS data and academic researchers from across the UoA.

To deliver on the next phase of our clinical innovation strategy, UofG – in partnership with a consortium of public and private sector partners, including multinationals (Thermofisher with Coriell Life Sciences, Siemens Healthcare, Canon Medical), and SMEs (BioClavis, MRCOiltech, Aridhia Informatics), (**Dominiczak**) – has recently secured £60M (Strength in Places Funding and in-kind investment) to expand the QEUH campus into a world-leading research cluster, to support clinical validation and adoption and offering greater incubation and growth space for SMEs.

Additional infrastructure available through this partnership includes: the **Robertson Centre for Biostatistics** (with an international reputation for clinical trials, epidemiology and health economics), a biorepository, and access to high quality patient data via the Community Health Index (CHI). Furthermore, our Clinical Research Facility (CRF) has sites in the QEUH, Glasgow Royal Infirmary, and the Beatson West of Scotland Cancer Centre. Together with two Clinical Trials Units (one dedicated to cancer trials and CRUK funded), the CRF provides UoA1 with state-of-the-art phase-I experimental medicine through to practice-changing and phase-4 clinical trial capacity and coordination capabilities (including international studies coordinated from Glasgow and sponsored by UofG in partnership with NHSGG&C).

1.9:DEVELOPING A CULTURE OF RESEARCH INTEGRITY.

UofG's approach to promoting a culture of research integrity is highlighted as a case study by the UK Research Integrity Office (UKRIO) and the Royal Society. This culture is supported by training for established staff and ECRs to better understand research integrity. The College Integrity Champion (**G.Graham**) disseminates best practice through regular presentations, and all staff complete a mandatory integrity training course. In addition, staff supervising ECRs undergo mandatory training which includes training on research integrity. UofG has also developed a 'Code of Good Practice in Research' for all staff, which complements the UKRIO checklist on good practice.

Each Institute also has a dedicated research integrity lead, who reports to the Research Integrity Champion and oversees the development of supportive actions in response to breaches in good practice (including suspected misconduct). These research integrity leads attend the College Research and Knowledge Exchange Committee, where research culture and practice are standing agenda items. This Committee is chaired by the College Dean for Research.

2.People

2.1:OUR STAFF.

We support numerous, diverse staff, who are integral to delivering a complex and high-quality research and teaching output. Each Institute has silver Athena SWAN status and is focused on the development of an inclusive culture that supports staff and students to achieve their potential.

UoA1 comprises 175 academic staff, as summarised below.

Staff Category	Job Type	Headcount	FTE	%age Female
REF Eligible Academic Staff	Professor	56	53.8	17.9%
	Clinical Professor	31	30.6	16.1%
	Reader	11	10.9	36.4%
	Clinical Reader	2	2.0	50.0%
	Senior Lecturer	36	35.9	33.3%
	Clinical Senior Lecturer	17	16.9	17.6%
	Lecturer	4	4.0	25.0%
	Senior Research Fellow	8	6.1	25.0%
	Clinical Senior Research Fellow	2	2.0	50.0%
	Research Fellow	8	7.8	50.0%
	TOTAL	**175**	**170.0**	**24.6%**
PDRAs/Research Fellows		**287**	**276.3**	**57.5%**
Technical Staff		**170**	**160.4**	**66.0%**

Since 2014, we have appointed three new professorial staff, four new senior lecturers and 29 new lecturers, 51 academic staff have left the unit. We thus have a net reduction in staff overall, against which we have consistently increased our metrics of income, published output and impact. We have achieved this in the following ways:

The UoA has actively recruited individuals with international reputations for high quality research, who, since joining, have attracted programme-level funding from MRC (**Marti**), Wellcome (**Marti, Maizels, Sinkins, Maloy**) and ERC (**Marti, Guzik, Castello**), valued at £15.8m. In addition, we have made the following appointments at our institutes:

- III: Microbial infection studies have been expanded by the recruitment of **Wilson, Castello, Hutchinson, Penades, Marti, Perona-Wright** and **Maizels,** and our aim to increase our reach into LMICs supported by the recruitment of **Sinkins, Ho, Cotten** and **Moxon.** Our expertise in basic and clinical studies of arthropathies has been strengthened by the appointment of **Basu**, **Millar** and **Kurowska-Stolarska**, with **Otto** and **Robertson** recruited to provide bioinformatics expertise.
- ICAMS: Recruitment of **Leiper**, **Fuller** and **Miller** has extended expertise in vascular injury and endothelial dysfunction, with **M.Petrie** appointed to enhance clinical trial activities.
- ICS: Research into cancer metabolism was enhanced by recruiting ECRs **Helgason** and **Maddocks** to tenured posts, while **Cagan** was recruited to strengthen precision oncology and to provide leadership for translational science throughout the UoA. **Bushell's** recruitment has greatly strengthened research into protein synthesis and its impacts on tumour growth**.**

2.1.2:Thematic integration through strategic appointments.
Many senior academic appointments have enhanced thematic integration within UoA1. For example, **Guzik's** (recruited to ICAMS), research crosses boundaries between immunology and cardiovascular disease, while **Maizels** and **Otto** (III) work at the interface of molecular parasitology and immunity. **Coffelt, Carlin, LeQuesne** and **Roberts** (ICS) were appointed to develop cancer immunology research, while **Lang** (ICAMS) was recruited to support the focus on 'cardiovascular oncology'.

2.1.3:Underpinning excellence with specialised support.
To support research excellence, UofG is developing new and formal career tracks for a cohort of postdoctoral-level scientists and technologists (section 2.2.2). Promotion criteria and grade descriptors have been published for these new career tracks, making it easier: (a) to establish these roles, (b) to develop individual staff and to support research-enabling and support services, and (c) to provide clear, long-term career structures. Academic activity in the UoA is supported by 183 professional services staff, including 131 technical and infrastructural staff.

2.1.4:Future staffing strategy.
The UoA1 strategy group coordinates recruitment and staffing strategy across the UoA (section 1.7). Targeted recruitment of internationally excellent candidates into strategic areas will be driven through a dedicated 'head-hunting' team, reporting to the strategy group and making use of funds redirected from retirees and additional UofG strategic investment funding. We will also establish a 'war-chest' to provide financial support for new recruitments. Finally, the Strategy Group will co-ordinate and adopt a more direct approach to ECR/Fellowship support and recruitment, aligning this, where possible, with our strategic goals.

2.2:SUPPORTING STAFF TO ACHIEVE THEIR POTENTIAL.

We aim to support staff to be as productive and successful as possible and to ensure that each staff member achieves their academic goals and ambitions. This approach sits at the centre of our research strategy. Feedback is constantly monitored and results from annual staff surveys are considered seriously and acted upon to ensure that the leadership continuously improves the environment for staff across the UoA. Directors of Institute, or their designates, meet regularly, both formally and informally, to discuss common issues and to enact solutions. Engaging all members of staff is a priority, and this is done successfully through 'Open Forums' and 'Town Hall' meetings. The

communication strategy developed to support staff has been central to our response to the Covid-19 pandemic and has allowed us to keep staff informed of all relevant issues and to address concerns in a rapid and sensitive manner. This has allowed us to liaise with staff to help minimise downtime for 'wet lab' researchers during the pandemic and to ensure that they have been able to return to work, where appropriate, in a safe and supportive manner.

2.2.1:Performance and Development Review (P&DR).
Staff are assessed annually at P&DR. The discussion of promotion opportunities is mandatory at these reviews to encourage a structured approach to career mapping and realistic planning. These reviews also highlight those that should be rewarded for excellence in overall performance. In collaboration with HR, our UoA has introduced extensive training for both line managers and staff to ensure the process is a constructive dialogue between reviewer and reviewee that aims to assess and to improve performance via training and support, as required.

2.2.2:Developing 21st Century research careers.
Over the past 20 years, the nature of biomedical research has changed markedly, with projects now depending on a wide range of expertise, including in core research skills, such as transcriptomics, proteomics, bioinformatics and statistics. Whilst individuals contributing such expertise are indispensable to many studies, they are only occasionally acknowledged as being either first or senior authors on publications. They are also rarely principal applicants on significant competitively funded grants. As such, these individuals are at a disadvantage when being assessed for promotion, according to typical university-based promotion criteria.

To more fully recognise the contribution of our core researchers, UofG has established a new "Research Scientist & Technologist" career track with leadership from UoA1 (**Dominiczak, G.Graham**). This track offers flexible promotion criteria that are better aligned to the nature of multidisciplinary science. As a result, we are now leading the University sector in the reorganisation of research careers; UoA1 has 31 staff appointed on these tracks.

- *Research Scientist track:* is designed for those with high level technical and analytical expertise and who contribute to a broad range of university projects, such as experts in transcriptomics, proteomics, bioinformatics and statistics. This track's promotion criteria highlight involvement in (but not the leading of) key research programmes and the contribution of core expertise to externally funded grants and incorporates individuals who run high-level technical infrastructure, such as imaging facilities, which serve the broad needs of the University community.
- *Technical and Specialist track:* is aimed at individuals who have specific technical expertise in which they demonstrate a national and international lead.

This career framework has been recognised by the Royal Society and the Academy of Medical Sciences and has informed career planning at other institutions.

2.2.3:Wellbeing initiatives.
A range of well-being events, such as yoga, mindfulness classes and social events, regularly bring staff together in informal settings. Team building exercises are encouraged at the local level, such as lab away-days and clinical team retreats. Funding is made available to support these events given their priority and importance.

We also have dedicated and trained mental health first aiders in all buildings and posters in prominent positions providing contacts for these individuals.

The Covid-19 pandemic has brought a range of new challenges in terms of staff and student well-being. Many UoA staff now work exclusively from home, raising logistical issues concerning access to appropriate office equipment and feelings of isolation and loneliness. We have provided staff with all required equipment, including ergonomic seating and computer peripherals, and have markedly increased the frequency of online meetings to ensure that staff have regular contact with colleagues. Together with UofG Estates and Commercial Services department, we have adapted all buildings to be fully compliant with Government restrictions to ensure that those who have to return to work (e.g.

wet lab scientists) feel comfortable and can access UofG car parks at a nominal charge of £1 per day.

2.3:SUPPORT FOR EARLY CAREER RESEARCHERS.

Training and mentoring the next generation of biomedical scientists is fundamental to our overall research strategy. We have therefore put the following career-development initiatives in place:

2.3.1:Early Career Development Programme (ECDP).

ECDP fulfils a UofG commitment to develop its early career academic staff. It aims to develop high achieving, high performing academics who will help UofG to deliver its vision and ambitions. The programme provides learning and development opportunities across the academic role, a mentor to provide support and advice, and annual objectives set to enable academics to develop their abilities and achievements, with a view to meeting the criteria for promotion to Grade 9 (senior lecturer equivalent) within a defined timescale. This initiative is helping UofG to reverse a reduction in female academic staff traditionally between Grades 8 and 9 by supporting female ECRs to progress to more senior grades. Within UoA1, 22 (77% female) staff have benefitted from this programme.

2.3.2:In-house Fellowship funding opportunities.

UofG has dedicated substantial funding to support Research Fellowships, making £6.8m available to support two schemes: Lord Kelvin Adam Smith (LKAS) fully funded research fellowships and LKAS Leadership fellowships, which provide substantial match-funding for those applying for external fellowships. These schemes enable outstanding researchers, with the potential to become leaders in their field, to be recruited at an early career stage. Each fully funded fellowship runs for five years and covers salary costs and an allowance for research costs. Since its inception, UoA1 has benefited from five fully funded LKAS fellowships and nine LKAS Leadership Fellows (including **Cordero, Helgason, Miller, Brennan, Sheiner**, **Wilson**). Collectively, these fellows have published 124 outputs, with a FWCI of 3.01 and secured £7.6m in research income, demonstrating the value of attracting and supporting talent from an early stage.

2.3.3:Pump-priming initiatives.

ECRs are encouraged to apply for internal funds, such as Wellcome Trust Institutional Strategic Support Fund (ISSF), to support and develop their research. Seven ISSF-funded Fellowships have been awarded to UoA1 ECRs. For example, **Sheiner** was awarded an ISSF Fellowship on mitochondria biogenesis in *Toxoplasma* parasites, which established her at UofG and supported her tenured academic position in 2014. During this time, her research on parasitic survival and virulence received support from several funders, including the Royal Society of Edinburgh, BBSRC, MRC, and a Wellcome Investigator award, totalling £3.9m.

2.3.4:Mentorship.

All ECRs can have a mentor to advise them on career development, research objective setting and promotion prospects, and access to peer mentoring through two successful networks (sections 2.3.5, 2.3.6). In addition, the UoA provides intensive training in grantsmanship and interview technique to ECRs applying for grants and fellowships (section 3).

2.3.5:Network for Early career Researcher Development (NERD) group.

Feedback from the UoA's ECR community has highlighted that top-down support, while well meaning, often fails to adequately identify and address the issues of most concern. For this reason, they established the cross-institute NERD group, which brings together ECRs from across UoA1 to discuss issues of common concern, and to examine collaborative opportunities. This group aims to identify impediments to career development within the ECR community and to provide training and support that meet their needs. They also identify the challenges facing ECRs, and advocate for their needs to senior management. The group hosts regular internal and external speakers to provide guidance on career opportunities, University administrative issues, research integrity and grant writing. NERD also runs regular social events to enable ECRs to interact with each other in an informal context and to discuss issues of concern in the absence of more senior University staff, who

might impede free discussion. NERD members sit on the management committees of each of the UoA's three institutes and attend the College Management Group to represent ECR interests.

In parallel, our early career clinical research staff have established a similar group, which meets regularly and focuses on issues of specific relevance to early career clinical academics.

2.3.6:Academic Mid-Career leadership GrOup (AMIGO).
Recognising the gap in support for mid-career academics, AMIGO was created as a cross-disciplinary, cross-college network for leadership, mentoring and peer-support in medical, life and social health sciences for mid-career academics.

2.4:ENHANCING STAFF COMMUNICATIONS.

Since 2014, we have made major improvements to our internal communication structures and have put into place several initiatives to ensure a sense of community across the grades. Some of these are common across the UoA, but others are specific to individual research areas, particularly those located at geographically discrete sites. These initiatives include:

2.4.1:Town-hall meetings.
We hold regular (every 2-3 months) Town-hall or Open Forum meetings to which all staff are invited. These meetings provide opportunities for open discussion, question and answer sessions, transmission of higher-level information from College and University, and support networking between staff. Minutes and an action plan are produced at the end of each meeting.

2.4.2:Director's Surgeries.
In each Institute, the Director, Deputy Director and Head of Administration are available once a month to discuss any confidential issues with staff members. This initiative has been extremely useful in highlighting specific areas of concern for individual staff members.

2.4.3:Enhanced communication.
Weekly newsletters provide updates on activities across our UoA, including outputs and funding success. In addition, we provide comprehensive annual reports for each of the UoA's component Institutes. Importantly, newsletters, annual reports, social media interactions, and information about local seminars and other activities are circulated widely to staff and students. We have also introduced electronic noticeboards throughout UoA buildings that highlight key daily events and other information important to staff. Finally, we have invested in 'Communications and Web Officers', who lead the communication portfolio to ensure that relevant information such a news, research highlights and priority calls, are communicated to all.

2.5:EQUALITY AND DIVERSITY.

UoA1 Institutes are committed to improving diversity and equality, which is also a standing item at each Institute's, and each Research Group's, management meetings. We adhere to UofG's Equality and Diversity Policies, including mandatory equality and diversity and unconscious bias training, particularly for those involved in recruitment. Each Institute holds Silver Athena SWAN awards, and our self-assessment teams share best practice and initiatives across the UoA, which is important as the three Institutes have similar staff profiles with common concerns and requirements.

In support of equality and diversity, we:

- Have a culture of flexible working and core-hours, which limits the scheduling of meetings to 10am to 4pm.
- Have robust cross-Institute staff and postgraduate student induction arrangements, including equality and diversity relevant policies, work-life balance, and welcoming groups for international staff and students with diverse cultural backgrounds.
- Offer an 'Academic Returners' Fund to provide additional support to staff returning to work, to minimise the impact of extended leave on research activities. We have extended this to all staff on academic career tracks (including PDRA and our new Research Scientist and Technologist career track), returning from adoption, maternity or paternity leave, and to partners who have

taken extended leave through the Shared Parental Leave Policy of four months or more. Applicants can request up to £10,000 to support research-related activities, which is available throughout the applicant's first 12 months' return following leave. Three UoA1 staff have accessed this additional support, keeping their research and career development on track.

All involved in REF processes (including output review and selection) within the UoA have undertaken mandatory training, including on ED&I principles, unconscious bias, and sensitive data handling. In accordance with the UofG's Code of Practice, outputs were selected and allocated to authors to maximise the UoA's Grade Point Average (GPA). An interim equality impact assessment of our methodology indicated there was no significant bias against any protected characteristic.

2.6:PGR SUPPORT.

This UoA aims to provide a strong and supportive environment for all doctoral students, to train bright minds and prepare them in a specialty-specific manner but also equip them with broad transferable skills.

In addition to PhD studentships provided through our Centres of Excellence (section 1.4), we have also attracted funding for the following doctoral training programmes:

1. Wellcome Trust four-year PhD programme on integrative infection biology: recently successful bid for a Wellcome trust doctoral training programme in infection biology supports seven studentships per year, including two from an LMIC to enhance local training needs.
2. BHF MRes/PhD programme: The successfully renewed BHF-funded MRes/PhD programme (for 2021-2025) supports cross-discipline projects within UoA1. Since 2014, over 30 PhD students have graduated through this programme alone.
3. TRACC Programme (Train and Retain Academic Cancer Clinicians): a joint initiative (CRUK, £6.2m, 5 years) between UofG and University of Edinburgh (UoE) to train the next generation of leading academic cancer clinicians via an integrated clinical academic training programme. TRACC provides opportunities to work in cutting-edge laboratories with renowned scientists and clinicians. In 2020, an additional £256K from Astra Zeneca was secured to support a further fellowship.
4. MRC Doctoral Training Partnership in Precision Medicine: a large flagship doctoral training programme run in partnership across the UoE and UofG, with the Karolinska Institute as an external partner. It is co-funded by the MRC and the partner universities, and since 2016 has recruited 140 students.

2.6.1:Doctoral research student recruitment.

The recruitment process is centralised through a College-wide Graduate School and based purely on candidate quality. Prospective students apply for one of several advertised opportunities. The best applicants are interviewed, and positions awarded to the highest quality interviewees. The students then select their project of choice, which in our experience, helps to maximise quality and allows students an informed choice of the programme of work they wish to pursue.

Advertising material, including example projects and supervisors, webpages and interview panels are designed to promote an inclusive and diverse experience, and interview questions are carefully chosen to ensure equity of opportunity for candidates from diverse backgrounds. In addition, when students with apparent, or declared, disability are appointed they are provided with full support throughout their studies.

The recruitment of students from diverse backgrounds into PG research is further promoted through the inclusion of equality and diversity training within the Undergraduate Life Sciences degrees at UofG (from 2020 onwards). This compulsory course was developed with funding from Wellcome Trust Institutional Strategic Support Fund (ISSF) and challenges perceptions of a career in research.

2.6.2:Doctoral research student training provision.

This training includes initial induction that covers communication and expectation management of supervisors/students, e.g., regular, minuted meetings, decisions, assignments and timelines. Student progress and quality of experience are assessed twice in the first year and then annually by an independent assessment team. Any problems are dealt with by the PGR convenor in the first instance. We also offer comprehensive pastoral care from independent academic assessors and via our peer-support networks and counselling service. UofG runs workshops to support PGR student mental health (e.g., managing stress, overcoming perfectionism, getting a good night's sleep), in addition to community initiatives, such as regular lunchtime walking groups and a PGR garden. Our Graduate School provides a Research Training and Personal Development Programme that includes over 90 short training course options aligned with the Vitae Researcher Development Framework and delivered during core hours across various dates, venues, and format (on-line and on campus) to ensure equitable access for all students (equality and diversity training is mandatory in Yr1).

2.6.3:Skills training provision.

Given that many doctoral students will choose to pursue careers outside academia, UofG and UoA1 provide a skills training portfolio of sufficient breadth and depth to equip students to develop their general employability skills. At the end of month-2, students meet with their supervisor to complete the 'Training Needs Assessment' and agree a 'personal development plan' for training provision, which is reviewed annually as part of a 'Research Development Log'.

2.6.4:Specific PGR support initiatives.

Major elements of PGR support in UoA1 include:

- Institute-specific inductions, provided by each Institute's PGR group, introducing students to Institute structure and opportunities, PhD studies, and available resources. Postgraduate convenors give presentations supported by senior academic staff. Students receive an induction pack, including Athena SWAN materials, and pointers on UofG policies and website links. Postgraduate Taught (PGT) students also attend both Institute and programme-specific induction. Induction materials (available electronically) make clear that trainees can request a supervisor of a specific gender and all requests are granted.
- The allocation of two supervisors and two advisors per PGR student. Advisors are independent of supervisors to enable proper mentorship and oversight. An extensive network of student mentorship and pastoral care is also available via the Graduate School. This supervisory network ensures that students can access a wide range of PG modules in a student-focused manner to support their development of multidisciplinary and discipline-specific skills. PGR students participate in the Graduate School's progress review, receiving dedicated time to reflect on training needs, skills acquisition, and career progression, with progress documentation being reviewed by a convenor and two assessors (not their supervisor). Students self-assess, and supervisors complete progress reports. This work is included within an academic's P&DR, workload allocations, and contributes towards promotion criteria.
- Annual Student Conferences and Institute Awaydays, during which students present posters and presentations and gain valuable networking opportunities. PGR students are also encouraged to join the NERD initiative through which they can access wide-ranging advice, including CV writing and scientific career progression. Journal clubs and regular social events are also organised for our PGR students.
- A comprehensive UoA1 seminar series and local International Conferences, which students are encouraged to attend, giving them access to high calibre, internationally recognised research experts.
- Rewards to recognise excellence in PGR student performance. For example, this UoA offers an annual award for the best thesis by a clinical research fellow and by a basic science PhD student (£1000 each from Institute funds and a valedictory seminar). In addition, we run poster presentation sessions for PGR students and award prizes for the best posters and presenters.
- A "Three Minute Thesis" competition, in which doctoral students have three minutes to persuade an audience and a panel of judges of the significance of their research. This initiative provides an entertaining learning experience.
- Student discussion panels with successful female and male academics about career

development.

To mitigate some of the problems of the **Covid-19** pandemic and subsequent **lockdowns**, we have encouraged all PhD students to spend lockdown writing a substantive chapter of their thesis to replace a results chapter. This could take the form of a grant application, review related to their research or a bioinformatics analysis. Students can also apply for a fully funded extension to their studies where lockdowns have significantly delayed their projects. Since its implementation, this scheme has supported 39 UoA1 students with funded extensions, ranging from 3-6 months.

3.Income, infrastructure and facilities

3.1:OVERVIEW.

Since 2014 and underpinned by a range of investments in both staffing (sections 1 and 2) and infrastructure (below), our research income per FTE has increased from £372k in 2013/14 to £477k in 2019/20. As detailed in section 2.1, our staff recruitment strategy, aligned with UofG's support to attract '4*' Professors, has allowed us to recruit staff who have attracted a number of prestigious programme-level grants. We are consistently ranked 3rd in the Russell Group for research income per FTE (HESA Cost Centre 101 Clinical Medicine) and the total research income for UofG's UoA1 has increased by 16% since 2014.

Our focus on enhancing research excellence by providing a supportive environment, in which staff have the tools required to achieve their potential (section 2 and below), has ensured that 98% of our Research & Teaching staff currently hold a research grant (compared to 79% in 2013), with new awards of almost £65m in 19/20.

3.2:ENHANCING INCOME.

Nine dedicated professional service staff provide support to UoA1 Institutes to nurture grant applications through their preparation, submission and delivery. This initiative has revolutionised how grants are prepared and managed, provided costs and time savings, and increased confidence amongst staff. As well as managing peer review processes for all applications and mock interviews (e.g. for fellowships), this team has improved the efficient use of grant funding across our research portfolio and diversified our funder portfolio, by increasing awareness of available opportunities and by helping to coordinate large and complex grant applications. Furthermore, we:

- Have established an intensive grant mentoring programme, targeted at ECRs but available to all staff.
- Run a pump-priming scheme to provide two years initial support for early career clinicians to experience research prior to applying for external fellowship funding. 100% of individuals in receipt of this funding have successfully transitioned to externally funded fellowships.
- Have initiated a similar scheme for basic researchers with a view to attracting high calibre ECRs to our UoA.
- Offer an intensive course of interview practice and mentoring for those invited to interview for Fellowship, Centre-level or Programme-level funding. Again, this has proved to be very successful.
- Run regular internal training courses on grantsmanship to improve grant writing abilities.

Funding highlights since 2014 include:

- >£40m in funding for our research Centres of Excellence (section 1.4).
- 26 staff with Chair/programme grant-level funding (defined as funding for 5 years or more) from Wellcome, MRC, EU, BHF, ARUK and CRUK.
- Fellowship funding of over £29m for 141 competitively awarded fellowships from external sources, since 2014, ranging from career entry fellowships (e.g. Sir Henry Dale Fellowships and MRC Career Development Fellowships) to Wellcome Principal Research Fellowships. This funding includes £13.2m of fellowship funding from Wellcome Trust (15 fellowships), £4.3m from CRUK (8 Fellowships), and £3.1m in MRC funding (14 fellowships).

3.3:ENHANCING OUTPUT.

Our outputs are highly cited, with over 7,000 papers receiving 230,000 citations across the REF period, ranking UofG 3rd in Russell Group for FWCI in the "Medicine" subject area (UofG FWCI of 2.79 compared with Russell Group average of 1.61). We enhance the quality of research output in various, tailored ways and by supporting and mentoring staff, as outlined below.

- We co-localise ECRs with experienced academic staff, who provide mentorship in project management, staff supervision and manuscript preparation. The recruitment of several senior scientists (SL, Reader, Professor), who bring acquired expertise to the mentoring role, has enhanced this initiative since 2014.
- We maintain cutting-edge research facilities for imaging, multi-omics analysis, and high-quality animal husbandry, including outstanding genetic-engineered murine models and derived xenografts capabilities (section 3.4).
- We provide access to an extensive, integrated academic/clinical research infrastructure (section 3.4.6) that supports experimental through to practice-changing clinical studies with international impact.
- We offer an extensive publication-mentoring process, including internal review and revision to promote rigour and excellence prior to submission.
- We invite leading journal editors to provide internal seminars to guide and advise researchers on publishing and publishing innovations that support reproducibility and good research reporting practices.
- We instil a collaborative approach, which we believe offers the best chance of 4* outputs. Since 1st Jan 2014, UoA1 researchers have produced 5,906 REF-eligible publications, 9.8% co-authored from multiple Institutes and 58.8% with international collaborators. UoA1 researchers also publish with non-academic authors, including with industry, NHS, government, NGOs and patient representatives. For example, since 2014, 22.8% of publications have been joint with NHS authors and 12.9% with industry.
- We bring knowledge, know-how and outputs previously hidden from view into the public domain, in keeping with the principles of Open Research and by working with UofG's Library and Data management teams. This includes the innovative step of depositing the underpinning trial data for a key clinical trial framework under a single DOI (http://dx.doi.org/10.5525/gla.researchdata.819). In one example, an entire framework and dataset for an interdisciplinary project on the Future of Cancer Precision Medicine was deposited (DOI: 10.5525/gla.researchdata.843).
- We mandate that all primary, UoA1 research publications are fully compliant with Open Access (OA) policies. Staff from the UofG library provide invited talks to researchers to explain this initiative, the importance of OA, and how to achieve OA publications. Within the assessment period, 84.5% of UoA1 research publications were made OA, with 100% of staff having an ORCID.

3.4:DEVELOPING THE UoA RESEARCH INFRASTRUCTURE.

Since 2014, we have invested £70m in improving our research infrastructure and cross-cutting technologies, and have appointed highly-skilled technologists to oversee key infrastructure, ensuring their career progression through the newly defined Research Scientist and Technical and Specialist career tracks (section 2.2.2).

Specific highlights in terms of research infrastructure include the following:

3.4.1:Scottish Centre for Macromolecular Imaging (SCMI).

With £560k of matched investment and £4.4m from MRC, UofG established the Scottish national cryo-electron microscopy resource. This is supported by a state-of-the-art cryo-electron microscope, housed in the CVR, managed by dedicated staff and accessible to researchers throughout Scotland and beyond. This equipment is transforming our structural biology expertise and is expected to increase the number of protein structures of scientific and therapeutic importance that we can define.

3.4.2:Preclinical imaging infrastructure.
To maximise the benefits from our high-level expertise in various imaging technologies we appointed an imaging technologist (on the technical and specialist career track) to integrate imaging capacity across UoA1. Importantly, the imaging technologist is supported by other core technical staff who can run experiments for researchers when required. This is particularly important when the imaging approaches required are complex and beyond the capacity of the relevant research group. Importantly, this imaging expertise is also aligned with that present in the Imaging Centre for Excellence (section 3.4.6.1) and can be readily accessed by researchers at a low cost.

3.4.3:Cellular analysis infrastructure.
Since 2014, the flow cytometry and cell sorting expertise present across UoA1 has been integrated and managed by a dedicated technologist with assistance from core-funded technicians. We now have a very well-developed cellular analysis and sorting facility used by researchers throughout the UoA. Costs are kept as low as possible to ensure ease of access for researchers, regardless of the extent of their funding base.

3.4.4:Glasgow Polyomics Facility.
Established with £2.2m from Wellcome Trust ISSF, this facility embeds omics technologies within UofG and provides cutting-edge support for next-generation sequencing, metabolomics, proteomics and transcriptomics. Since its inception, Glasgow Polyomics has completed over 1,000 projects, co-authored 164 papers and contributed to over £51m of external funding. Highlights include **Barrett's** EPSRC grant to develop a metabolomics sensor (£3m), **Meissner'**s Wellcome Trust Senior Fellowship renewal (£2.2m), **Marti**'s Wellcome Trust investigator award (£1.38m), **Cordero**'s Wellcome Fellowship award (£969k) and **Leung'**s Prostate Cancer Foundation Award (£564k) and Prostate Cancer UK award (£463k). In addition, Glasgow Polyomics has secured industrial contracts with Life Technologies, Anacor Pharmaceutics Inc., INVISTA, BASF, GSK, AstraZeneca and Novartis.

3.4.5:Wolfson Wohl Cancer Research Centre.
This dedicated translational Research Centre (£13m) was erected on UofG's Garscube campus, adjacent to the CRUK Beatson Institute. It houses most of UofG's cancer researchers and is where GPOL and PRECISION Panc (**Biankin**) are sited. Its proximity to the CRUK Beatson Institute promotes resource sharing and cross-collaborations.

3.4.6:Integrated world-class clinical innovation facilities.
QEUH represents an investment in Glasgow and Scotland of ~£1Bn. Opened in 2015, it is the largest acute hospital in Western Europe and includes maternity, paediatric and adult services on a single site. UofG has invested over £50m in new physically linked facilities. These, alongside a purpose-built Learning & Teaching Centre for postgraduate and medical training, include:

3.4.6.1:Imaging Centre of Excellence.
This £30m Centre, is supported and run by dedicated imaging experts, providing a hub for imaging research, and access to research-dedicated 3T MRI, large-detector CT systems, and one of the world's few 7T MRI scanners. Research at this Centre includes industry collaborations (e.g. Canon Medical), the application of AI to acute stroke imaging, and research into the natural language processing of radiology reports. The Centre also provides a nexus for academic, NHS and industrial expertise in brain imaging. To date, more than 5,000 research and clinical MRI and CT scans have been completed.

3.4.6.2:Stratified Medicine Scotland-Innovation Centre (now Precision Medicine Scotland).
This UofG-led initiative, supported by £4m from Scotland's CSO, coordinates Scotland's precision medicine community and aims to deliver precision medicine programmes more efficiently and effectively. It acts as an initiator for precision medicine research and has driven commercial collaborations in cancer and chronic diseases (e.g., AstraZeneca £1.9m, Roche £63k, UKRI-funded collaborations). Precision Medicine Scotland was recently renewed with a further £9.5m in core funding to support the effective implementation of precision medicine into the NHS, including an ambitious pharmacogenomics workstream under the £60m 'Living laboratory' Strength in Places

award, which will support the growth of the Scottish Life Sciences sector through a pipeline of sustainable projects funded by industry.

3.4.6.3:Clinical Research Facility.
Enhancing an existing network of clinical research facilities across NHSGG&C's eight hospitals, this £5m facility is dedicated to precision medicine clinical trials in adults, adolescents and children.

3.4.6.4:Clinical Innovation Zone.
This UK Science Park-Accredited facility provides industry with access to world-class academic and clinical scientists within a single state-of-the-art structure and was established to capitalise on the integrated expertise of academic/NHS/industry to tackle global health care challenges and to maximise patient benefit. To date, 15 organisations, consisting of local and international SMEs, have joined the Clinical Innovation Zone and over £88m of collaborative research income has been secured with UoA1 academics.

3.4.6.5: Legacy infrastructure from MRC/EPSRC Glasgow Molecular Pathology Node.
The UK's largest such Node ran from 2015 to 2019, supported by a grant of £3.4m (**Oien**). It aimed to integrate academic pathology in the NHS and fund pathologists (19 in total) to dedicate time to research and training ECRs. The Node supported 26 research projects, partnered with six industry organisations, conducted a range of events that engaged with >40 industry partners, and leveraged an additional £32.5m of research funding. Its legacy includes an integrated approach to pathology across GHSP and has directly driven:

- The integration of the UofG-led (Harrison, **Muir**), (£16m) industrial-Centre for Artificial Intelligence Research in Digital Diagnostics (iCAIRD), a 15-partner consortium including NHS, academia and industry e.g., Canon Medical and Philips, within the Clinical Innovation Zone.
- The Integrated Technologies for Improved Polyp Surveillance (INCISE) consortium, a £3.37m programme (**Edwards**) to develop a risk stratification tool for bowel cancer, in partnership with NHS and industry (Canon Medical, Bioclavis, OracleBio).

3.4.7:ASTERIX.
Adaptive **S**tratification of COVID19 **T**o facilitate **E**ndotype-di**r**ected **I**ntervention Studies (ASTERIX) is a prospective, single-centre observational cohort study (**McInnes**). Modelled on other UofG-led initiatives, it leverages our strengths in clinical research and data science, and close collaboration with NHSGG&C, to define the natural history of Covid-19 and clinico-molecular subtypes associated with adverse outcomes. It aims to identify discrete patient sub-groups (endotypes), based on a range of demographic, clinical and laboratory biomarkers, that predict progression though different stages of disease severity and the likelihood of response to therapies, according to their mode of action. ASTERIX also provides an infrastructure that enables rapid response and access to Covid-19 cohort data to clinicians and researchers across the UK.

3.4.8:Rapid Response to Covid-19.
In response to the pandemic, we initiated a rapid response fund to pump-prime collaborative research related to Covid-19, with ~£50k ring-fenced to support applications from ECRs. With £120k from ISSF, we are supporting a range of short-life collaborative projects including four applications with front-line NHS clinicians, enabling UofG's scientific expertise to contribute to the global fight against Covid-19.

3.4.9:CRUSH (Covid-19 Drug-Screening and Resistance Hub).
This national resource, funded by £2.5m from LifeArc and MRC to the CVR, is dedicated to supporting and accelerating antiviral innovation and translation. CRUSH offers a fully integrated hub for pre-clinical drug screening and resistance assays for SARS-CoV-2 and other high-consequence viruses in high-containment facilities.

3.5:NHS COLLABORATION AND PARTNERSHIP.

We have developed a closely integrated research environment with NHSGG&C, capitalising on substantial infrastructure investment around QEUH and our strategic partnership via GHSP. Shared

responsibilities and seamless governance, pharmacovigilance etc for clinical trials and translational research is facilitated through UofG direction of research and innovation activities in NHSGG&C (R&D Director**, Brittenden**) and the Golden Jubilee National Hospital (R&D Director, **Berry**). Wider engagement with other academic and NHS institutions in west of Scotland occurs via the West of Scotland Health Sciences Network. Trial delivery is via our CTUs (comprising the Robertson Centre for Biostatistics and CRUK CTU) and state-of-the-art Clinical Research Facilities at QUEH, Beatson West of Scotland Cancer Centre and Glasgow Royal Infirmary sites (>£5m investment), which work together under unified management structures.

We are integrated at scale to deliver research and support outstanding medical education (UofG's Medical School ranked 1 in UK, 2020). 1,684 NHS staff have honorary contracts and are affiliates with UoA1 areas. Of these, 86 honorary Clinical Professors and 118 Associate Clinical Professors were appointed since 2014. Four CSO-funded NRS Research Fellows were appointed at UofG to integrate clinical research activities across the thematic priorities of UoA1. Commensurate with this, 35.1% of our selected outputs are with NHS colleagues (12.7% submitted with NHSGG&C) are included in this return. Moreover, our shared income from awards led by either UofG or NHSGG&C amounts to £156m. Examples of our integrated approach to research with NHS colleagues include: iCAIRD (section 3.4.6.5), where UofG has deployed additional posts within the NHS to enable integration of the iCAIRD platform with the NHS SafeHaven.

Training and supporting clinicians to engage with research is a vital part of our activity. The **GATE** programme (Glasgow Academic Training Environment) offers academic enrichment for FY1/FY2 trainees, to retain talented medical graduates on an academic track. Thereafter, our Clinical Training and Advisory Committee oversees clinical lecturer development with a focus on wider clinical research training opportunities via doctoral training programmes (offered by our Centres of Excellence and TRACC) and response mode awards, given to NHSGG&C trainees, national and international candidates. We have also trained 256 clinical research fellows with response mode funding since 2014 and aim to strengthen NHS clinical careers in academia. As an example, **Blyth** started as an NHS consultant, received an NRS Fellowship and was appointed in 2020 as Professor of Respiratory Medicine in UofG; **M.Petrie** served as an NHS Consultant, as Director of the Scottish National Advanced Heart Failure Service until 2014 and was recruited to the UofG as Professor of Cardiology in 2016.

Senior academic leadership is provided to the NHS at both local and national level. For example, **Dominiczak** is a non-executive board member of NHSGG&C, and **Evans** sits on the Scottish Government's SAGE committee in response to Covid-19.

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

Our ethos is to deliver benefits to health and quality of life through a culture of engagement with funders, policy makers and wider society. Specific examples are described below to illustrate the range of activities that our academics have undertaken.

4.1:CONTRIBUTION TO THE RESEARCH BASE.

4.1.1:Grants panel membership.

Our academics actively participate in funding and publishing decisions, as described below, contributing to the scientific community and its place within wider society, in alignment with UofG's values and the principles of collegiality and civic responsibility.

4.1.1.1:National.

Wellcome Trust:
G.Graham (Chair, Expert Review Group in the immune system in health and disease), **Marti** (member, science interview panel), **Waters** (member, Sir Henry Dale interview panel), **Willison** (member, clinical fellowships interview panel), **Sinkins** (member, International Interview

Committee), **Sheiner, S.Graham** and **Palmarini** (members, Expert Review Group in pathogen biology), **Maloy** (member, Expert Review Group in the immune system in health and disease), **Machesky** (member, Sir Henry Dale Fellowship Committee), **Touyz** (member, Physiology in health and disease).

UKRI:
McInnes (Deputy Chair, MRC Experimental Medicine panel), **Palmarini** (member, MRC infections and immunity Board), **Carmody** (core member, BBSRC committee D), **Garside** (Chair, NC3Rs studentship committee), **G.Graham** (member, UKRI regenerative medicine panel), **Dominiczak** (Chair, MRC Translational Research Group), **Berry** (member, Clinical). **Siebert** (Deputy Chair, NIHR UK MSK Translational Research Collaboration). **Chalmers** (Member MRC Molecular and Cellular Medicine Board).

Cancer Research UK:
Evans (member, Industry Combinations Alliance Committee, Clinical Expert Review Panel), **Holyoake, Oien** (member, Clinical Expert Review Panel) **Norman** (member, CRUK Pioneer Awards Committee).

Chief Scientist Office:
Davies (Chair, Experimental and Translational Medicine Panel), **Goodyear** (member, Experimental and Translational Medicine Panel), **Leonard** (member, Experimental and Translational Medicine Panel), **Mark** (member, Experimental and Translational Medicine Panel).

BHF:
Leiper (Associate Medical Director), **Maffia** (member, Fellowships committee, BHF's Advisory Council), **Touyz** (member, Fellowships committee).

Diabetes UK:
J.Petrie (member, grant awarding panel).

Versus Arthritis:
Siebert (Chair, adult inflammatory arthritis research advisory group, previous chair, progress review committee), **Basu** (member, research advisory group), **Goodyear** (member, research advisory group).

Multiple Sclerosis Society:
Goodyear and **Edgar** (members, Grant Review Panel).

Breast Cancer Now:
Evans (Chair, Catalyst Programme Committee), **Macpherson** (member, Scientific Advisory Board), **Coffelt** (member, Grants Committee).

Tenovus Scotland:
Helgason and **Shiels** (members, Scientific Advisory Committee).

Royal Society:
Sinkins (member, Newton Advanced Fellowships panel).

4.1.1.2:International.

African Research Excellence Fund: **Garside** (member, Fellowship panel).

Canadian Institutes of Health Research: **Touyz** (member, Cardiovascular B panel), **Evans** (member, "High Fatality Cancers" Panel, 2016)

Catalan Biomedical Research: Harnett (member, funding panel).

Cystic Fibrosis Trust: Harnett (member, Strategy Implementation Board).

EMBO: Machesky (member, Young Investigator Programme).

European Commission: Keith (member, European Research Council (ERC) Starting Grants panel; Vice Chair, Horizon 2020 Science with and for Society; Chair, Innovators Grant Committee), **Harnett** (member, new concepts in patient stratification and Horizon 2020 programmes).

European Society of Cardiology: **Smith** (member, Council).

French National Cancer Institute: Copland (Programme for Hospital Clinical Cancer Research), **Evans** (co-Chair, Scientific Evaluation Committee, Designation of Early Phase Clinical Trials Centers in Adult and Pediatric Oncology)

French Agence Nationale de la Research: Sinkins (pre-proposal evaluation panel)

German Federal Ministry of Education and Research: Goodyear (DLR e:Med Systems Medicine Research Consortium Grant Panel).

International Agency for Research on Cancer (part of the WHO): **Keith** (member, Fellowships & Training Committee)

Italian Ministry of Health: Maffia (member, Ricerca Finalizzata Grant Panel).

Union for International Cancer Control: Keith (Chair, Technology Training Fellowships, Chair, Yamagiwa-Yoshida Memorial International Cancer Study Grants).

VLIR-UOS (Belgian Development Cooperation): **Keith** (member, Selection Commission North).

World-Wide Cancer Research: Norman (member, Grants Committee).

4.1.2:REF panel activities.

UofG has the highest staff representation on REF panels of any UK university and is supporting this engagement by allowing REF-involved staff to withdraw from teaching and administrative duties for the duration of the REF exercise and by providing research leave for up to 6 months following completion of the exercise. Our UoA emphasises the importance of engaging with REF panel activities where possible, and our staff will contribute in the following ways: **Dominiczak** (Main panel A), **Graham** and **Touyz** (UoA1), **Palmarini** (UoA6).

4.1.3:Editorial Activities.

Most submitted staff from UoA1 have reviewed for journals, including specialist and high impact science journals, and many hold editorial posts as well. Examples include:

Editorial board membership:
Maffia: Scientific Reports, British Journal of Pharmacology, Frontiers in Immunology and Frontiers in Pharmacology.
Goodyear: Rheumatology, Scientific Reports.
Barnett: Glia.
Willison: Nature Clinical Practice Neurology, Journal of Neuro Immunology, Clinical and Experimental Immunology.
S.Graham: Biochemical Society Transactions.
McLauchlan: Journal of Biological Chemistry.

Associate/Deputy Editors:
Basu: Arthritis and Rheumatology, BMJ Case Reports, BMC Rheumatology.
Maffia: Cardiovascular Research; Associate Editor, Pharmacological Research.
McInnes: Annals of Rheumatic Diseases.

Editor/Editor in Chief:
Maffia: Health Section, Frontiers for Young Minds.
McCulloch: Molecular and Biochemical Parasitology.
Sinkins: Viruses, Insect Molecular Biology, Tropical Medicine, Infectious Diseases.
Dominiczak: Hypertension.
Guzik: Cardiovascular Research.
Touyz: Clinical Science.
Baillie: Journal of Cell Signalling.
Stott: Age and Ageing.
Evans: British Journal of Cancer (clinical subjects).
Milling: Immunology.

4.1.4:Conference organisation.

Examples of UoA1 involvement in organising conferences and symposia of international significance include:

G.Graham: European Chemokine and Cell Migration Conferences 2015, 2017, 2019.
Willison: Centenary meeting for Guillain-Barre Syndrome.
McLauchlan: 25th International Symposium on Hepatitis C Virus and related viruses.
Basu: 18th and 20th International Vasculitis and ANCA Workshops.
Maizels: Parasitic Helminths, New Perspectives in Biology and Infection.
S.Graham: International Gap Junction Meeting, 2017.
Smith: ESC Working Group in Cardiac Cellular Electrophysiology Meeting 2017
Dominiczak/Touyz: European Society of Hypertension/International Society of Hypertension International meeting.
Edgar: The 7th International Molecular Mechanisms of Axon Degeneration Meeting 2019.
Maffia: Joint ASCEPT-BPS Scientific Meeting 2015 (Hong Kong); Joint BSCR/BAS/BCS Spring Meeting 2016, 2017.
Kohl: IMAV (International Meeting on Arboviruses), 2015, 2017.

4.1.5:Influencing policy.

Senior leaders across UoA1 have helped to develop national and international scientific and clinical policy in key strategic areas, including in the following roles:

McInnes: President, European League Against Rheumatism (EULAR).
Biankin: Executive Director, International Cancer Genome Consortium.
Sansom: Director, MRC-UKRI National Mouse Genetics Network.
S.Graham: Chair, Biochemical Society.
Dominiczak: Chair, Equality & Diversity Working Group, Medical, Dental and Veterinary School Councils (2016-2020); Vice President, Life Sciences, Royal Society of Edinburgh (2012–2015); President, European Society of Hypertension (2013-2015).
Davies: General Secretary of the Society for Endocrinology (2018-22).
MacLean: Vice-President, (Life Sciences) Royal Society of Edinburgh (2018-2021).
J.Petrie: Chair, Board of Trustees, Novo Nordisk UK Research Foundation (2017-).
Sinkins: Policy advice to Governments of Malaysia, Cambodia, Paraguay and Maldives on dengue control.
Smith: Vice President, President and past President, ESC Working Group in Cardiac Cellular Electrophysiology (2012-2018).
Stott: Chair, Association of Academics in Geriatric Medicine UK (2012-)
Touyz: President, International Society of Hypertension (ISH) (2014-2016); Chair, Women in Hypertension Research Programme, International Society of Hypertension (2016-2019); President,

European Council on Cardiovascular Research (ECCR) (2018-2020); Scientific Officer, Canadian Institutes of Health Research (2017).
Biankin, Evans: All-Party Parliamentary Group on Pancreatic Cancer 2014.
Touyz, MacLean, Padmanabhan: Cross-Party Parliamentary Group on Hypertension 2019.
Siebert, McInnes: Cross-party group, Arthritis and Musculoskeletal conditions.

4.1.6:Leadership for development of national and international resources.

External collaborations between UoA1 staff/institutes and other Institutions are extensive and include:

- **Immune-Mediated Inflammatory Disease Biobanks in the UK (IMID-Bio-UK)** led by UofG (**McInnes**, Director) and funded by MRC, brings together five universities (UofG, Queen Mary University London, Newcastle University, University of Manchester, University of Cambridge), four industry partners (Abbvie, Janssen, Novartis, Qiagen) and seven charities (British Sjögren's Syndrome Association, Lupus UK, National Rheumatoid Arthritis Society, PBC Foundation, Psoriasis Association, Use My Data, Versus Arthritis) to produce one single searchable and analysable dataset of eight immune-mediated inflammatory disease cohorts / tissue biobanks.
- **BT-Cure** was an Innovative Medicine Initiative (IMI)-funded research project (€35m) that aimed to develop new therapies for rheumatoid arthritis (RA), consisting of 38 (academic and industrial) partners from across Europe. **McInnes, Garside** and **Brewer** were members of this consortium.
- **RT-Cure (Rheuma Tolerance for Cure)** is a large, pan-European initiative funded by the IMI, consisting of 20 partners from academia, pharma and SMEs, working with patient research partners. Its main aim is to prevent RA or its progression by inhibiting the expansion of pathogenic autoimmune responses at early disease stages and to develop tools to monitor immune tolerance. UofG members (**Goodyear, McInnes, Garside and Brewer)** are involved in all this project's work packages and lead an exemplar clinical trial (ICoSRA).
- **The Scottish Early Rheumatoid Arthritis (SERA)** study, led by UofG **(McInnes),** is a Pan-Scotland inception cohort of RA and undifferentiated arthritis patients. It involves three Universities (Glasgow, Edinburgh, Aberdeen), all Scottish NHS boards, and collaboration with Wyeth and Pfizer. It has produced contemporary phenotypes and outcomes for early RA and facilitated the discovery of phenotypic and prognostic biomarkers.
- **ScOttish Psoriatic artHritis Observational Study (SOPHOS),** led by UofG **(Siebert),** this is a Pan-Scotland early cohort of PsA patients, involving three Universities (Glasgow, Edinburgh, Aberdeen) and all Scottish NHS boards. It has produced contemporary phenotypes and outcomes for early PsA and facilitated the discovery of phenotypic and prognostic biomarkers.
- **CRUK Grand Challenge** "Studying tumour metabolism from every angle" This team of 12 physicists, biologists, chemists, biochemists, technology innovators, and industry partners, led by National Physics Laboratory, includes **Sansom,** and will provide new insights into the molecular pathogenesis of tissue-specific cancers (with funding of £20m over 5 years).
- **The Translational Pharmacology Laboratory** is a CRUK Centre for Drug Development Biomarkers Centre of Excellence, embedded within UoA1, which supports pharmacodynamic studies within CRUK's Centre for Drug Development multi-centre early phase clinical trials.
- **PRECISION Panc (Biankin)** is a UK-wide, UoA1-led, initiative to accelerate pancreatic cancer treatment into the molecular age of oncology, such that biopsy and molecular phenotype-directed care and therapeutic development becomes routine clinical practice, enhancing scientific discovery and improving outcomes. It is supported by ~£10m from CRUK, ~ £4m from Celgene, and is a platform for other pharmaceutical and biotechnology companies to join.
- **Anti-Vec (Sinkins).** This UoA1-led network aims to facilitate the development and implementation of novel control strategies for vector-borne diseases of significant importance to human / animal health in LMICs. It has ~600 members in 68 Countries and was awarded ~£1.7m from GCRF/BBSRC, $700K from Open Philanthropy and has supported 11 pump-priming projects, meetings, training workshops and exchange visits.

4.2:CONTRIBUTION TO ECONOMY.

4.2.1:Industrial/Corporate Partnerships.

We place considerable importance on our interactions with industry and on the translation of our research discoveries, as reflected by 10% of our research income coming from commercial sources. Since 2014, UoA1 has sought to significantly enhance our interactions with industrial and corporate partners. These efforts are supported by the TRI initiative's opportunity audits (section 1.6.3) and by the development of industry space within our academic-clinical infrastructure at QEUH (section 3.4). Below, we describe specific examples of our substantive, mutually beneficial, interactions with industry.

4.2.1.1:Strategic alliances with:

- AstraZeneca to support a range of studies, including clinical trials of AstraZeneca compounds (e.g. CXCR2 inhibitors), initiated as a result of our basic research activities in the cancer immunology area. In addition, the UoA1's GLAZgo Discovery Centre (section 1.4.4) represents a joint UofG/AstraZeneca research initiative.
- UofG/Eli Lilly Research Centre (section 1.4.5), which is focused on identifying and validating first-in-class novel therapeutic targets for rheumatic diseases using near-patient approaches.

4.2.1.2:Partnership approach to therapeutic strategies:

- Global-industrial partnerships include those with AZ, Celgene, MiRagen, Novartis, Pfizer, and Genkyotex, which advance shared therapeutic strategies (**Baillie, MacLean, Touyz, Leiper, Mercer, Biankin, Evans**).
- UoA staff (**McMurray, Jund, Petrie(M), Lang, Mark, Petrie(J) Sattar**) have contributed strategic input and leadership to >15 multi-centre cardiovascular trials since 2014, involving major pharma collaborations (e.g.,Amgen, AstraZeneca, Bayer, BMS, GSK, Novartis, Servier, Boehringer Ingelheim, Novo Nordisk, SQ Innovations, Corvia, Medtronic).
- UoA staff have contributed leadership and collaborated on major clinical cohorts and clinical trials across immunopathogenesis (e.g., BMS, AZ, Lilly, Novartis, J&J, UCB, Oxford BioDynamics, MedAnnex, Istesso), building on our international reputation for near-patient studies.
- We have contributed to major, investigator-led musculoskeletal disease-focused pharma collaborations with UCB, BMS, Amgen (previously Celgene), Boehringer-Ingelheim, Janssen (**Siebert, Goodyear, McInnes**).
- Over the REF period, the clinical research performed by UoA1 clinical academics has generated £43.7m research income from industry partners.

4.2.2:Contribution to the local economy.

Working in partnership with NHSGG&C and Glasgow City Council, UofG's clinical innovation zone (CIZ) at QEUH currently supports ~70 commercial FTEs (and more broadly supports an additional ~230 academic and clinical FTEs) and has attracted SMEs locally and internationally, including from America, Germany and Singapore. The proximity of academic (**Dominiczak, Barrett**) and industry expertise (Bioclavis) within the NHS enabled the Lighthouse Lab in Glasgow (LLiG), one of the Government's national testing centres for Covid-19, to be rapidly developed and scaled up, resulting in ~650 new jobs in the region and new opportunities for skills development as LLiG grows.

4.3:CONTRIBUTION TO WIDER SOCIETY.

4.3.1:Partnering with international networks.

Through international and national collaborations with other cardiovascular research centres of excellence in Canada, USA and Europe, UofG has established an outstanding programme of vascular biomedicine, including a summer school for early career scientists. To further strengthen our vascular biomedicine strategy, our BHF CoE partnered with the Canadian Vascular Network (CVN), leading to new joint projects and three publications, two biennial international summer

schools, and the awarding of international grants (Canadian Institutes of Health Research (CIHR) (**Delles** (UofG)/Pilote (CVN).

4.3.2:Positioning Public and Patient Involvement (PPI) Partners as Influencers in Research & Education.

Patients can influence all stages of the cancer research pathway – from basic knowledge discovery to clinical trials and healthcare delivery – and can play a key role in education systems designed to reach broad audiences. As part of our strategy to progressively integrate PPI into key strategic UoA1 activities, we have worked with local PPI representatives on educational projects and platforms, making available to all the resulting PPI-led skills, knowledge, contribution and roles.

4.3.3:Development of online course 'Research Impact: Making a difference'.

With leadership from UoA1, this online course teaches how to identify and evidence research impact (www.futurelearn.com/courses/research-impact/6). It has run six times since 2018, with over 3,500 learners from across the globe, including ~30% from LMICs. Our PPI representative also teaches on this course, thus giving PPI equal prominence with the contributors from industry, NHS, Academia and public sector organisations. By embedding PPI as a core component of this course, we have increased awareness and education around PPI in the context of impact.

4.3.4:Interactions with LMICs.

UofG supports the 17 UN sustainable development goals. As such, it aims to engage with LMICs in a respectful 'do no harm' approach and to have strategic priorities on research partnerships, collaboration, education and recruitment. UofG's key strategic research collaborations, centres and partnerships with/in LMICs exemplify its role an 'agent for positive change and development', to promote further partnerships, support local capacity strengthening, and recruitment.

Educational projects: Much of the UoA's collaborations are with African countries, spanning education and research, such as the UoA1-led Beit-UofG Masters programme (**Garside**). This partnership with Beit Trust supports two students per year (from Malawi, Zambia or Zimbabwe) to undertake UofG Masters degrees, and is now in its second, five-year iteration. All previous students have gone on to PhD studies and/or employment, after obtaining merits or distinctions. In addition, the Wellcome-funded PhD programme (**Marti**) in Integrative Infection Biology offers two of its seven PhD scholarships per year specifically to African students.

MEBOP and AFRIBOP: The UoA-led annual AfrIBOP course has run for 5 years and hosts fellows from across Africa. The UoA also runs the Diploma in Tropical Medicine and Hygiene, which provides sponsored places for students from LMICs. Another example of the UoA's international educational involvement is its involvement in advanced training courses for students from geographic areas underserved for such opportunities. The Middle East Biology of Parasitism (meBOP) includes theoretical and hands-on lab training, taught by a team of international leading biologists. It has run annually since 2016 and trained >60 students, postdocs and early career group leaders from across the Middle East and Sub-Saharan Africa and has enhanced networking despite regional conflicts.

Significant research links: UoA1 has significant research links across Africa, including with Institutions in Uganda, Kenya and Malawi. During the Covid-19 pandemic, these links have enabled CVR staff to provide support for and to run projects with collaborators in: MRC/UVRI & LSHTM Uganda Research Unit/Makere in Uganda, KEMRI-Wellcome in Kenya, and the College of Medicine in Malawi (**Robertson** funded by Wellcome Trust). These projects build on partnerships sustained over the years (for example, **Cotton** has a joint position at CVR and the MRC/UVRI & LSHTM Uganda Research Unit). In another example, research on mosquito symbionts for disease control (**Sinkins**) includes a partnership with *icipe* (International centre of insect physiology and ecology) in Kenya on *Anopheles* mosquitoes and malaria transmission-blocking, leading to recent awards of $3.1m to UofG and $2.2m to *icipe* from Open Philanthropy. **Delles** and **Maffia** are also leading a relationship with the African Research Universities Alliance (ARUA), which has led to the

establishment of the ARUA Non-Communicable Disease Centre of Excellence, funded by UKRI for £2m.

Other productive research and teaching collaborations involve institutions in South Africa. **M.Petrie** works with collaborators at the University of Cape Town on peripartum cardiac disease; **Delles,** with the MRC group on hypertension at North-West University; and **Touyz** is the Carnegie visiting professor at the University of Witwatersrand.

Beyond Africa, UoA1 researchers are working towards projects for dengue virus control using *Wolbachia* symbionts in Malaysia, Maldives, Paraguay and Cambodia.

On the ground capabilities: The Blantyre-Blantyre project (**Garside**), a collaboration between UofG and the College of Medicine of the University of Malawi (UNIMA), is funded by Scottish Government International Development, World Bank and Wellcome Trust (total, £1m) and aims to strengthen laboratory capacity in Malawi and to study multimorbidity. It brings together colleagues with expertise in non-communicable disease with those with expertise in infectious disease (building on WCIP's long-term engagement with endemic countries). **Ho** has worked with the Malawi Ministry of Health to set up national influenza surveillance and has conducted a prospective cohort study on SARS-CoV-2 exposure in Blantyre, Malawi, which generated the first data demonstrating a high prevalence of asymptomatic infection in this country.

4.4:HONOURS AND AWARDS RESOGNISING OUR CONTRIBUTIONS AND ACHIEVEMENTS.

Prestigious fellowships: We have been recipients of numerous prestigious fellowships, including 14 Fellows of the Academy of Medical Sciences, 20 Fellows of the Royal Society of Edinburgh, and 6 Wolfson Research Merit awards.

National Queen's honours: We have also been recognised in the Queen's honours list, including **Dominiczak** (DBE), **Vousden** and **McInnes** (CBEs) and **Delles** (MBEs) and **Neil, Liew** and **Thomson** (OBE).

Major International awards of research excellence: McMurray (Gold Medal, European Society of Cardiology), **Touyz** (Hypertension Research Excellence Award, American Heart Association), **Sattar** (Camillo Golgi Prize from the European Association for the Study of Diabetes).