Institution: University of Strathclyde
Unit of Assessment: 3
1. Unit context and structure, research and impact strategy

1.1. Achievement of strategic aims for research and impact

The University of Strathclyde is a research-intensive technological university, still true to its founding principle as *A Place of Useful Learning*, focused on the translation of research outcomes for the benefit of society as a whole. The University strategy, 2014-2020, had seven Strategic Research Themes to meet complex contemporary challenges, for which multidisciplinarity is essential. *Health & Wellbeing* is one of these University themes and is central to the work of this Unit of Assessment (UOA) whose collaborative nature is shown by its composition. In this UOA are the Strathclyde Institute of Pharmacy & Biomedical Sciences, the School of Psychological Sciences & Health and key research groups in the Departments of Mathematics & Statistics and Computer & Information Sciences.

Collectively our primary strategic aim for research and impact is to turn outstanding academic activity – documented in our research output – into benefits for health and wellbeing globally, by working with strategic partners, nationally and internationally.

Health is not simply an absence of illness, but a state of complete physical, mental and social wellbeing. Research to solve wide ranging problems necessarily requires a multidisciplinary approach, from genomics, cells and biological systems to individual and population health and wellbeing, examining physical and mental health socially and personally. Strathclyde excels in all of these.

Research within this multidisciplinary UOA is organised strategically into three themes: *Health Care & Data Systems*; *Health Behaviours & Interventions*; *Medicines, Therapies & Diagnostics*. All that we do can be understood under these headings. Each theme contains three research groups – details are in Section 1.3.

Achievement of our strategic aims is dependent on the generation of new knowledge within these three themes providing foundations upon which impact is built. Our impact case studies highlight this. From *Health Care & Data Systems*, three cases explain how we are improving patient care and changing policy and practice, nationally and internationally, by creating new antibiotic guidelines, establishing safer use of high-risk medicines and changing cervical screening policies. In *Health Behaviours & Interventions* we are tackling the increased prevalence of obesity through the creation of new global and national guidelines for its prevention. The impact cases in *Medicines, Therapies & Diagnostics* cover improvements in industrial processes associated with the design, synthesis and formulation of pharmaceuticals using continuous processing and advanced manufacturing technology, while mass screening and detection of bacteria and toxins in food addresses an unsung global problem: the WHO estimates that 600 million people per year fall ill, and 420,000 die, after eating contaminated food. Drug discovery is also part of our impact: we describe the creation of a new class of anti-infective drugs, now in the last stages of clinical trials.

Research and impact in relation to global health challenges from this UOA goes much further. Its multidisciplinarity is shown by the fact that the underpinning research for the case studies crosses three of Strathclyde's four Faculties: Science, Humanities & Social Sciences, and Engineering. The full set of Faculties is completed by work in collaboration with the Strathclyde Business School on

the automation of the storage and distribution of medicines in hospital and community pharmacy settings. This research in *Health Care & Data Systems* has continued for over a decade, helping to create a centralised robotic Pharmacy Distribution Centre that has replaced 11 in-hospital pharmacy stores in NHS Greater Glasgow & Clyde. In *Health Behaviours & Interventions* we highlight a different approach to patient care: the development and testing of Emotion Focused Therapy. Since 2013 our research has informed mental health policy and enhanced counselling and psychotherapy practice globally through accredited training standards: there are now accredited therapists in 28 countries. This person-centred approach is reflected also in research that has shaped the Suicide & Self-Harm Reduction Strategy in Scotland. In contrast again, in *Medicines, Therapies & Diagnostics* the work of the long-established Cancer Research UK Formulation (CRUK) Unit is important for developing anti-cancer drugs suitable for Phase I and II clinical trials. It was very positively assessed by a CRUK site visit in 2019 and recommended for continued support to 2025, with a total commitment of £9.3M, including funding for 22 full time equivalent (FTE) staff and an extra £500K for 3 PhD studentships, helping maintain the pipeline of high quality academic publications. In this theme we also have the EPSRC Centre for Continuous Manufacturing & Advanced Crystallisation (CMAC), created to revolutionise pharmaceutical manufacture; it provides one of our case studies. It operates in close collaboration with industry and in 2016 CMAC and the University of Strathclyde were the first academic institution to win an award from the International Society for Pharmaceutical Engineering Facility of the Year Awards programme. The award highlighted that students working with such technology and in such a collaborative environment will be the pipeline for the pharmaceutical professionals of the future.

These examples showcase how we are achieving our strategic aims for research and impact using a carefully thought-out research structure. Within this, impact is considered, supported and prioritised by involvement of end users at the initiation of project planning and throughout research and impact generation. This is achieved through the embedding of industry partners, medical practitioners and end users within research groups. Occasions where impact is not explicitly planned but arises from basic research may take longer but are equally well supported. Because the University as a whole is focused on the translation of research outcomes for the widest benefit, there are mechanisms in place to help staff steer a pathway to impact. These are unpacked fully in later Sections.

1.2. Future strategic aims and goals for research and impact

In REF2014 we identified support for cross-Faculty developments, creating new initiatives, expanding internationalisation and increasing external relationships as priorities for the coming years. The 2014-2020 overarching University strategy clarified and rationalized how we approach Health & Wellbeing. For example, in REF 2014 the Department of Biomedical Engineering was best positioned in UOA3 but is now in UOA12 (Engineering) while new research groups in the Departments of Computer & Information Sciences and Mathematics & Statistics are well-suited to UOA3. Changed intra-university demography has created a better focused approach for this UOA. We continue to give proper consideration to health and wellbeing across the lifespan, from problems of childhood obesity, through young people's mental health and suicide prevention, to the diseases of old age, whether cardiovascular, metabolic or neurological. Our strategy for health and wellbeing will stay committed to the delivery of diagnostic and treatment solutions together with preventative measures, all set in a context that recognises health not just as the absence of illness, but a state of physical, mental and social wellbeing that must be actively maintained. **As such, our future strategic aims and goals are to develop, in partnership with industry and health care providers, solutions for major problems of health and wellbeing.** High quality academic research, evidenced by publications and informed by end-users, is the foundation for our ability to translate new knowledge into practical benefit.

In support of our strategic ambition to translate research outcomes into global benefit, we established new strategic initiatives that support research and impact to help partners in industry, the NHS and patient groups. In all our endeavours interdisciplinary research is vital – research into Health & Wellbeing is a global task, rarely falling neatly into one academic discipline. Examples of large scale initiatives already underway and which will deliver future strategic benefit are:

Health & Care Futures (H&CF) Created in 2019, the ambition is to contribute towards the improvement of a range of health-related outcomes through academic activities and in collaboration with health and care professionals. These include improving health service outcomes through more effective and efficient delivery; better patient-centred outcomes, improving the experience of health services; and better care-provider outcomes through enhanced leadership training, improved managerial competence and confidence, updating skills and knowledge and building personal resilience. Nationally, the focus is on the NHS but there is global relevance. H&CF has three areas of activity: Future Medicines, Future Technologies (led from this UOA) and Data Driven Health & Care and Future Organisation. It plays into each of the UOA research themes but with particular relevance to *Health Care & Data Systems*. Collaborators include NHS Lanarkshire, NHS Ayrshire & Arran, NHS Greater Glasgow & Clyde (focusing on children's services), the National Golden Jubilee Hospital in Glasgow, North Lanarkshire Council, Aberdeen City Council and NHS Education for Scotland. The 9-strong Executive for Health & Care Futures is led by Maguire as Convenor and includes MacLean, Watson and Boyd; Bennie, Boyter and Grealy serve on the 25-strong Leadership team.

Health Data Research UK is a national federated institute across 31 locations, established in 2016 with a 20 year vision for large scale data and advanced analytics to benefit patient interactions, clinical trials and biomedical discovery and enhance public health cross the UK. It has an initial £54M partnership investment over five years from the MRC, the British Heart Foundation, Chief Scientist Office (Scotland), EPSRC, ESRC, Health & Care Research Wales, National Institute of Health Research (England) and The Wellcome Trust. It is a successor to the Farr Institute, which was established in 2013 as a UK-wide institute to develop and deliver data science for health. Led by Professor Marion Bennie from this UOA, Strathclyde was a critical part of the Scottish centre, leading the gathering, curating and use of real-world national data on medicines for Scotland. This enabled records linkage for studying the benefits and risks of medicines in routine clinical practice. Outputs from the Strathclyde team included the development of a natural language processing algorithm to prepare structured outputs from free-text dose instructions (estimated at 100 million items annually). Available for research use through a national platform, it is used to drive health system quality improvement programmes. To continue this work, staff from this UOA (*Health Care & Data Systems*) who were heavily involved in Farr will continue to engage with Health Data Research UK, which partners the five Scottish medical schools and Strathclyde; the Associate Director is Bennie whose continuing involvement is mission critical.

The Digital Health & Care Institute (DHI), established at Strathclyde in 2016, is part of the Scottish Funding Council's Innovation Centre Programme to support transformational collaborations in the delivery of health and care. The University of Strathclyde hosts it, with Glasgow School of Art as partners. DHI works closely with NHS Scotland and the Scottish Government. It has an independent Board and CEO, Professor George Crooks, who is also a member of the Health & Care Futures Executive. DHI operates within a governance framework supported by the University. The institute was established to deliver on initiatives in connected health, meeting patient needs by having individuals fully engaged in self-tracking biological, physical, behavioural and environmental information, using wearable technology to track and analyse weight, energy, mood, sleep quality, cognitive performance and exercise. Current priorities cover cancer, cardiovascular disease, chronic respiratory disease, diabetes, healthy ageing and mental health. The *Health Care & Data Systems* research theme in this UOA has multiple links with DHI and *Medicines, Therapies & Diagnostics*

research has broad collaboration with DHI on the VALMED project, sponsored by the pharmaceutical industry, to explore new digital solutions to understand better the value of medicines. DHI submits funding proposals with this UOA, most recently in the Cancer Medicines Outcome Programme, concerning phase 1 development of prototype digital solutions for collecting PROMS (Patient Reported Outcome Measures) for cancer medicines treatments.

Health Technologies Cluster. Scotland's Innovation Districts are industry facing and complement initiatives focused on the NHS. The University stimulated and anchors the Glasgow City Innovation District. To enable effective access to Strathclyde's research, six new Clusters were formed within this District. One such cluster is Health Technologies, established in 2018 and focused on digitally enabled patients using medical devices for monitoring and diagnostics that will help transform our health services. It is central to the work of *Health Care & Data Systems* theme in this UOA. The Cluster provides a collaborative centre for a range of organisations including pharma, medical diagnostics, sensor/monitoring and technology companies. An embedded development currently in planning is a Living Lab to provide physical and virtual platforms for collaborative citizen science. It will benefit all this UOA's research themes, but especially *Health Behaviours & Interventions* and *Health Care & Data Systems*. It will be located within a second Technology & Innovation Centre (TIC2) in the next REF period. Plans exist for a data lake, a virtual reality lab, and highly flexible lab spaces conceived and developed for use by various groups, such as the Digital Health & Care Institute, patient groups, the Age Friendly Academy and other networks. We are engaging over 2000 citizens, industry partners and clinical and academic researchers to co-create a facility to work on real-world health issues.

Medicines Manufacturing Innovation Centre. The success of the award winning EPSRC Centre for Continuous Manufacturing & Advanced Crystallisation (CMAC), a core element of the *Medicines, Therapies & Diagnostics* research theme, stimulated the launch in 2018 of the state-of-the-art Medicines Manufacturing Innovation Centre (MMIC). MMIC is a £56M project under construction in Renfrewshire and owned by the Centre for Process Innovation with Strathclyde as the strategic partner university. MMIC was funded initially by founding partner companies AstraZeneca and GSK (£7M each), Innovate UK (£13M through the UK Industrial Strategy Challenge Fund) and Scottish Enterprise (£15M). CMAC is supporting MMIC by providing a pipeline of research outcomes that have been proven at up to Technology Readiness Levels 4-5. MMIC, operating at higher technology-readiness-levels as a GMP facility, will ensure the UK is a technology and innovation leader in continuous pharmaceutical manufacturing.

1.2. The structure of the unit and its relation to future strategic aims

Structurally, the major foundations of this UOA are in the Strathclyde Institute of Pharmacy & Biomedical Sciences (SIPBS) and the School of Psychological Sciences & Health (PSH). The UOA also includes research from the Digital Health & Wellness Group in the Department of Computing & Information Science and the Health Statistics & Modelling Group in the Department of Mathematics & Statistics. Moreover, because of its cross-cutting nature, health-related research and impact appears in other UOAs with which members of UOA3 collaborate. For example, biomedical engineering (which in 2014 was in UOA3) has multiple interactions, notably under Health Behaviours & Interventions, developing rehabilitation programmes and devices for stroke patients.

The creation of dedicated research groups enables us to build on our strengths, maximise efficiency, and avoids dissipating effort. How the research groups relate to our research themes is shown in Table 1. All research groups have focus and critical mass: the FTE data in Table 1 relates only to academic staff and does not include research staff and doctoral students, technical staff and honorary staff or external collaborators working within groups. Critical mass enables sustained delivery of excellent research for practical benefit within and beyond academia.

Table 1: Research Groups in the UOA – Total FTE: 90.4.

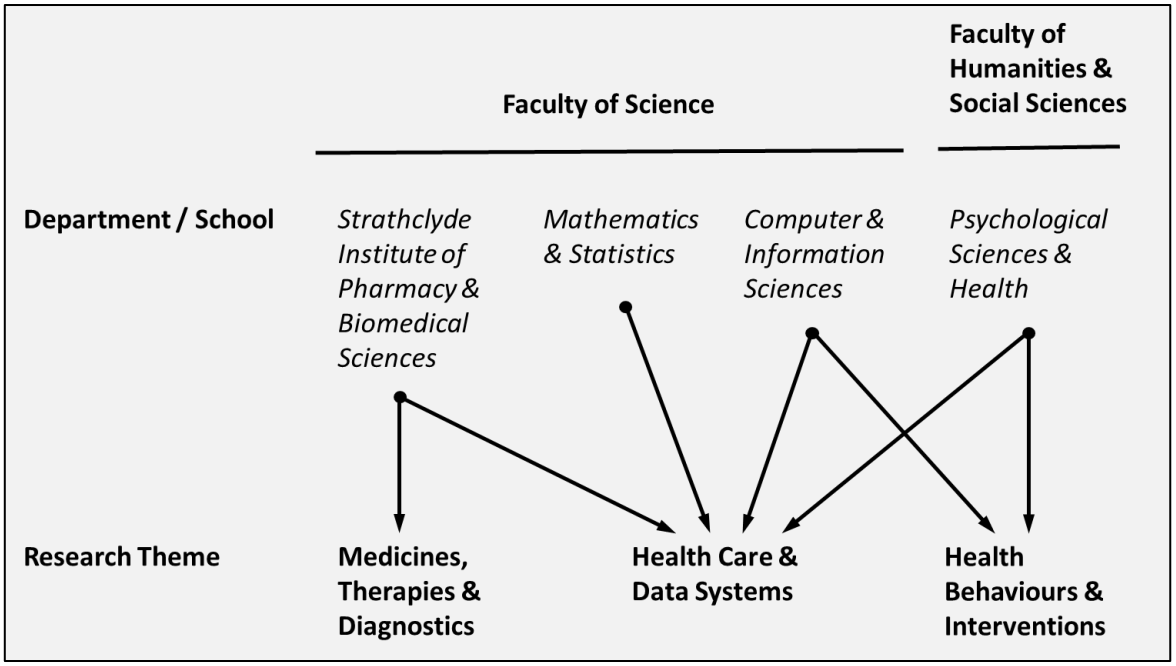
Theme	Core Research Groups	Headline rationale: research into …	FTE
HEALTH, CARE & DATA SYSTEMS	**Digital Health & Wellness**	… digital health interventions, evaluated and co-designed with citizens and industry to deliver health and social care solutions.	3.0
	Health Statistics & Modelling	… public health epidemiology in particular regarding infectious diseases, with strong links to Health Protection Scotland.	2.4
	Pharmacoepidemiology & Health Care	… person-centred, safe, effective medicines use & public health improvement: practical health informatics.	4.4
HEALTH BEHAVIORS & INTERVENTIONS	**Physical Activity for Health**	… development of interventions to encourage lifelong participation in more physical activity, less sedentary behaviour.	5.2
	Psychology & Counselling	… health behaviour change, cognition & neuropsychology; development of counselling for client well-being.	17.6
	Speech & Language Therapy	… theoretical understanding of speech & language to develop new approaches for patients and service delivery.	4.0
MEDICINES, THERAPIES & DIAGNOSTICS	**Cellular Basis of Disease**	… molecular & cell biology: cardiovascular & metabolic diseases; inflammation; cancer; neurology & mental health.	25.6
	Microbiology & Industrial Biotechnology	… basic microbiology with outcomes in antimicrobial resistance, novel therapies, drug targets & vaccine development.	9.0
	Pharmaceutical Sciences	… drug discovery, formulation & delivery, including nanomedicines; manufacture and materials, crystallization & particulates.	19.2

Alongside existing groups are the major new national and university initiatives outlined above (Section 1.2). These developments align and integrate with our research groups, encouraging production of demand-led research. Progress in all of the current groups and new initiatives is regularly monitored and supported. We will continue making strategic decisions to tailor the capability and capacity of research groups for maximum effectiveness in generating quality academic outputs supported by a diversified income portfolio and enabling impact. The structure of the unit and its future strategic aims necessarily depend on our people strategy, which encourages the most talented scientists to work here. Targeted recruitment enables us to reinforce areas of strength, while opportunistic recruitment can both reinforce what exists and initiate new areas of activity.

1.3. How the future strategic aims will be taken forward

Management and decision making operates through a layered architecture. Overarching strategy is set by the University Executive Team, chaired by the Principal. Institutional initiatives such as Health & Care Futures and the Health Technology Cluster ensure the success of inter-disciplinary research and impact into external organisations. Managerial and administrative responsibilities are cascaded through the University. Figure 1 shows how this relates to the UOA research themes.

Figure 1: Faculties, Departments & Schools and the UOA research themes.



It is important to know that the Faculty of Science and the Faculty of Humanities & Social Sciences are structured slightly differently (which is why the former has Departments and the latter, Schools). Nevertheless, each Faculty has an Executive Dean supported by Vice-Deans holding targeted responsibilities in research and in knowledge exchange. Faculty management teams and associated committee structures back this work. Likewise, Departments and Schools have a Head with overall responsibility, supported by internally appointed directors of research and knowledge exchange, and an internal committee structure.

The organisational layered architecture means that the individual Departments and Schools operate within a strategic framework but have autonomy to exercise professional judgement about the specifics of research and impact. Contained within the overarching strategy, local decisions are made about the formation of research groups, enabling a nimbleness of operation, sensitive to University plans, new developments in academic and professional disciplines as well as national and global needs. Decisions about investment, whether in new staff, infrastructure or facilities, are made strategically, local decision making reinforced by Faculties and University, dependent on the scale of the decision at hand. Fundamentally, people are central to everything. In whichever Department or School an individual researcher is line-managed, their performance is critical to the achievement of the strategic aims in each of our three research themes. How they are supported to deliver research and impact is described fully in Section 2.

Future scoping is essential for taking forward aims that are achievable and valuable. The initiatives already described in this statement were not developed capriciously but with careful scoping. They balance existing staff capabilities that can be built on; the needs and priorities of external agencies,

including the Government, NHS and industry; and necessarily, funding opportunities through diverse streams, including UKRI, third sector grants, industrial sponsorship international agencies and the opportunity to leverage matched funding from multiple sources.

The mechanisms for scoping are multidimensional: individual members of staff and research groups, Faculties, University Executive and professional services are all alert to opportunities to grow the contributions and impact of the UOA. There are mechanisms for regular and meaningful consultation with the NHS and external partner organisations. For example, an NHS/University Joint Board in Pharmacy meets quarterly, enabling discussion with NHS Directors of Pharmacy and senior representatives of Community Pharmacy Scotland. Consultation with industry is likewise embedded at every level. For example, the CMAC management team is supported by an Industry Supervisory Board and benefits from having a full time industrial director.

1.4. How we work: research integrity, open science, equality, diversity & inclusion

Research integrity is essential in the pursuit of excellence. The University is committed to the UUK *Concordat to Support Research Integrity,* demonstrated through the University *Research Code of Practice,* supplemented by a *Policy and Code of Practice for Postgraduate Research Study*. It supports guidance and training to nurture a culture that embraces honesty, rigour, transparency and open communication, and care and respect. We expect the highest standards of our staff, but research integrity is not simply assumed. Policies and practices are documented in annually updated *Research Integrity Statements* and training courses are provided by the Organisational Staff Development Unit (OSDU) for early-career (including postdoctoral researchers, research fellows and research assistants), mid-career and established academics Courses in research integrity are not once-in-a-lifetime: staff are expected to maintain professional competency throughout their career. Despite this, regrettably, misconduct occasionally happens. The UOA and University take seriously all allegations and investigate them using the confidential process described in the *Research Code of Practice*.

Research Ethics is mission critical because of our work with human participants and *in vivo* research with laboratory animals. Research ethics is covered by two University processes, one for human participants, one for *in vivo* research. Work with the NHS is dealt with through the NHS Integrated Research Application System (IRAS) – once NHS approval is agreed, the Convenor of the University Ethics Committee normally endorses the application for the University. Research with human participants is based on three key principles: respect for persons (for example, there must be fully informed consent); beneficence (that is, avoid harm, benefits must outweigh risks, and risks must, as far as possible, be understood and minimised); and justice (for example, there should be a fair selection of participants and a fair distribution of benefits and burdens). The University Ethics Committee has overall responsibility but operates a devolved structure. SIPBS, PSH, CIS and M&S have local ethics committees acting independently within agreed parameters, with their decision making monitored centrally. University Ethics Committee membership includes academic staff from all four Faculties and experts from outside the University. The chair is an Emeritus Professor remote from the day-to-day working of the University. Committees in Departments and Schools are staffed only by academic members. The University *Code of Practice on Investigations Involving Human Beings* (now in its eighth edition) guides both the University and local committees.

Research using living animals is regulated by the UK Home Office under the Animals (Scientific Procedures) Act 1986. It prescribes a statutory Animal Welfare & Ethical Review Body whose membership includes academic and technical staff as well as external members. It has a remit to advise staff, review applications, monitor activity and report on animal welfare. It undertakes critical assessment of all Project Licence applications assessing *inter alia* the scientific benefit of the work weighed against the cost to the animals, the application in the proposed work of the 3Rs (Reduction,

Refinement and Replacement) and the facilities and expertise available. The commitment of staff in this UOA to good principles is shown by their winning competitive funding from the National Centre for the Replacement, Refinement & Reduction of Animals in Research (13 grants, total >£220K). It highlights our commitment to undertaking the animal research essential for translational studies by continuously improving practice and reducing animal numbers.

Data protection: The University in all its activities complies with the General Data Protection Regulations. The Information Governance Unit manages this, providing advice and guidance to all staff. Issues relating to this are also addressed by the University Ethics Committee. Review of applications to undertake research in which people are the participants always considers, *inter alia*, issues of anonymity, data sharing and secure data storage.

Open science: The UOA supports and values openness. Open access publishing is inherent to and essential for our research culture, making research findings and ideas as open as possible to as wide an audience as we can. We are fully compliant with Open Access requirements, facilitated by the University's Open Access Service, which provides support, advice, advocacy and training, including publishing using Green and Gold Open Access routes. The Service administers the UKRI Gold fund for payment of processing charges, and the Charity Open Access Fund. Researchers in this UOA follow funders' guidance on the creation of Data Management Plans. Information about staff and their work is freely available through our centralised management system (PURE).

Equality, diversity & inclusion: Principles governing research integrity, ethics and openness would be undermined if we failed to treat staff themselves with dignity and respect. Having integrity with regard to research ideas and products without integrity in regard to each other would simply be wrong. The University acknowledges that students and staff bring different cultures, lifestyles, experience, ideas and knowledge to the learning, research and working environment. We are committed to providing an environment where students, staff, visitors and contractors are treated with dignity and respect, the principles of which are captured in the Dignity & Respect policy. A comprehensive review of equality, diversity and inclusion is in Section 2.4.

2. People

2.1. UOA Staffing strategy

Critical for continued good performance is a recruitment strategy that encourages the most talented scientists to work at Strathclyde. Targeted recruitment enables us to reinforce areas of strength, while opportunistic recruitment both reinforces what exists and initiates new areas of activity. As well as appointing staff to routinely advertised positions there are two schemes for attracting candidates. The Strathclyde Global Talent Programme (GTP) attracts senior academic leaders who can immediately develop impactful research at scale. The Chancellor's Fellowship scheme recruits early career academics who are mentored and developed within a training and support programme that allows them to progress as part of a diverse and inclusive cohort of future leaders. Fellowships last for five years, initially focused on research with teaching and citizenship tapering in over time. Subject to satisfactory performance, Chancellor's Fellows can expect to translate to tenured senior lectureships at the conclusion of their award.

Table 2 shows the numbers of staff, segmented by gender, appointed into different staff categories. The gender balance favours female appointments not through positive discrimination but by inclusive advertising and appointment procedures. Over this REF period we have recruited staff from other Scottish universities, UK universities (including Aston, Bath, Birmingham, Bristol, Cambridge and Surrey) and internationally (including the Charité Universitätsmedizin in Berlin, University of Helsinki and Yale University). Reinforcing success and recruiting into areas of identified need have

consolidated our existing research strengths. These appointments have helped a continuing uplift in research performance. For example, one of the UOA's most successful EU grant winners is Professor Yvonne Perrie, a GTP appointment. The output of PHA-ST-TRAIN-VAC, a €1.06M EU Innovative Training Network, partnered with GlaxoSmithKline and managed by Strathclyde, developed key understanding on formulation and manufacture of mRNA vaccines. We have been early investigators and promoters of this technology, paving the way for development of lipid nanoparticle based vaccines. Perrie contributed her expertise to the UK Government vaccine task-force and into the MHRA COVID-19 Vaccines Benefit Risk Expert Working Group.

Table 2: New appointments during the REF period by gender (F female, M male)

Staff category	SIPBS	PSH	HSM	DHW	UOA3
Chancellor's Fellows	6F:7M	4F:0M	2F	0	**12F:7M**
GTP Professor	4F:1M	2M	0	0	**4F:3M**
Professor	1M	0	0	1F	**1F:1M**
Lecturer/Senior lecturer	1F:3M	6F:2M	1M	1F:1M	**8F:7M**

DHW: Digital Health & Wellness research group (Computer & Information Sciences)
HSM: Health Statistics & Modelling research group (Mathematics & Statistics)
PSH: School of Psychological Sciences & Health
SIPBS: Strathclyde Institute of Pharmacy & Biomedical Sciences

2.2. UOA Staff development

All staff are supported in their career development. It begins with a staff induction programme tailored to job families and continues through mentoring and the annual Accountability & Development Review (ADR). The ADR at Strathclyde includes everyone, regardless of location, job family or contract status. It uses current best practices of organisational management. This includes setting objectives for the coming year aligned with the values of the organisation (*Bold, Collaborative, Ambitious, People-Oriented, Innovative*). Reviewees are coached by their reviewer to ensure that they set SMART (*Specific, Measurable, Actionable, Realistic, Timebound*) objectives for research, teaching and knowledge exchange, and for their professional development. This last objective is often challenging, but vitally important because it gives all staff a genuine opportunity to reflect on aspects of their career that they want to enhance, at whatever point on their career journey they find themselves. Development activities may include advice on opportunities within the UOA, the University or externally. Table 3 lists some of the external programmes staff attended.

Staff are positively encouraged to engage with the training available through in-house schemes like the Faculty grant-writing challenge (with peer support and structured deadlines for grant writing) and courses offered by the Organisational & Staff Development Unit (OSDU).

OSDU offers multiple courses to support and develop all categories of staff. Two are of particular interest. SPARK is Strathclyde's Programme for Academic practice, Researcher Development & Knowledge Exchange. It is designed to provide staff from across each of the University's job families with flexible, individualised, and progressive routes for personal and professional development. This can lead to a postgraduate certificate (PGCert) and collection of 30 or more SPARK credits may also be a probationary requirement for some new staff. Various pathways offer classes aligned to each of the University's academic professional job families: Learning & Teaching in Higher Education,

Academic Practice, and Research & Knowledge Exchange. SPIRAL is the Strathclyde Programme in Research And Leadership. It aims to improve research performance, increase research income, grow our postgraduate population, build strong external links, internationally, with academic partners, business, government and the third sector in order to advance our impact. Since 2015, the UOA has had 764 staff attendances at courses organised through the SPIRAL and SPARK programmes, STEP (the Strathclyde Teaching Excellence Programme) and the Researchers' Development Programme. Of special note is that material from the Grantmanship Training Program was converted by two members of the UOA and translated into a bespoke University-wide course Research Bidding & Design: Getting Started. This has been organised by OSDU from 2017 for all University staff; to date, 51 UOA staff have attended it, including 8 early career researchers. The course was online during lockdown to support those working remotely.

Table 3: External courses attended by UOA3 staff, 2014-2021

Activity	N	Notes
Advance HE Aurora programme	8	*University has 5-6 funded places each year.*
EMBO New PI / Lab Leadership Course	2	*Residential Programme, Heidelberg, Germany*
European Crucible	2	*24 professionals selected across Scotland)*
Grantmanship Training Program	1	*The Grantmanship Center, Louisville, USA*
Homeward Bound	4	*International women in science leadership program. ~80 participants selected globally each year by peer-review*
Ingenious Woman Programme	2	*SFC: 3 residential workshops for women in STEM*
RSE Young Academy of Scotland	5	*Professionals (~50) from all sectors across Scotland.*
Scottish Crucible	2	*~30 professionals selected across Scotland*
Strategic Women in Leadership	1	*Residential Programme in Johannesburg hosted by Wits & Milpark Business Schools*
SULSA Early Career Research	2	*Scottish Pooling initiative*
SULSA Leaders Fund	3	*Scottish Pooling initiative*
Winston Churchill Memorial Fellowship	1	*Secondment abroad to share global learning across the UK. 150 Fellowships / year.*

Another important pillar of our approach to staff development, also operated though OSDU, is to encourage staff to engage with the University mentoring scheme: Mentoring@Strathclyde. This matches a person with relevant experience to another who will benefit from it, through regular mentor/mentee meetings: 46 UOA staff have been mentors and 28 mentored. Within the UOA we also provide local mentoring to all staff. For example, a New Leader's Academy was established in the Faculty of Humanities & Social Sciences in 2018 to deliver training and peer-support for career

development, promotion, and leadership for early career and mid-career staff, which has benefited the PSH staff in this UOA.

While recognising the importance of development opportunities for all staff, regardless of job family or career stage, careful attention is paid particularly to early career researchers. This category includes those appointed to Faculty positions, including first time lecturers and Strathclyde Chancellors' Fellows, but also postdoctoral research associates on fixed term contracts. The University fully supports the UK *Concordat to Support the Career Development of Researchers* to improve the employment and support for researchers and research careers. Strathclyde has held the EU HR Excellence in Research Award since 2011 in recognition of its commitment to supporting the personal, professional and career development of its researchers. Early career researchers are supported by the ADR, mentoring and the availability of a rich diversity of training programmes run by OSDU. Within the UOA, they also have opportunities to engage with research supervision by working with undergraduate and Masters project students and by helping training doctoral students, all with supervised oversight. Early career researchers are encouraged strongly to present their research to the academic community within the University, and national and international conferences. Grant-writing challenges within the UOA also benefit early career researchers, for whom winning their first grant is an important career step.

Staff development also extends to the support given to new appointees: we recognise that new staff need resources to establish their work. Newly appointed Chancellor's Fellows and GTP Professors are prioritised for internal PhD studentship schemes and supported consumables budgets, targeted equipment purchases, and reduced teaching and administrative loads for an initial period of their appointment. Start-up funds (automatically £10K for Chancellor's Fellows, £25K for GTP Professors) from internal resources are also available and matched funding can be made available to help purchase expensive new items of kit. Major investment to support new staff in this UOA has included new mass spectrometry and HPLC facilities. To strengthen research teams, new professorial appointments have been supported by recruitment of additional lecturers. For example Dr Lian Tian joined from Queen's University in Canada to reinforce new initiatives in cardiovascular science generated by the appointment of Professor Mandy MacLean as a GTP in *Medicines, Therapies & Diagnostics*. Likewise when Professor Roma Maguire was recruited from the University of Surrey to work in *Health Care & Data Systems*, two other permanent staff transferred with her.

Promotion is a key discussion point at ADR and anyone suitable for promotion is highlighted by the reviewer, especially to encourage those who may have shown reluctance to put themselves forward. Equity in promotion is a high priority. Promotion workshops are held twice per year, with a special care to make sure that potentially under-represented groups are fully involved. All staff are mentored through the promotion process, which uses clear and open performance criteria. In addition, exceptional performance of staff at all levels is recognised through an annual Contribution Pay programme, rewarding staff through salary increases or one-off payments. Professorial staff can also continue to advance. The University operates a Professorial-zoning system (zones 1 to 4). Post ADR, promotion between zones may be recommended by University's Senior Academic Review & Development panel. Table 4 shows the numbers of men and women promoted in the UOA since 2014. Promotion to Professor is the only category in which men outnumber women (in contrast to our new appointments: see Table 2). There is a pipeline for gender balance in all promotion categories.

Table 4: Promotion during the current REF period.

Promotion	Women (N)	Men (N)
Chancellor's Fellow to Senior Lecturer	6	2
Lecturer to Senior Lecturer	8	6
Senior Lecturer to Reader	4	2
Reader to Professor	1	3
Professorial zoning		
One to Two	0	2
Two to Three	1	1
Three to Four	0	1
TOTAL	**20**	**17**

2.3. Support mechanisms and evidence of training and supervision of PGR students

We are a developer of elite talent with a thriving international postgraduate community spread throughout the UOA. 417 PGR students (Doctoral and Masters-by-Research) were enrolled during the current REF period and 286 graduated with a PhD.

Funding for studentships comes from a variety of sources, including UKRI, charities and industry. Some funding comes through UKRI funded Doctoral Training Centres (Table 5) supporting an area of excellent research in which numerous supervisors and students work. Other funding is won by individual members of staff to drive a specific project in their area of expertise. UKRI DTCs have researcher development built in, while some independent funders have their own residential researcher development events (Medical Research Scotland for example). Critically, no student is left without support, whether from their DTC, independent funder, University or within the UOA. Valuable peer-to-peer support, interdisciplinary training, mentoring and good role models establish positive norms and expectations for all students.

Table 5: Externally funded Doctoral Training Centres

Funder	Name	Start	End
EPSRC	Applications of Next Generation Accelerators	2011	2018
EPSRC / MRC	OPTIMA Optical Medical Imaging	2014	2023
EPSRC	Medical Devices & Health Technologies	2003	2022
EPSRC	Continuous Manufacturing & Crystallisation	2012	2019
ESRC / SFC	Scottish Graduate School of Social Sciences (renewed 2017)	2011	Ongoing

In addition to UKRI DTCs the University sponsors its own Centres for Doctoral Training, in order to generate cohorts of students with cognate interests. The internal CDTs with which this UOA is involved are listed in Table 6. These integrate support from, variously, industry (both global concerns

and local SMEs), the NHS and the Scottish Government and the Scottish Universities Life Sciences Alliance (SULSA).

Table 6: University of Strathclyde Centres for Doctoral Training

Research Theme	Strathclyde CDT
Health Care & Data Systems	• Digital Health Implementation & Analytics • Human Centric AI in Healthcare • Strathclyde Diversity in Data Linkage
Health Behaviours & Interventions	• Communication Disorders • Strathclyde Centre for Doctoral Training in Social Transformation for Wellbeing
Medicines, Therapies & Diagnostics	• Developing Advanced Technologies to Combat Antimicrobial Resistance • Industrial Biotechnology • Transformative Technologies for Future Nanomedicines

It is important that both supervisors and students are trained and supported. The *Strathclyde Supervisor Development Programme* is aimed at anyone involved in PGR supervision. It covers initial supervisor training and supports continuing development. A conversation about PGR supervision is maintained through the ADR and mentoring by senior staff gives further support. Additionally, each new member of staff is assigned a buddy who advises on best practice for supervision. New members of staff are encouraged to take on second supervisor roles to broaden their experience before becoming primary supervisor.

Support for students themselves comes through the University's *Researcher Development Programme* that covers four domains: knowledge and intellectual abilities essential for doing research; personal effectiveness as a researcher; research governance and organisation to establish knowledge of the standards, requirements and professionalism to do research; and engagement, influence and impact, developing the knowledge and skills to work with others and ensure the wider impact of research. Within the UOA, all students go through periodic review. Reports are submitted each year which helps students and supervisors keep track of performance and maintains completion rates. Our aim is to provide the best experience to our PGR students but if issues arise, our PhD student progression databases allow quick identification of problems that are then followed up by departmental Graduate Schools to implement supportive remedial action and safeguard individual student progress.

All PGR students are embedded in research groups (Table 1) and are expected to contribute fully through seminars, conferences and group meetings. As well as this, research support comes from schools and departments and from the University, with funding to support conference attendance for example. All doctoral candidates are automatically members of the Strathclyde Doctoral School (or Humanities & Social Sciences Doctoral School for PSH) which provides a comprehensive student-centred research and training environment. Central to this are programmes organised by the students, such as the Doctoral Researchers Group, self-organised PhD Research Days and a peer mentoring programme. It is also recognised that support for career development goes beyond research: PGR students are full members of committee structures and are encouraged to undertake teaching duties, once properly trained.

2.4. Support and promotion of equality and diversity

The University has been an active participant in the Athena SWAN programme since it began. SIPBS and PSH currently hold bronze awards. The number of male and female FTEs in each of the UOA research themes is shown in Table 7. Of the total 90.4 FTE, 49.4 are male and 41 female.

Table 7: Gender breakdown in the UOA by research theme

Research Theme	Male FTE	Female FTE
Health Care & Data Systems	3.8	6.0
Health Behaviours & Interventions	9.6	17.2
Medicines, Therapies & Diagnostics	36	17.8

Our practices are based on the University *Equalities and Outcomes Action Plan* which embeds an equitable approach to recruitment, support and promotion for everyone in the UOA. The UOA is able to apply a range of benefits and policies that help staff balance work and family commitments from which staff have benefited. These include maternity and paternity leave and support, adoption leave and pay, parental and shared parental leave, support for carers, flexible and homeworking arrangements, as well as family-friendly research leave. These benefits and policies are in place for all staff on a permanent contract and are pro-rata for part-time staff. Our UOA takes an individualised and proactive role in providing staff cover and support for maternity and adoption leave. A meeting is arranged with the line manager to detail the workload to be covered. Health & Safety risk assessments are put in place, and guidance is provided on who to contact in HR for advice on relevant policies. Staff are reassured that time off is allowed to attend medical appointments. During leave, staff are given up to 10 Keeping in Touch days to enable staff to keep abreast of the developments and help relieve some of the anxiety associated with returning to work. On returning to work, staff are supported with flexible return schedules and benefit from HR policies such as: Family Friendly Research Leave that allows returning academic staff to focus on their research; Ordinary Parental Leave that allows staff to take up to 4-week unpaid leave per year up until a child is 18; Carers Leave that helps carers better balance their work and caring commitments; and the right to apply for Flexible Working – all staff in the University employed for at least 26 weeks can request to work flexibly from home.

All academic, teaching and administrative staff in the UOA have undertaken the Diversity in the Workplace training module, which is currently being refreshed for all staff. Additionally, staff involved in any aspect of recruitment complete training on Recruitment & Selection and, Gender Matters & Unconscious Bias. Our adverts include a named contact for informal enquiries and the statement 'We value diversity and welcome applications from all sections of the community'. Online interviews with flexible timing are offered to candidates with caring responsibilities/disabilities.

Support for equality, diversity and inclusion is enhanced by family-friendly working (for example by holding meetings during core business hours, 10:00-16:00), regular rotation of local management positions (for example committees for Research & Knowledge Exchange, Learning & Teaching and Equality & Diversity) and the use of deputy roles for these, which provide resilience and lets staff new to a role acclimatise. Within SIPBS there is an annual Athena SWAN Researcher's Award and lecture. Support for equality and diversity can also be seen in the numbers of staff attending external courses (Table 3) many of which are specific for career and leadership development in female academics.

3. Income, infrastructure and facilities

3.1. Income for research and research impact

The total income for research in the UOA is shown in Table 8. The resilience of our income is highlighted by its robust consistency across the REF period and the diverse sources: UKRI awarded 34% of our total income, Charities 27%, Industry 20% and Government agencies (including EU and NHS) 19%. Changing demographics in the UOA – the numbers of Strathclyde Chancellor's Fellows and new Professors appointed – and the new initiatives outlined in Section 1 are cause for optimism about sustainability and anticipated growth. Funding from industry doubled over this REF period, indicative of a strong engagement with end users and likely pathways to impact from our research.

Table 8: Research income through the REF period, in £ Millions, from 642 unique awards.
UKRI income includes all research council grants, UKRI income-in-kind, and income from learned societies, including The Royal Society & Royal Society of Edinburgh; Charity and Industry income are from both national and international sources; Government income includes that from the UK, EU and NHS.

Year	13-14	14-15	15-16	16-17	17-18	18-19	19-20	Σ
UKRI	2.47	2.92	3.14	3.20	2.93	2.90	2.76	20.32
Charity	2.38	2.55	1.96	2.12	2.66	1.89	2.29	15.85
Industry	1.02	1.01	1.48	1.58	1.91	2.88	2.24	12.12
Gov't	1.60	3.02	1.90	1.09	1.41	1.16	1.18	11.36
TOTAL	**7.47**	**9.50**	**8.48**	**7.99**	**8.91**	**8.83**	**8.47**	**59.65**

Research across all the research themes is well funded, to cover a raft of different health related issues. For example, researchers in the *Health Care & Data Systems* had funding from Greater Glasgow & Clyde NHS for a flagship cancer medicines outcome programme (£449K Bennie, Kurdi & Kavanagh) while in digital health, the EU funded work on integrated personalised care for patients (£507K Maguire). Likewise, *Health Behaviours & Interventions* research has diverse funding. For example, EPSRC supported work in speech and language therapy (£348K Cleland) and grants have been won from the Chief Scientist Office to investigate psychological barriers to seasonal influenza vaccines (Williams *et al.* £162K) and in physical activity for health (£91K Reilly; £51K Grealy). There are also serial charity grants for research on physical activity for health (£81.3K Cunningham Trust, £74.7K Hannah Research Foundation, £39.9K Glasgow Children's Hospital: Reilly & Kirk).

Because of the intensity of the laboratory work, the largest amounts of funding were awarded for *Medicines, Therapies & Diagnostics* research. For example, EPSRC continues to support work in CMAC (£2.7M Florence *et al.*; £1.2M & £1.1M Halbert & Florence; £0.96M Ter Horst & Oswald) and, as noted, CRUK supports research in the Formulation Unit. There are also many grants for research in basic science with strong potential for application, from both the BBSRC (in microbiology for example: £0.6M Hoskisson & £0.7M Hunter & Hoskisson) and MRC (in cancer for instance: £1.1M Mackay *et al.)* Industrial funding continues to be a significant stream with income from big pharma (including GlaxoSmithKline, Pfizer and Allergan) and SMEs (for example Morvus, Ryboquin, Gene Solutions) growing by more than 100% over the REF period (Table 8). We have also had excellent success with KTP grants – 7 in the current REF period.

3.2. Infrastructure and facilities to support and deliver research and research impact

The University provides centralised support to manage, operate and maintain work. In this context it is important to acknowledge the contributions of the professional services within the University. As an illustration, Mironid® is a company formed by Strathclyde researchers and housed within SIPBS. Mironid® rents office and lab space and contracts for services. Research & Knowledge Exchange Services, Estates, and the Safety, Health & Wellbeing team were critical in making this happen and provide essential research support – accommodation, infrastructure, cleaning, hazardous waste disposal, security – that is properly contracted, managed and delivered. In addition, targeted University support helps individual schools and departments with administration of the complex management of research. For example, staff in PSH have access to a dedicated Faculty Research and KE team and a Faculty Editor who provide pre and post-award support. At project conception, the costing and pricing module within the University's financial management system makes the costing of grant applications and knowledge exchange work seamlessly integrated.

The University also manages and distributes, on a competitive basis, a number of funds that can be used to prime and stimulate research and impact. These include the EPSRC Impact Accelerator Account, the SFC funded Global Challenges Research Fund and the Knowledge Exchange Development Fund. Small grants from these funds (<£10K) have been won by staff across all three of the UOA's research themes. In addition, Strathwide is an internal initiative to connect researchers across the University helping them, for example, organise small conferences, and STEMequals is an EPSRC funded project designed to enhance inclusivity.

As another central service, research data and outputs are stored centrally on the University's data storage service, which has back-up and enhanced security features to ensure that data are protected to the highest standards. This is a critical aspect in most research, and integral to our ability to collaborate flawlessly with external partners, whose work may be commercially sensitive. Finally, for research and impact information, PURE allows us to document, track and obtain all open access publications, gold and green. PURE is also a repository for data, stored in a FAIR manner with a published DOI.

Technical staff are a critically important backbone to the infrastructure supporting the work of the UOA. We have a combined cohort of over 40 technicians covering a raft of specialist jobs: stores management (essential for lab work); local IT technicians (who also work on software programming and signal processing); experts in specialist kit (from eye tracking to mass spectroscopy); and animal husbandry and welfare. The majority are employed by the University but there are six CMAC technicians supported by industrial income generated through proprietary projects. In SIPBS, technical staff demographics have been reshaped by hiring more junior technicians with a better gender balance, part of our commitment to achieving and promoting equality of opportunity in research and working environments.

The research groups in this UOA3 are housed in buildings on the compact and efficient John Anderson Campus in the centre of Glasgow. The *Medicines, Therapies & Diagnostics* research groups (as well as pharmacoepidemiology) are in the Robertson and Hamnett buildings, two interconnected wings making one space. Both wings contain generic and specialist lab space, cellular and open-plan office space, flexible conference rooms and social & learning spaces used by all members of staff and students. CMAC, because of its scale and fundamentally interdisciplinary nature, is housed in the Technology & Innovation Centre (TIC) where there are labs, office and social space, and a range of meeting rooms. The £89M TIC was created to accelerate industry and academic collaboration and co-location to deliver impactful research outcomes: CMAC is a prime example of this. Research in *Health Behaviours & Interventions* is housed in the Graham Hills Building; research in *Health Care & Data Systems Computer* is in contiguous levels of the

Livingstone Tower. In each of these buildings there are dedicated and generic labs, office and social spaces. All the buildings described have fully comprehensive wired internet connections and Wi-Fi available throughout. Access to all the buildings is fully compliant with relevant legislation for accessible campus and assistive technologies.

Because the research in this UOA is diverse – from counselling through epidemiology and telehealth to molecular biology and genomics – the infrastructure and facilities required to produce world-leading research and impact is necessarily varied.

Health Care & Data Systems Infrastructure & Facilities: Research infrastructure and facilities to support digital health, health statistics and pharmacoepidemiology is less to do with physical lab space and more about providing the ability to collect, use, share and store data. The provision of excellent and secure IT capability is central to this. Work that requires simulations or fabrication is undertaken in collaboration with partners such as the Digital Health & Care Institute, commercial partners and the NHS – Scotland has an excellent patient database that can be securely accessed for research use. The Digital Health & Wellness Group benefited from refurbishment of accommodation using University funds (£113,000). Improvements were made to enhance interaction, support and collaboration between peers and colleagues. In particular, the *Usability and User Experience* Lab is a bespoke accessible and reconfigurable lab space for conducting a wide range of research including usability studies, fabrication of technologies, prototyping, and co-design sessions with stakeholders. Specialist equipment in this lab includes a digital camera, recording equipment, dictaphones, Virtual Reality headsets, wearable devices and a desktop computer for running user studies.

Health Behaviours & Interventions Infrastructure & Facilities: This research is managed within PSH, where there are both generic and specialist infrastructures. For example, there are 13 research stations for studies using small equipment, an editing suite, and a technical workshop available for all research groups. In addition, there are specialist laboratories for research in ageing and neuropsychology, psychophysiology and body composition labs, and a psycholinguistic suite for use in speech and language therapy. In terms of dedicated equipment facilities, researchers have five state-of-the-art eye-trackers, electroencephalography, transcranial direct current stimulators, transcranial magnetic stimulation, virtual reality and motion capture systems.

Medicines Therapeutics & Diagnostics Infrastructure & Facilities: This research is all managed by SIPBS. The £36M Hamnett Wing lab space is largely open-plan, staff being allocated bench space according to need. There are shared services including a sterile suite, cell culture, radioactivity handling, -80^{o}C freezer storage and molecular modelling suites. This facility also houses the Strathclyde Fermentation Centre, used for applied microbiology. The Robertson wing also houses generic lab space, darkrooms and the specialist units described below. The CMAC laboratories in TIC are also used by staff, giving access to pharmaceutical formulation, processing and testing capabilities unrivalled within the UK and amongst the best in the world. Particular specialised infrastructure supporting this theme includes:

- The **Biological Procedures Unit** is licensed under the Animals (Scientific Procedures) Act 1986 to house mice, rats, hamsters, guinea pigs, gerbils, rabbits, zebra fish and pigs. In 2016 there was a major refurbishment, costing £590K. It contains 23 animal rooms containing conventional and individually-ventilated cages; four rooms for large animal research; and 11 rooms for behavioural and physiological analyses. It has a large operating theatre; six procedure rooms; imaging and irradiation facilities. The University has signed the *Concordat on Openness on Animal Research* and fully supports and endorses the ARRIVE guidelines developed by the NC3Rs.
- The **Cancer Research UK Formulation Unit** prepares and manufactures experimental anti-cancer drugs, contributes to clinical trials and projects of all 18 Experimental Cancer Medicine

Centres in the UK and also elsewhere in the world. The CRUK Formulation unit hosts GMP production facilities for specialist pharmaceutical products for Phase 1 clinical trials.

Laboratory equipment is a necessity for research in biological and pharmaceutical sciences and we continually review equipment capability to meet core and specialist needs using the best kit. Equipment procurement is guided by strategic priorities including support for early career researchers and new appointments. Funding comes from an annual University allocation and targeted external awards. There have been considerable successes, helping create world-class labs including:

- CMAC, through the UK Research Partnership Investment Fund, won over £10M for high level equipment, including Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) for surface analysis and depth profiling applications of a wide range of materials including pharmaceuticals.
- Next Generation Sequencing: an Illumina Miniseq was purchased by SIPBS to consolidate and improve molecular biology. It has enabled securing of >£5M in research grants (including Innovate UK £1.5M; BBSRC £612K; MRC £687K; BBSRC £557K).
- Over £1M was spent using internal resources to support *inter alia* confocal microscopy, cell sorting, HPLC, pharmaceutical analysis (matched funding for EPSRC bids), nuclear magnetic resonance imaging and mass spectroscopy. New Chancellor's Fellows and GTP Professors benefitted from new kit and lab refurbishments.

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

We produce research outcomes that make a difference, whether individually or in collaboration. Nationally and internationally, our aim is for outcomes with a beneficial impact on people, organisations and communities. The wide range of engagements outlined below reinforce the importance of our contributions.

4.1. The Research Base: research collaborations, networks and partnerships

Collaboration is part of the landscape in Scotland. The Scottish Government created pooling initiatives – collaborations across Scottish Universities – supported by the SFC and Chief Scientist Office. Strathclyde was a founder member of SULSA (*Scottish Universities Life Science Alliance*) which exists to develop a coordinated approach to life sciences. For example, SULSA was critical in developing the National Phenotypic Screening Centre which opened in 2015, in Dundee, and is vital for work in drug discovery. Strathclyde has always had a member on the SULSA Executive Committee (currently Pyne) and Hoskisson Chairs SULSA Ecosystems. In 2018, Strathclyde became the seventh member of SINAPSE (*Scottish Imaging Network: A Platform for Scientific Excellence*) which works in experimental and diagnostic imaging, from intracellular to whole body; McGeown represents Strathclyde on the Executive.

The interdisciplinary nature of Health & Wellbeing creates an intrinsically cooperative approach. Our research base is founded on collaborations, networks and partnerships, nationally and internationally. Section 1 included information about new initiatives that began in this REF period: Health Data Research UK, the Digital Health & Care Institute, the Health Technologies Cluster, the Medicines Manufacturing Innovation Centre and CMAC. Our participation and leadership in these illustrate a pervasive commitment to collaborations, networks and partnerships that benefit our research bases and our relationships with end-users. Significant examples of what we do include:

Postgraduate networks – developing elite talent

- Internationalisation of our work was highlighted in 2014 as a strategic ambition. One way in which we have done this is to increase the mobility of our doctoral students. The University Global Engagements Fund was used to develop collaborations with Hong Kong University of Science &

Technology (HKUST – MoU signed, 2016)) and Nanyang Technological University (NTU). Doctoral students in Medicines, Therapies & Diagnostics benefit from these partnerships. Joint students are currently at Strathclyde (4) and HKUST (3). Likewise, CMAC and NTU share PhD studentships: two Strathclyde students spent time at NTU and 5 NTU students in CMAC.

- Ter Horst coordinates and chairs the Steering Committee of the *CORE network (Continuous Resolution and Deracemization of Chiral Compounds by Crystallization)* a four year Marie Skłodowska-Curie Innovative Training Network (€4M) for 15 early career researchers. Four PhD students carry out their PhD research at Strathclyde. Ter Horst is also PI in the €4M Horizon 2020 *Amecrys Network*, a universities/industry partnership looking at crystallisation and monoclonal antibodies.

- Since 2014, we have built research collaborations with partners in the Middle East through teaching opportunities which doctoral alumni stimulated. Delegations visit frequently, establishing a network of alumni in senior positions. We are starting collaborations in areas such as diabetes, microbial resistance, cancer, health service research and drug development that have the potential to work across all three of our research themes. In addition, female members of academic staff in some Saudi universities are eligible to apply for PhD entry under our External Joint Supervision Programme. This allows for study to take place in Saudi Arabia with occasional student visits to Strathclyde.

International collaborations that enhance the research base

- UOA staff have conducted research to give their work impact with international reach, through EU programmes. Notable EU grants include *eSMART, a controlled trial to evaluate electronic symptom management* (**Maguire & McCann** £830K, 2017-2019); ADLIFE: Integrated personalized care for patients with advanced chronic diseases to improve health and quality of life (**Maguire** *et al.* £507K, 2020-2023); *SeaBioTec* (**Edrada-Ebel** £7.5M – £1.55M to Strathclyde, 2012-2016) and *OrBiTo Innovative Medicines Initiative:* In Vivo *Predictive Biopharmaceutical Tools*. (**Halbert** *et al*. £454K 2012-2018).

  Global programmes are not always on this scale but are no less valuable, maybe even more so. For example, research on antimicrobial resistance with colleagues in Africa led to the development of web apps for nationwide surveillance of antibiotic use. Likewise, materials developed through international partnerships informed the Commonwealth Partnerships for Antimicrobial Stewardship Toolkit developed by Commonwealth Pharmacists Association. Table 9 lists the most substantial non-EU international grants.

Table 9: Selected global (non-EU) externally funded collaborations with a value of >£50K. *Awards in local currency converted to GBP. There are multiple Initiatives across themes in, for example Ghana, Kenya, Malaysia and Saudi Arabia. The University operates a Global Enhancement Fund, small grants for travel to enable international collaborations. In the REF period 30 awards were made at a total cost of ~£60K.*

Health Care & Data Systems		
Bennie	Brazil	Royal Society Newton Fund: £74,000
Bennie	Brazil	Royal Society Newton Fund: £99,909
Kurdi	South Africa	South African MRC: £55,000
Kurdi	Scandinavia	Nordic Network for Covid-19 Epidemiology: £1,184,708
Health Interventions & Behaviours		
Reilly	Australia	National Health & Medical Research Council Australia: £593,216
Medicines, Therapies & Diagnostics		
Carswell	Saudi Arabia	R&D Office, Ministry of Education, Saudi Arabia: £194,437
Hoskisson	Mexico	Royal Society Newton Fund: £111,000
Roberts	USA	Defense Threat Reduction Agency, USA: £879,862

4.2. The Economy & Society: relationships with key research users, beneficiaries and audiences

Relationships with key research users, beneficiaries and audiences are fostered in several ways, perhaps most notably by the substantial investment in the Technology & Innovation Centre, opened in 2015, giving physical evidence of University commitment to relationship building. However, individuals are often the prime movers, helped to achieve high visibility by support with internal awards to attend research conferences, undertake research visits, and to identify and secure international collaborations, academic and external. This is actively supported within academic Schools, Departments and Faculties where there are officers responsible for knowledge exchange, internationalisation and outreach who advise on the development of the most appropriate strategic directions. The UOA also takes advantage of the EPSRC Impact Accelerator Fund to stimulate interactions: 12 awards worth >£127K were made in the REF period, mostly for commercialisation or secondment into industry.

Substantial examples of relationships with key research users and beneficiaries are present throughout this submission, most obviously in our impact case studies. More examples of working relationships with key research users includes:

Structural relationships that benefit end users

- **CMAC** is a core element of the *Medicines, Therapies & Diagnostics* UOA research theme. Established in 2011 and led by Professor Alastair Florence, it was created to revolutionise the way pharmaceuticals are made. The approaches devised and adopted within CMAC have been developed through close collaboration with industry and the support of its Tier 1 partners, GlaxoSmithKline, AstraZeneca, Bayer, Lilly, Novartis, Pfizer, Roche and Takeda. CMAC has a £150M funding portfolio and currently has over 130 staff and researchers, including academics,

post docs, and more than 30 PhD students, as well as an experienced support team. CMAC research provides one of this UOA's impact case studies.

- Since 1983 The **CRUK Formulation Unit** has handled around 100 compounds and manufactured over 1,000,000 product units. Several of the compounds have been passed to companies for further development and are used worldwide for cancer treatment. The Formulation Unit has contributed to a range of national and international research programmes such as the EU Innovative Medicines Initiative, OrBiTo (Oral Biopharmaceutical Tools). During 2017/2018, the Unit participated in a knowledge exchange partnership (worth >£600,000) with US Company ProNAi to develop novel anticancer drugs.

- Perrie is a partner in the **Horizon 2020 *Tuberculosis Vaccine Initiative***, a non-profit foundation crossing Universities and industry. Other stakeholders include the EC, WHO, the Bill & Melinda Gates Foundation, the European & Developing Countries Clinical Trials Partnership, the European Investment Bank, and the Norwegian and UK Governments. Perrie also secured a four-year Marie Skłodowska-Curie Innovative Training Network on *Leveraging Pharmaceutical Sciences and Structural Biology Training* to develop new vaccines. The project unites Strathclyde and GlaxoSmithKline Vaccines Srl (Italy) and funds 4 PhD students.

- **Collaboration with the NHS** is enhanced by staff who have joint or honorary appointments with the NHS. These include: in *Health Care & Data Systems*, Honorary posts with Public Health Scotland (**Kavanagh**) and NHS Lanarkshire (**Maguire**); in *Health Behaviours & Interventions*, Honorary appointments with NHS Research Scotland (**Parra**), NHS Lanarkshire (**Cogan, Cleland, Lowit**) and NHS Greater Glasgow & Clyde (**Cohen**); and in *Medicines, Therapies & Diagnostics* there have been three joint appointments with the NHS (**Akram, Bennie, Thomson**).

  Over 30 staff have conducted research with the NHS and international hospitals, working on projects that directly impact patient care. Examples include: in *Medicines Therapies & Diagnostics*, **Batchelor** has conducted several clinical studies with NHS partners including the ACCEPT trial across 14 hospitals: >600 children were asked about their use of oral liquid medicines. In *Health Behaviours & Interventions*, **Cleland**, in Speech & Language Therapy, is part of an EPSRC funded Healthcare Impact Project (£965K, 2017 to 2020) involving four NHS boards, Grampian, Greater Glasgow & Clyde, Lothian and University College Hospitals London and an SME, Articulate Instruments Ltd. In *Health Care & Data Systems*, **Maguire & McCann** are running the eSMART European clinical trial which aims to transform cancer care and reduce healthcare costs. Funded by the EU, this involves hospitals internationally.

- A *Science Across Virtual Institutes* (SAVI) award (£500K jointly funded by the National Science Foundation in the USA and EPSRC) established an **International Institute for Advanced Pharmaceutical Manufacturing**. It brings together world-leading academic expertise to deliver new end-to-end continuous manufacturing capabilities that will transform the global supply chain for medicines. CMAC, the Centre for Structured Organic Particulate Systems in the USA and the Research Center Pharmaceutical Engineering in Austria operate this joint programme to create a vibrant international manufacturing research community.

- Strathclyde researchers benefit from the presence of the **Industrial Biotechnology Innovation Centre** (IBioIC), hosted by the University. It was established to apply the research talent of Scottish universities in commercialising industrial biotechnology. This has provided a route for working with big pharma (such as GlaxoSmithKline) and SMEs (such as Ingenza and Xanthella) which has helped leverage UKRI finding.

- **Spin-out company formation** was part of our strategic plan in 2014 and we have increased activity during the current REF period. While others are in development, the current most significant are:
    - **Mironid**® secured £4.3M in Series A funding in 2016 and is building a portfolio of early stage drug discovery programmes. By targeting cyclic AMP degrading phosphodiesterase enzymes, the company is developing treatments for a range of indications including chronic inflammation, kidney disease and cancer.
    - **MGB Biopharma**. Research on anti-infective drug candidates based on DNA minor groove binders led to the formation of this company. During the current REF period, it raised >£11M in equity and public funding and proceeded to complete successful phase 2a clinical trials, with phase 3 trials approved. The primary drug candidate has been shown to be completely effective against *Clostridioides difficile* infections, out-performing the existing benchmark (vancomycin). Antibiotic resistance has not been seen owing to the novel multi-target mode of action of the drug, making this only the fifth antibiotic compound publicly recognised as entirely novel, by WHO criteria.
    - **3F-BIO** was established in 2015 to commercialise patented technology from Strathclyde. It produces ABUNDA® mycoprotein, a high-quality source of healthy protein and fibre, created using a zero waste process. The company has raised over £7M and created 15 jobs.

Individual relationships that benefit end users

Below are highlights of interactive gains that beneficiaries make from the work of individual members of UOA staff.

Health Care & Data Systems

- **Consultancy** includes **Young** who provides statistical consultancy to the NHS. **Barry** is an expert member of the Royal Statistical Society's *Statisticians for Society* initiative and volunteers for a charity, the *Consortium for Street Children* to provide expert advice on appropriate counting methods for street children across the world; UNICEF have disseminated the findings. **Maguire** is a member of the core consultancy group informing Digital Health & Care Strategy for Scotland. **Kavanagh** holds an honorary position with Public Health Scotland as statistical consultant.
- **Licensing**: **Maguire** is licencing eSMART in Canada.

Health Behaviours & Interventions

- **Consultancy** includes **Cleland** is Secretary of the *International Clinical Linguistics and Phonetics Association*, the foremost association for clinical linguistics with worldwide membership. **Fleming** provides sleep and fatigue management expert consultancy to MacMillan Cancer Support and Breast Cancer Care. **Lowit** is speech & language therapy advisor for the charity Ataxia UK. **Reilly** was a member of the Ending Childhood Obesity (ECHO) Science & Evidence Group 2014-2016, leading to the ECHO Report & Strategy; and was lead for physical activity in the WHO Healthy Life Trajectories Initiative 2016-2018. **Reilly** chaired and **Hughes** and **Janssen** were members of the committee that prepared the *UK Health Department Physical Activity Guidelines* for the Under 5s, 2019 and **Mavroeidi** was a member of the guideline development group for older adults. **Rasmussen** was an adviser on *Scottish Government Suicide Prevention Action Plan* and is a British Psychological Society

Expert Adviser to Scottish Parliament on Suicide Prevention. **Robertson** was consultant with ONFIDO, a company specialising in photo recognition technologies.

- **Licensing: Cohen** has licencing in the pipeline for paediatric recurrent respiratory papillomatosis, diagnostic and monitoring Inventions.

Medicines, Therapies & Diagnostics

- **Consultancy** includes **Cunningham** is patency consultant to Marks & Clerk LLP. **Edrada-Ebel** was a member of the legal policy committee for SeaBiotech and member of the PharmaSea Advisory Panel of Policy and Legal Experts. **Khadra** is advisor to Saudi Food & Drug Authority. **MacLean** is consultant for Altavant Sciences, which has a primary interest in pulmonary hypertension. **Mullen** is scientific advisor to Ryboquin, Nanogenics and Ilera healthcare companies. **Perrie** is a member of the Commission of Human Medicines Expert Advisory Group (2013-present) and expert panel member for Medicines & Healthcare Products Regulatory Agency. **Watson** has a consultancy business, *Watson Research and Training Ltd*. providing consultancy on research, research training and personal development.
- **Knowledge Transfer Partnerships**: include **Mullen** with AB Vista and with Novabiotics; **Perrie** with MW Encap and with Lamellar Biomedical; **Brown** with Process Systems Enterprise and with Perceptive Engineering
- **Licensing Income** from research has come over the last 5 years from the work of **Mackay** (Gene Solutions), **Mullen** (Drug Delivery International), **Pritchard** (Serometrix), **Stimson** (R-Biopharm Rhone).
- **Patents** include: **Hoskisson** (as a co-inventor) 2020: *Susceptibility Methods*. **McNeil, Fazenda & Johnston** 2014: *Bioprocess for coproduction of ethanol and mycoproteins*. **Mullen**, 2018*: Oral thin films* (licensed to 3F Bio). **Roberts**, and six partners through the University of Chicago, 2015: *Compounds and methods for treating, detecting and identifying compounds to treat apicomplexan parasitic diseases.* **Roberts** with the UK Government Defence Science & Technology Laboratory, 2018: *Methods for the preparation of a pharmaceutical-vesicle formulation and associated products and uses*.
- **Contract research** worth a total of over £0.5M includes **Perrie** with AMRI Global, a US based contract manufacturer with a site in Glasgow. Knowledge transfer agreements have been made with GSK (**Hoskisson**), Jansen Pharmaceuticals and Lamellar Biomedical (both **Perrie**).

Outreach to wider audiences

We engage with the general public and school students to build enthusiasm and understanding, and to encourage younger people to enter into health science research. The University organises several events: *Engage with Strathclyde*, *Images of Research,* and *Explorathon* (all detailed in the Institutional Statement). We also participate in the *Glasgow Science Festival* to reach industrial and public audiences. Some examples of our outreach are:

- **Health Care & Data Systems: Barry** 2018, *Sense About Science Evidence Week* event in the UK Parliament; **Egan** 2019, a talk on technology, wellbeing and health in the 2019 Digital Health & Care Festival; 2018-19, invited speaker in the promoting excellence programme in dementia, flagship NHS Education training for clinicians to improve their skills in dealing with dementia; workshops and events relating to progress in technology for health and wellbeing at Scottish Care Events and NHS International conferences.

- **Health Behaviours & Interventions: Brown-Nicholls** 2017: spoke about aging on *Good Morning Scotland*, BBC Radio Scotland; 2018: took part in the *Scottish Older People's Assembly*, Scottish Parliament; 2018: a press release to advertise the intergenerational engagement project involving West Lothian Schools was picked up by local newspapers, STV and BBC Scotland evening news programmes. 2019: Scottish Government Age Equality Network Seminar, Glasgow: *Community-based intergenerational engagement: Investigating the impact on older adult volunteers*; 2020: interviewed on *The Great British Intelligence Test* a Horizon programme for BBC2. **Fleming** developed and delivered two CPD workshops for schoolteachers in Scotland to inform education professionals of the importance of good sleep for adolescent mental health and learning.

- **Medicines, Therapies & Diagnostics: Cunningham** 2015-18: *Social Mobility Foundation* mentor in Biology; 2019 presented in *The Departure Lounge* for the Academy of Medical Sciences to encourage a national conversation about death and dying. **Currie** wrote an article for *The Statesman* newspaper in India on anti-cancer cardiotoxicity. **Kurdi**: research on the cost of cancer management in Kenya was covered by the Kenyan national press. **MacLean** is a local organizer of *Café Scientifique*. Schools outreach from SIPBS includes the *Harry Potter Potions Class* explaining pharmacology and a *Skype a Scientist* event. Staff involved are **Boyd**, **Cunningham**, **Jiang**, **Khadra** (STEM Ambassador), **Moreira**, **Oswald** and **Rattray**.

4.3. Wider activities and contributions

The wider activities and contributions catalogued here show how staff in this UOA give their time and effort to make sure that their disciplines thrive and that the work of this University and UOA is visible and valued. Staff throughout the UOA review grant applications for UKRI and the major independent grant-giving bodies, nationally and internationally; review manuscripts submitted for publication at major journals; and routinely act as external examiners for PhD *viva* examinations at other Universities, nationally and internationally: notable examples are Hoskisson, Reilly and Seib who between them conducted 27 UK and 19 international PhD *viva* examinations. In addition, our wider contribution is show by:

- **Boards & Committee Memberships**: **Bennie** immediate past chair EuroDURG, the European Drug Utilization Group; **Boyd** Medical Research Scotland; **Batchelor** Academy of Pharmaceutical Sciences; **Bushell** Federation of European Neuroscience Societies; **Cleland** Chair, Scottish Speech Sound Disorders Clinical Excellence Network; **Cohen** Vice-Chair, NHS Research Ethics Committee; **Florence** Chair, British Association for Crystal Growth; **Flowers** National Aids Trust; **Gould** Glasgow Clyde Education Foundation; **Hoskisson** Royal Society of Biology & Microbiology Society; **Kavanagh** Royal Statistics Society; **Maclean** Vice President, Royal Society of Edinburgh; Glasgow Children's Hospital Charity**; Perry** President, Controlled Release Society; **Plevin** executive board member and Honorary Treasurer, British Pharmacological Society; **Pyne** Chair, National Science Advisory Committee of Tenovus Scotland; **Reilly** Active Healthy Kids Global Alliance; Glasgow Children's Hospital Charity.

- **Editorial Positions:** recent memberships of editorial boards and guest editorships include: **Barry** *Scientific Reports*, **Batchelor** *Scientific Reports,* **Chamberlain** *Journal of Biological Chemistry***, Cleland** *International Journal of Language & Communication Sciences* and *Clinical Linguistics and Phonetics,* **Edrada-Ebel** *Scientific Reports,* **Gould** *Scientific Reports,* **Maguire** *Sensors,* **Mavroeidi** *PLoS One* and *Journal of Ageing & Physical Activity,* **Nicholls** *Frontiers in Psychology,* **Perrie** *Journal of Pharmacy & Pharmacology* and *Pharmaceutics*, **Pyne N** *Cellular Signalling*,

Pyne S *Cellular Signalling*, **Reilly** *Pediatric Obesity*, **Seib** *Scientific Reports*, **Thomson** *Journal of Antimicrobial Chemotherapy*, **Williams** *BMC Psychology*, **Wozny** *Scientific Reports.*

- **Membership of Academies:** 45% staff are members or elected Fellows of a professional academy including: Academy of the Institute of Bologna, Academy of Medical Sciences, Academy of Pharmaceutical Sciences, British Pharmacological Society, International Society for Computational Biology, International Society of Pharmacoepidemiology, Physiological Society, Royal College of Nursing Royal Pharmaceutical Society, Royal Society of Biology, Royal Society of Chemistry, Royal Society of Edinburgh, Royal Society of Edinburgh Young Academy of Sciences, Royal Society of Medicine, Royal College of Nursing, Royal College of Speech & Language Therapists, Royal Statistical Society, UK Oncology Nursing Society.

- **Institutional Prizes:** CMAC and University of Strathclyde are the first academic institution to win an award from the **International Society for Pharmaceutical Engineering Facility of the Year Awards** programme. This is the premier global awards programme recognising innovation and creativity in facilities serving the regulated healthcare industry. CMAC was chosen because of its exemplary collaboration between industry, academia and government, which was judged to represent the future of pharmaceutical manufacturing and supply chain R&D frameworks. It highlighted that students working with such technology and in such a collaborative environment will be the pipeline for the pharmaceutical professionals of the future.

- **Individual prizes:** as well as regular best poster or article awards, staff in each research theme have won major prizes. For example: **Halbert** 2018: Eminent Fellowship of the Academy of Pharmaceutical sciences of Great Britain; **Kavanagh** 2018: the Royal Society of Edinburgh Sir Thomas Makdougall Brisbane Medal, an early career prize for outstanding, internationally renowned research in public health epidemiology and health informatics; **Maclean** 2017: the Reynold Spector Award in Clinical Pharmacology, given by the American Society for Pharmacology & Experimental Therapeutics; **Mavroeidi** 2018: work with NHS Lanarkshire on pyjama paralysis in hospital inpatients won the Scottish NHS Team Award; **Parra** 2020: the International Neuropsychological Society Arthur Benton Mid-Career Award, given in recognition of an individual who has made a substantive independent contribution to brain-behaviour research; **Perrie** 2019: the Royal Pharmaceutical Society Harrison Memorial Medial, awarded every two years, for outstanding contributions in advancing pharmaceutical science; **Pratt** 2018: British Association for Psychopharmacology Senior Public Communication Prize; **Wozny** 2019: Brain & Behavior Research Foundation Young Investigator Award.

This evidence shows that the contributions made by UOA staff were instrumental to the success of a wide range of projects and initiatives and to core professional bodies and their activities. The achievements illustrate the broad base of impact across the UOA, true to the University's founding principle as *A Place of Useful Learning*. Furthermore, our wholehearted commitment to equality, diversity and inclusion has been a stimulus to the vitality and sustainability of our research activities and their impact.