Institution: University of Strathclyde

Unit of Assessment: 3 Allied Health Professions, Dentistry, Nursing and Pharmacy

a. Overview

We describe the research environment for UoA3, which has an overarching focus on *drugs, devices, diagnostics and interventions*. We are submitting staff from three departments whose underpinning and applied research aligns with the Pharmacy and Allied Health Professions areas. The departments and associated research groups are:

1. Strathclyde Institute of Pharmacy & Biomedical Sciences (SIPBS), Faculty of Science: Research groups - Medicines Use & Health, Pharmaceutical Sciences, Infection Immunity & Microbiology, Cardiovascular Research, Cell Biology, Neuroscience.
2. Department of Biomedical Engineering (BME), Faculty of Engineering: Research groups - Rehabilitation Engineering, Medical Devices & Diagnostics, Cell & Tissue Engineering.
3. School of Psychological Sciences & Health (SPSH), Faculty of Humanities and Social Sciences (HASS): Research groups - Health & Nutrition, Speech & Language Therapy.

b. Research strategy

Institutional level strategy

Strathclyde is a Technological University with a strong focus on using our research, knowledge and capability to meet current and future challenges. The University has identified Health as one of its priority research areas and we recognise the necessity and value of technological innovation and multidisciplinary approaches to meeting the challenges that global demographic change and economic pressure are generating on health delivery.

We place our research at the heart of health innovation and translation, combining knowledge of living systems and the application of advanced science and technology to generate products and interventions. To this end, our health research is consistent with the University's founding philosophy of being *a place of useful learning.* Furthermore, it is strongly affiliated to the University's Technology and Innovation Centre (TIC), a £90M investment that will be fully operational in 2014. The Centre will be a hub for collaborative research between the University and external partners and through interactions with health services, businesses and policy makers, will enable us to develop translational research shaped to the needs of stakeholders, advancing knowledge, healthcare and quality of life. Our strategy has been informed by UK Government and Department of Health reports including *Innovation Health and Wealth – Accelerating, Adoption and Diffusion in the NHS* (2012) and is aligned to key aspects of RCUK's cross-council *Excellence with Impact* agenda and the goals of the *Lifelong Health and Wellbeing* theme. Through the TIC project we are in the process of creating a cross-faculty strategic initiative, Health Technologies at Strathclyde (HTaS) to support and grow integrated and sustainable multidisciplinary research in health within and beyond the institution. This is intended to be a stimulus for closer cooperation between researchers from diverse disciplines that will advance our translational research and further develop the University's health research portfolio and global reputation. An example of our increasing global development is the recent signing of a memorandum of agreement with the International Prevention Research Institute (IPRI; Lyon, France) to form the Strathclyde Institute of Global Public Health, which will align with and complement the work of the Medicines Use & Health Research Group in SIPBS.

Current position and developments since RAE 2008

Since RAE 2008, each UoA3 department has been transformed through staff re-profiling, mergers, estate investment, relocation and development. In total more than 30 staff returned to RAE 2008 have retired or moved to senior positions in other academic establishments or industry. This has been compensated by 26 new academic staff and a significant rise in the number of fixed term post-doctoral research contracts (for example, numbers in BME have trebled since RAE 2008) reflecting our success in growing research capacity.

SIPBS was formed in 2006 by amalgamation of 5 departments covering pharmacy and life sciences, and advances Strathclyde's record of successful drug-related research. The department is housed in the John Arbuthnott Building whose two wings (the final £36M Hamnett Wing opened

in 2011) provide co-location and laboratory support to all SIPBS research groups. At the REF 2014 census date SIPBS is submitting 53.9 FTE academic staff and has 74 postdoctoral researchers (PDRs) and 149 postgraduate PhD researchers (PGR) supported by 47 technical staff. Adjacent to SIPBS is the Wolfson Centre housing the new (2012) Department of BME. BME is a merger of the National Centre for Prosthetics & Orthotics with Bioengineering (a research department with a 50 year track record) creating a unique training and research department within the UK. BME will benefit from an estimated £12M estate investment starting in 2014. BME is contributing 13 FTE academic staff to the submission who work with 10 technical support staff, 17 PDRs and 65 doctoral students. In 2012, the University formed the Faculty of HASS, moving it to refurbished accommodation (£38M). With HASS co-located close to the neighbouring Wolfson and Arbuthnott buildings, the University has created a significant health research community with easy access to key laboratory infrastructure and support facilities based in the eastern quarter of the campus. The Speech & Language Therapy and Health & Nutrition research groups of HASS included here comprise 8 academic staff and currently have 6 PGRs, 1 PDR and a 0.5 FTE technician.

To support coordination of the various strands of health related research and enable participation of staff from the Research Groups, an HTaS Director was appointed in December 2102 to work with academic and administrative personnel from each participating Faculty and the University's Research and Knowledge Exchange Services (RKES). The Director is being tasked with identifying cross-disciplinary activities for development, aligned to the needs of external partners from industry and the public sector. This will benefit from the recent creation of an HTaS International Advisory Panel (IAP) to provide advice on strategy development and delivery. It includes leading executives from pharmaceutical and medical technology industries, investor groups, NHS R&D, representatives of the Scottish Medicines Consortium and the Chief Health Professions Officer in Scotland. Collectively the combination of new appointments in the participating UoA units and new infrastructure, allied to the formation of HTaS, has contributed to a growing sense of purpose and vitality in health research at Strathclyde.

Research Strategy Implementation

Strategy implementation is coordinated through departmental Research and Knowledge Exchange Committees (RKEC). The committees are chaired by senior staff (Departmental RKEC Directors) and typically include membership from contract research staff, doctoral students and technical support staff in addition to Research Group Coordinators. The new Director of HTaS also attends these committees. An important role for these committees is coordination of funding opportunities including annual competitions for PhD studentships and conference travel awards, as well as planning for purchase of equipment, laboratory upgrades and facility investment. Research management and reporting are facilitated through use of PURE, a web based researcher portal that also assists research dissemination through links to open access repositories. In addition, to promote inter-disciplinary research, we have developed annual research showcase events to which whole departments and also honorary appointees and external collaborators (for example from NHS and industry) are invited. The departments also host seminar programmes featuring internationally known guest speakers advertised through University-wide mailing lists and web-based notice boards. Notable research successes are publicised through the University's press office, web pages and in-house newsletters, distributed widely to stakeholder organisations.

Multidisciplinary Developments

All Research Groups are collaborative and without rigid boundaries: intergroup research is encouraged to add value, stimulate innovation and contribute to effective problem solving. Accordingly, all staff returned within this submission, belong to at least one research group but many contribute to more and all can participate in crosscutting research themes. Examples of recently developed themes are: CeNsUS (Centre for Neuroscience University of Strathclyde) a network focused on neuroscience, neurology and mental health that is building research partnerships in basic and translational neuroscience across academia, the NHS and industry; and RICAS (Research in Cancer at Strathclyde) a venture that aims to advance development of new cancer treatments from laboratory bench to the clinic. It is founded on our capabilities in the discovery of new drug targets, insights into cancer cell biology, drug design & modelling, lead identification & structure activity relationships, drug formulation & pharmaceutics and preclinical development & testing. Our cancer researchers are members of the West of Scotland Cancer Centre which aims to integrate strengths in cancer research across Glasgow.

Performance since RAE 2008

The UoA3 research groups have increased external funding during the current REF period. This is reflected through increased spend data per FTE and in a cumulative increase in the value and number of externally funded contracts. We also continue to build on the laboratory infrastructure investments detailed in RAE 2008. Further details on research income and infrastructure investment are given in section d. Continued growth in research funding is critically important and in this context increasing the number of applications aimed at longer and larger awards to promote sustainability has been a major factor contributing to the increase in research funding. An exemplar is provided by McConnell, an RCUK Fellow (2008-2013) and PI of a recent five year £1.5M MRC award in bioimaging. This is McConnell's second 5-year award in excess of £1M. With longer and larger awards providing sustainability in areas of our portfolio, a key research strategy is to direct resource to further build such areas of strength. However, we also remain attentive to shaping our research in a way that is responsive to the emerging challenges that link to demographic change.

Specific priorities for the next five years

1. Work collectively to increase strategic partnerships with industry, policy makers, healthcare authorities and social services to meet our excellence with impact agenda.
2. Support major cross-Faculty and cross-University developments such as the new national EPSRC Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation (CMAC) which is looking for quicker, more effective and sustainable methods of medicines manufacture. CMAC is a consortium (7 leading UK universities) directed by Florence that has attracted >£62M in two years including recurrent funding from GSK, Novartis and AstraZeneca.
3. Support new initiatives – for example a University philanthropic campaign is fundraising for The Centre for Bioengineering in Early Life (target £3M). This research centre aims to develop lifelong solutions to congenital problems of newborn children.
4. Support an expanded internationalisation programme. As an example of recent success, in 2011 Strathclyde was chosen as the exclusive European partner university for South Korea's Global Industry Academia Cooperation Programme (GIACP). The objective of GIACP is to foster joint research activities leading to commercialisation agreements between Korean SMEs and the University. Staff included in UoA3 have received funding towards investigating ideas for collaborative research. Also, as noted earlier, the University has recently joined with IPRI in Lyon to form the Strathclyde Institute of Global Public Health. This Institute will promote collaborative research leading to joint funding opportunities in global health issues – from major diseases such as cancer to problems that require technological solutions such as provision of clean water and effective sanitation in low income countries.
5. Increase our interactions with other universities and clinical research centres, building on past experiences and successes during the REF period. For example: (i) SIPBS has been a member of the Scottish Universities Life Sciences Alliance since it began in 2007. This has brought 2 new academic appointments with research support, 2 research assistant posts, a technologist, 8 studentships, £125,000 funding for new equipment and increased collaboration. (ii) Researchers in SIPBS participated in an Integrative Mammalian Biology Capacity Building Award in partnership with the University of Glasgow that attracted £3M from the BBSRC, DTI, BPS Integrative Pharmacology Fund, HEFCE, MRC and the Scottish Funding Council (SFC) to build capacity and support teaching, postgraduate training and research. (iii) Strathclyde is a founding consortium partner with Dundee, Edinburgh, Glasgow and St. Andrews in one of four MRC UK Centres of Excellence in e-Health Informatics. (iv) BME is a partner in the SFC-funded research pooling initiative the Glasgow Research Partnership in Engineering (GRPE) part of which supports rehabilitation engineering research at the Universities of Strathclyde, Glasgow, and Glasgow Caledonian University. A major focus of the £1.2M funding was to collaborate in the creation of a unique academic and clinical research centre located within the Queen Elizabeth National Spinal Injuries Unit (QENSIU) at the Southern General Hospital. With an established research focus, the QENSIU is the only British member of the European Multicentre Study about Spinal Cord Injury linking 21 spinal injury centres across Europe. (v) BME manages the Centre for Excellence in Rehabilitation Research (CERR) a Scottish Government Health Directives-funded initiative (total award value £2.6M, 2011-2017) aimed at promoting innovative multidisciplinary research in rehabilitation, assistive technologies, independent living and

rehabilitation practice. (vi) SIPBS staff led a consortium (with the Department of Pure & Applied Chemistry (PAC), eleven other Scottish Universities, and three industry partners) which was awarded £13M in 2013 from the SFC for an Innovation Centre in Industrial Biotechnology focused on better production of medicines. (vii) BME equip and manage new motion analysis facilities that form part of the refurbished NHS Greater Glasgow and Clyde (GG&C) Clinical Research Facilities at the Royal Infirmary in Glasgow, which supports increased clinical trials activity in orthopaedics, rehabilitation and devices.

6. Increase the number of spin-out companies formed from the departments submitting to this UoA. At present there are 6 potential start-up companies within the University spin-out pipeline related to activity in UoA3. Much of the improvement in commercialisation activity stems from successes in Proof of Concept funding from agencies such as Scottish Enterprise (for example. Medical Devices & Diagnostics Research Group has received more than £0.9M since 2009 and Houslay and N. Pyne in SIPBS received ~£0.5M in 2012). Over the REF period 14 patents have been granted to SIPBS and BME (7 to each), with SIPBS having 5 and BME having 4 exclusive license agreements in place.

c. People, including:

(i) Staffing strategy and staff development

Staffing strategy: The structures of the contributing departments are designed to support all aspects of new medicines development, medical devices, physical, speech and cognitive rehabilitation, and disease prevention. This is reflected in the multidisciplinary staffing strategies of the departments. For example, in SIPBS there is a spectrum of researchers – molecular scientists working at the level of the gene or receptor, medicinal chemists involved in drug design, synthesis and formulation, *in vivo* scientists who test potential drugs in animal models, through to pharmacists who directly interact with patients. Some of the pharmacists hold joint appointments with the NHS (Akram; Thomson; Bennie [Chief Pharmaceutical Adviser for National Services Scotland]) and we encourage the awarding of honorary research appointments to NHS employees with a view to furthering our research interactions (see section e). Moreover, we have staff with health-related expertise in materials, robotics, artificial intelligence and mechanical and electronic engineering. Health and Care Professions Council registration is also a factor in our staff profiles and we have a number of people qualified to engage in extra contractual referral schemes and clinical research. All staff working with the NHS have honorary appointments and 7 visiting professors hold NHS clinical appointments.

Our staffing strategies are directed by the University's commitment to excellence in research, knowledge exchange and education. At departmental level this leads to strategies designed to support current success, ensure the continued viability of key areas and open positions in areas of future impact (such as health informatics, digital healthcare, smart materials). An example of support for current success is that we are seeking to grow Speech & Language Therapy by recruiting a professor, a reader and a lecturer. Generally, our approach has involved recruiting early career staff – research leaders of the future, allowing them to develop under the umbrella of our Research Groups. As an example of the success of this strategy, Dufès , an external post-doctoral researcher appointed as a lecturer in 2006, won the 2012 Tom Gibson Memorial Award, a biennial award from the Royal College of Physicians and Surgeons, Glasgow that recognises outstanding young researchers involved in multidisciplinary activity. Nurturing talent is in keeping with the developing leader policies of the research councils and major medical charities and is supported by the launch in 2013 of the Strathclyde Chancellor's Fellowship Scheme. This will recruit high quality postdoctoral researchers into tenure-track positions. New young appointees at Strathclyde are all aligned to RCUK priorities and possess the ability and drive to become involved in multi-disciplinary Faculty and University initiatives.

Staff Development: We are committed to staff development in research at all grades as demonstrated by the inclusion of a specific section for reporting research achievements and setting future targets and objectives within the University's annual Accountability & Development Review (ADR) for all staff. It focuses on (*inter alia*) research and knowledge exchange allowing staff to reflect on their achievements in the past year and to develop plans for the coming year. Nominally ADR is an annual review, but it is a continuous process incorporating regular meetings with named senior staff members to review performance and agree mechanisms to support staff in reaching their research objectives and potential. The ADR is one mechanism through which staff ready for

promotion are identified. University promotion processes reflect KE success as well as research, teaching and citizenship; a staff category – KE Professional – is a job family introduced in 2013 for staff with this as their primary focus.

Although all employees go through the ADR process, the UoA3 departments have additional strategies to ensure a smooth developmental path for probationary academics. These include light teaching and administration loads and mandatory certification courses incorporating components such as formal training in postgraduate student supervision. The University also runs Mentoring@Strathclyde to assist staff with career development. All probationary staff have a mentor responsible for introducing them to the relevant Research Group and assisting them in becoming fully integrated into the University. The mentor role also includes provision of timely and constructive feedback in support of research proposals prior to submission.

All staff are encouraged to participate in the Strathclyde Researcher Development Program (RDP) a comprehensive University-wide programme of development activities. It has been specifically designed to meet the needs of Strathclyde's researcher community, providing a range of opportunities to continue their personal, professional and career management skills development. The RDP recognises all career paths and aims to help researchers (including postgraduate students) enhance their skills and competences for current and future roles within academia and other sectors. The programme has been nominated in 2011 and 2012 for the THES award for early career research support. The RDP works in concert with the recently launched Strathclyde Program in Research and Leadership, which coordinates and delivers participation workshops and master classes for all career levels. In addition, the Concordat to Support the Career Development of Researchers is implemented at a University level to ensure best practice is disseminated throughout the University. Implementation of the Concordat and the schemes described above has meant that the University achieved the EU HR Excellence Award in 2011.

The University is committed to Equality & Diversity: training for both staff and students is a priority. All staff and students are required to participate in an online training course – "Diversity in the Workplace", which includes quizzes and a test. Electronic records of completion ensure compliance. The University is accredited at bronze level for our commitment to the Athena SWAN standards for supporting woman in Science, Engineering and Technology; SIPBS as a department has also achieved an Athena SWAN bronze award and has a Director of Equality and Diversity who convenes an active Athena SWAN group. A similar position exists in BME.

(ii) Research Students

Sources of funding: There is a thriving postgraduate community in the UoA3 departments supported by established, robust, professional pastoral care mechanisms. We take great care to ensure that postgraduate research students (PGRs) consider themselves part of an integrated community. This is particularly true for students participating in the range of doctoral training programmes we offer. At present we have the following doctoral training grants in UoA3: BBSRC Doctoral Training Grant (DTG: £0.46M); BBSRC Doctoral Training Partnership (DTP) award with the University of Glasgow (£2.8M); EPSRC Doctoral Training Centre (DTC) for Continuous Manufacturing and Crystallisation (£6M); EPSRC DTC in Medical Devices (£8.5M plus £4.3M renewal from 2014). This DTC is worthy of note. Operational since 2003, and with renewal of EPSRC funding through to 2018 it effectively constitutes another cross-cutting Research Theme. It is the University's largest single multidisciplinary DTP with a stable population of 40 PGRs linking a network of 80 experienced supervisors from 9 departments in 3 faculties with more than 60 clinical collaborators. It has also been instrumental in securing a growing IP portfolio, spin out company formation and the generation of funding from diverse sources including RCUK, Scottish Enterprise, Technology Strategy Board (TSB), NHS, industry, medical charities and foreign funding agencies. This DTC offers 8-12 four-year scholarships annually depending on a mix of core EPSRC funding, University, and additional scholarship funding. All projects are multidisciplinary, requiring either collaboration with an industrial partner or direct clinical engagement through NHS collaboration.

We also support doctoral studentships through annual University and Faculty competitions. Funding from an EPSRC DTG to the University, and the University studentship scheme, is awarded based on a detailed evaluation of project, candidate excellence and alignment to strategic priorities. We also gain additional funded doctoral student places through medical charity studentship competitions. Our total pool of registered doctoral students currently stands at 220 and we also have 22 MRes students. We also make extensive use of undergraduate internships and

vacation bursary schemes to promote doctoral study to our best undergraduates and we provide significant funding to encourage high achieving overseas applicants. For example, BME provides 10 annual scholarship awards of £2K/year to its best non-EU applicants. In addition, SIPBS makes a contribution from Departmental funds to the stipend and/or fees of 30-40 of its PGR body per annum at a cost of >£150,000.

CASE studentships have been awarded from MRC, BBSRC, EPSRC and Scottish Universities Life Sciences Alliance (SULSA) and aligned with companies including AstraZeneca, Diamond Light Source, Biomer Technology, Lamellar Biomedical, Medac GmbH, Morvus, Novartis and UCB Cell Tech. Studentship funding has also been won through peer review from sources including BHF, CRUK, Diabetes UK, Medical Research Scotland, International Spinal Injuries Research Trust and SULSA. In addition, SIPBS staff are involved in an innovative scheme that provides PhD registration and academic supervision to GSK employees while performing their work-based research within GSK.

Training and Facilities: Our awards and studentships have allowed recruitment of excellent students who significantly contribute to our research output and culture. Additionally, within the BBSRC DTP, it is compulsory for students to partake in a 3 month Professional Internship. Here they gain work experience in non-academic environments where they can develop greater understanding of the wider context of their research. While this is compulsory for BBSRC students, we are developing a similar optional programme for university funded studentships. Requests for exchanges between academic collaborators are also encouraged, with recent exchanges taking place with prestigious organisations such as MIT and Beihang University in China via a Scottish Executive funded exchange programme administered via British Consulate General.

We provide dedicated study areas for PGRs and offer laptops or access to desktop computing to all. Study areas are served by wired and wireless access to the University IT system, the library and the internet. Meeting rooms with data projection facilities are adjacent to study areas and can be booked by students for private meetings or meetings with external partners. These facilities serve to establish a research community and group culture across the PGR body and in each department the students participate in running PGR societies.

All PGR students maintain a personal development plan and are reviewed annually in line with QAA codes of practice using online monitoring and annual interviews. Annual student progress reviews are carried out by academic staff, independently of supervisors. Where necessary, follow-up meetings are arranged with students to ensure that progress continues on schedule and that all necessary resources are available to ensure completion of project work on time. A programme of in-house generic skills training within the overall framework of Sir Gareth Roberts Report *SET for Success* is compulsory, supported by the Faculties and the Educational Portal of Learning Services: PGRs must attain 60 credits at level 5. In SIPBS a Graduate School coordinates the review process and delivery of generic skills training, as well as additional classes considered essential for PGRs in Pharmacy and Biomedical Sciences (such as *Generic Biomedical and Pharmaceutical Research Skills* incorporating data handling and statistical interpretation, ethics and medicines regulation and database searching). This is mirrored in the provision to PGRs elsewhere within the UoA with appropriate adaptation in relation to degree specialisation. All RCUK students are encouraged to attend residential UKGradSchool events organised through *Vitae*, an organisation committed to realising the potential of researchers. We expect every student to present data to at least one international conference.

Research and Activities: All PGR students are associated with a Research Group and fully engage with their ongoing activities. In addition, each Research Group holds or contributes to annual Research Days that allow PGRs to showcase their research by oral or poster communications. It is normal practice for 3rd year PGRs to deliver a full seminar to their Research Group/department. The University PGR and postdoctoral community also run the University-wide Research Day, the aim of which is to allow PGRs and postdoctoral researchers (PDRs) to experience organising events and for the PGR and PDR community to network in an informal setting. In 2011, the postgraduate Strathclyde Bioengineering Society in collaboration with the University of Glasgow undergraduate student society successfully ran Biomed 2011, a UK wide IET post-graduate student conference focused on Biomedical Engineering.

Students are actively encouraged to become members of a relevant learned society and present their work at local, national and international meetings. To encourage this, 2nd and 3rd year PGRs

(and PDRs) can apply for Travel Awards. In SIPBS, for example, 80 were awarded during the REF period, with 61 going to PGRs. In BME there is a matched funding scheme to support PGRs attending international conferences. Furthermore, PDRs routinely hold coffee mornings to allow teams from different research groups to discuss research and technology exchange to promote collaborations. These meetings vary in format ranging from formal presentations to a 'speed-dating' approach where researchers have only minutes to present their research.

In recent years there has been increasing focus on PGR student engagement with KE in recognition of the importance placed upon this at the local, national and international level. While all students (and staff) are encouraged to attend monthly KE events offered throughout the University, direct opportunities can also be realised through the project champion scheme of the ERDF-funded KE-Hub located in SIPBS. The scheme allows researchers to take responsibility for achieving an impact-related outcome for a project or technology. Tasks are varied and can include market assessment and coordination of funding information. Critically, all tasks empower students and are designed to expose the champion to the needs associated with research project management and KE delivery. The scheme has proved attractive to young researchers and adds vitality to our research environment.

That our PGR support schemes are effective is shown by success when competing for prizes and awards. For example, Aldawsari (supervised by Dufès) was runner up for Scotland at the British Council's Shine! international student award, a competition involving more than 1200 students.

d. Income, infrastructure and facilities

(i) Governance

The University actively promotes excellent ethical research through its Research Code of Practice and adheres to the seven principles of the Nolan Committee on Standards in Public Life. It operates an integrated researcher support system with transparent policies and processes that are approved by the University's governing bodies and administered through Deans, Heads of Departments and Principal Investigators. Our Internal Audit Service provides assurance over the four key areas of Governance; Internal Control; Risk Management; and Value for Money. Senate provides clear guidelines for the handling of complaints or investigations of academic misconduct. RKES provides expert contractual support for the research community through grant and contract authorisation, commercialisation and IPR management. It also provides administrative support to the University Ethics Committee (UEC) which reviews research with human participants and experimental work involving living animals at the University. The UEC committee meets monthly. For research studies in partnership with the NHS, or involving patients under NHS care, the UEC cedes approval to the National Research Ethics Service. Research delivery is assisted through efficient information and electronic systems for financial monitoring of research contracts, approval for equipment/ consumable procurement and employment of contract research staff.

(ii) Research Income

Current funding of the UoA3 Research Groups submitting is diverse – RCUK, UK-medical charities, NHS, Scottish Executive agencies (including education, regional development and health), industry, EU and other overseas organisations. Our portfolio of active research awards associated with Principal Investigators from UoA3 research groups consists of 107 awards totalling £37M of which 11 exceed £1M (excluding non-RCUK CMAC funding, CDTs and other training awards).

In RAE 2008, our research groups collectively returned RCUK spend of £5.1M (SIPBS, £3.7M, BME, £1.4M). This has increased to >£12M during the period to REF2014. Contributing grants > £0.5M are (i) EPSRC: £5.9M to Florence for CMAC; (ii) separate EPSRC (£1M) and MRC (£1.5M) awards to McConnell for her work on advanced bioimaging; (iii) MRC: £0.57M on cellular protein regulation to Chamberlain; (iv) MRC consortia awards to P.Rowe from the Efficacy & Mechanism Evaluation and the Lifelong Health & Wellbeing programmes for work on stroke rehabilitation (£0.8M to Strathclyde); and (v) EPSRC: £0.55M on drug-eluting stents to SIPBS, BME, Mathematics and Mechanical Engineering. The successful Scottish consortia bid for a Centre for Excellence in e-Health also attracted MRC funding resulting in new collaborations between pharmacoepidemiology (Bennie) and signal processing/informatics researchers in Engineering and Mathematics. In keeping with our drive to support translational research, we secured an MRC Confidence in Concept award for early stage evaluation of translational research in drug discovery.

UK medical charity funding has risen by ~25% to £13.2M over REF 2014. This includes significant Cancer Research UK (CRUK) support of £4.1M for the CRUK Formulation Unit (Halbert), an additional £1.1M for our Small Molecule Drug Discovery program (MacKay), an Arthritis Research UK funded Programme Grant to Plevin and colleagues from Glasgow University (£1.2M) and two five-year Wellcome Trust Programme Grants (£1M to Harnett: novel drug development for mast cell-dependent inflammatory diseases; £0.72M to McCarron: calcium signaling in smooth muscle). Smaller awards cover research in speech and language therapy, physical activity, neurological rehabilitation, rehabilitation engineering and medical devices.

Targeting EU and overseas funding has also been successful. McNeil, leads a €7.5M consortium of 14 partners in 9 countries on the potential of marine biodiversity for generating novel pharmaceuticals and Wilson and Halbert won €0.45M as part of an EU Innovative Medicines Initiative grant. Both demonstrate our ability to compete for major peer reviewed overseas funding. This is reinforced by prestigious grants from NIH for protozoa drug target identification (two awards totaling £0.64M to Roberts) and the first American Asthma Foundation Senior Investigator Award made outside North America to Harnett ($0.75M). A £2M Translational Medicine Research Collaboration (Pfizer, USA) award was made to PsyRING (a joint NHS GG&C, Strathclyde, Glasgow University collaboration) focusing on understanding the causes and possible drug treatment of schizophrenia (Pratt). In translational wound sensor research, Connolly was awarded $1M from the Qatari National Research Foundation to support an international partnership with Hamad Medical Corporation, Doha. In the area of Physical Activity, Reilly won 2 international awards from the Heart Foundation of Australia (£0.14M).

Other notable research funding has arisen through the Scottish Governments Health Directives for the establishment of the Centre for Excellence in Rehabilitation Research (PI, Conway £2.6M) and TSB, which provided more than £1M for projects ranging from work on myoelectric prosthetics with Touch Bionics (Lakany, Conway) to the development of point of care diagnostic biosensors (Connolly). Further knowledge transfer funding includes 10 awards from Scottish Enterprise (Proof of Concept) for work on, for example, cardiovascular devices (Gourlay, £0.9M) and two ERDF awards (£1.5M) to support knowledge exchange and engagement with SMEs in the Life Sciences (KE-Hub) and Medical Technology (Strathclyde MedTech) sectors.

Participation in NHS collaboration and funded programmes are increasing, covering research in pharmacy, rehabilitation in gait disorders, orthopaedics and speech and language therapy. This highlights our growing research articulation with NHS in supporting research that leads to trials aimed at improving quality of life. Funding from The British Academy (Kuschmann), Stroke Association (MacKenzie), Dunhill Trust (MacKenzie) and NHS GG&C (Cohen) in speech and language therapy exceeds £0.4M, all of which aim to bring about improved management of a wide variety of communication disorders. In addition, in 2010 a Strategic Alliance with MAKO Inc. resulted in the funding of the first randomised clinical trial evaluating the accuracy of unicompartmental knee arthroplasty with and without robotic arm surgical assistance. This trial – 120 patients – is being conducted through collaboration between Biomedical Engineering (P Rowe, Riches) and orthopaedic surgeons from the Glasgow Royal Infirmary (see also section e). Further funding of £0.5M from the Efficacy & Mechanism Evaluation Board (EME) was recently approved.

(iii) Infrastructure and Facilities

Our research estate is co-located within the eastern sector of our campus. The quality of accommodation is high: £36M has been spent on a new building for SIPBS and £12M is being invested in BME to accommodate growing academic and research activity in medical devices, digital health and rehabilitation research. Co-location and clustering of academic and research staff is a deliberate policy planned to achieve a stimulating environment where a positive community ethos for creativity, innovation and excellence in research can thrive and be sustained. The design of the new Hamnett wing of the John Arbuthnott Building has been universally praised for its attractive working environment: we provide excellent modern office, workspace and social areas for our academic, contract researchers and PGRs. Facilities include a range of bookable conference suites (small to large) equipped with integrated systems for electronic communications and data projection. We provide all PDRAs with their own desk; wired internet access and storage, while for PGRs we provide either fixed or hot desking (dependent on year of study) write-up areas with web access (wired and WiFi) and storage for personal belongings. Critically, academic researchers, contract researchers and PGRs are based close to laboratories and experimental

facilities linked to their areas of need. Research space is generally divided along the lines of Research Groups, but equipment and facility sharing is encouraged across the University. Each laboratory or research facility has a designated person identified as being responsible for its successful day-to-day management and safe operation.

Our main research laboratories are located in the John Arbuthnott and Wolfson Centre buildings. In the Arbuthnott Building fully equipped laboratories for state-of-the-art biochemistry, immunology, microbiology, molecular biology, parasitology, pharmacology and pharmacy research are maintained to underpin the SIPBS focus on *New Medicines, Better Medicines, Better Use of Medicines*. Home Office-approved animal research facilities are located in the Arbuthnott building as are GMP production facilities for specialist pharmaceutical products for phase I clinical trials (see Specialised Laboratories below). In the Wolfson Centre, there are world class laboratories for biomechanics/motion analysis, human neurophysiology, medical robotics, cell and tissue engineering, toxicology/biocompatibility, advanced (bio)material testing, computer modelling, implantable and non-implantable medical devices. The Wolfson Centre also maintains Home Office approved laboratories and holds an Anatomy License for work with cadaveric human tissue. All studies involving human volunteers are conducted in DDA compliant laboratory spaces and have clinical examination areas available for general studies, as well as facilities for manufacture, fitting and evaluation of prosthetic and orthotic devices. The Centre also supports mechanical and electronic workshops. Off-campus research facilities at the Queen Elizabeth National Spinal Injuries Unit (Southern General Hospital, Glasgow) and at the Clinical Research Facility (Royal Infirmary, Glasgow) also support our translational and clinically relevant research programmes.

Driven by the ambitions of our researchers, we continually review equipment capability from its ability to deliver general and routine functions (core needs), but also to identify new technologies that can enhance laboratory sophistication, specialisation and international competitiveness (advanced needs). Equipment funding comes from a formulaic annual allocation from the University, from departmental allocation of overhead income and from equipment support on research grants. Equipment procurement is guided by strategic priorities including support for early career researchers. Large-scale infrastructural funding, for example via the Funding Council's Science Research Investment Fund (SRIF) has been used during the REF 2014 period. Major pieces of equipment covering the many components of the drug discovery process have been purchased during the REF period at a cost of >£1M. These strategic investments include a cell sorter, next generation gene sequencer, single crystal diffractometer and new tableting facilities. Similarly, in excess of £1.5M of new equipment has been installed in the Wolfson Centre and includes investments in advanced material testing laboratory facilities, digital body scanning and computer guided manufacturing of prosthetics and orthotics, a state-of-the-art computer assisted rehabilitation environment and a medical robotics laboratory. In addition to standard research laboratories we operate a number of specialised facilities:

- The Centre for Biophotonics: housing multiphoton confocal and fluorescent microscopes to facilitate our strong and increasing employment of bioimaging technologies.
- The Biological Procedures Unit: containing a wide range of animal species as well as gene-deficient, transgenic and reporter-gene mouse strains for the investigation of immunological aspects of disease through to testing of vaccine preparations and potential drugs.
- The CRUK Formulation Unit: a unique laboratory facility that produces anti-cancer drugs for clinical trials and projects in all 18 Experimental Cancer Medicine Centres in the UK and also elsewhere in the world (for example, in Australia and New Zealand).
- The Centre for Robotic Surgery at Strathclyde (CROSS): a newly established facility developing robotic devices to support more accurate and less invasive arthroplasty.
- Advanced Rehabilitation Research in Virtual Environments Laboratory (ARRiVEL): Commissioned late 2013 with the support of Motek Medical and Vicon this new facility provides a Computer Assisted Rehabilitation Environment for extending our rehabilitation engineering research capabilities for work in assistive technology development and evaluation.

With a history in drug-related research, we also support a unique natural product extract library comprising 5,000 plant species representing > 90% of plant families and facilities for *in silico* compound screening through our Drug Discovery Portal. This is a database of compounds for researchers to test virtually against biological targets identified as having a role in disease.

The £90M TIC investment will provide new opportunities to our researchers and will help our ambition to partner relevant stakeholders in providing solutions to health challenges in both pharmaceuticals and allied health areas. The first major health industry programme in the new TIC building will be CMAC in 2014. As the physical hub for research into the production of high value pharmaceuticals, CMAC illustrates the added value of industrial and academic collaboration in research. We aim to bring more of our research into translatable technologies and interventions that will return substantial health and economic benefits.

e. Collaboration or contribution to the discipline or research base

(i) Effective academic, NHS relations and industry collaboration.

Our researchers are committed to collaboration: many staff interact across academic, clinical and industrial communities. A number of our successful academic collaborations with other universities were highlighted in section B. With respect to clinical collaborations, several members of staff hold joint appointments with NHS Boards including NHS Greater Glasgow & Clyde (GG&C) and NHS National Services Scotland. In these capacities they contribute to and hold membership of a number of senior strategic NHS / academic fora. For example, Bennie sits on the Scottish Antimicrobial Prescribing Group, Farr Health Informatics Research Institute, Executive Governance Group and the MRC Scottish eHealth Research Centre Board. We are also represented on the Glasgow Biomedicine Board, which promotes translational research in the city and has oversight of all clinical trials in NHS GG&C.

Through the CRUK Formulation Unit, Strathclyde produces all formulations for CRUK drug trials and brings together teams from SIPBS, Chemistry and Chemical Engineering through joint awards (see section d, ii). CMAC pools researchers in science and engineering with major industrial partners and co-investigators from other UK universities. Two concurrent and complementary ERDF awards link the life science (KE Hub in SIPBS) and medical devices research sectors (Strathclyde MedTech in BME) by funding SME/academic partnerships, many of which progress to further funding relationships (currently > £2.5M).

Child health policy recommendations in the UK, Canada and Australia on obesity have come from collaborative research with the NHS in physical activity (Reilly and colleagues). Researchers in speech and language therapy have developed with NHS GG&C care pathways in paediatric voice disorders and provided practice guidelines to users on dysarthria, Parkinson's disease and cleft palate. Research engagement with the NHS is also strong across our pharmacy, rehabilitation, and medical devices research groups. Researchers in pharmacy participated in the highly successful development of NHS GG&C's robotics-led pharmacy distribution service, now a model for healthcare providers worldwide. Bennie as Chief Pharmaceutical Adviser, National Services Scotland, works closely with national and specialist services across Scotland in relation to patient safety and pharmacoepidemiology/ vigilance.

We have funded internships from the NHS to stimulate collaboration in pharmacy (Lannigan, NHS GG&C), rehabilitation (Legg, NHS GG&C) and digital health (Fergusson, NHS24). Collaboration and integration with NHS has also resulted in the adoption of new guidelines for antibiotic administration (Thomson). The MRC Lifelong Health & Wellbeing research programme brings Glasgow School of Art, Glasgow Caledonian University and NHS partners together with Strathclyde researchers in novel work on stroke rehabilitation (P. Rowe). Pre-clinical research and randomised clinical trials research also links NHS teams in various boards with groups active in diabetes, wound healing, prosthetics and orthotics, psychiatric disease, stroke, spinal cord injury, and movement disorders. We also have a strong portfolio of research in orthopaedic surgery (P Rowe, Riches) through industry-sponsored trials and in cardiovascular devices (Gourlay) with centres in Texas and Turkey. Through funding from the Scottish Government's Health Directorates we have formed the Scottish Rehabilitation Research Network to engage allied health professionals with the Scottish rehabilitation researcher base.

Company Formation & Licensing: Six companies have been formed (5 spin-outs and 1 start-up) and one license agreement signed over the REF period (detailed in the Impact Template).

(ii) Panel and Advisory Services to Grant Awarding Agencies

RCUK Panel Membership: S. Pyne – BBSRC panel member; Chamberlain, Flint, Harnett – BBSRC Pool of Experts; Black, Conway, Gourlay – chair and panel members, EPSRC responsive mode and specialist grant panels (including Challenging Engineering Fellowships, New Directions

Panel and Healthcare Programme Grants) and with Connolly, all members of the current EPSRC electoral college; Conway – member of the ESRC Commissioning Committee, Grant Awards Panel for the New Dynamics of Aging cross-council funding programme, and the joint ESRC & Canadian Institute of Ageing Panel.

Panel Membership of UK and International Funding Agencies: Royal Society Newton Fellowship panel (Connolly); Royal Society International Exchanges (Alexander; Houslay); Heart Research UK (Gourlay); Science Foundation Ireland (Gourlay, Harnett [Chair]); Asthma UK (Harnett); New Zealand Ministry of Science & Innovation (Gourlay); Translational Medicine Panel (Gourlay); Action Medical Research Bioengineering Panel and Arthritis UK (P. Rowe); Scottish Chief Scientist Office Experimental & Translation Medicine Grant Panel (P Rowe); Diabetes UK (Kirk); German BMBF Obesity Research Networks Panel (Reilly); German BMBF Integrated Research & Treatment Centres Panel on Obesity (Reilly); Research Grants Committee of the Research Consortium of the American Alliance for Health (D. Rowe); Qatar National Research Fund (Connolly); Bill & Melinda Gates Foundation (Connolly); Cancer Research UK's New Agents Grants Committee (Halbert); TSB Biocatalyst Panel (Gourlay); National Nanotechnology Advisory Panel of the Research Infrastructure Support Program, The National Research Foundation, South Africa (Alexander).

Grant Agency Advisory Board Activity: Conway – member of EPSRC Strategic Advisory Teams (SAT) for M3E, Healthcare and Engineering from 2008 to 2013 covering development and implementation of the current EPSRC Delivery Plan. He also participated in EPSRC SAT scoping events leading to the 2013 Centres for Doctoral Training call (£350M) and other grant programme scoping activities including the Lifelong Health & Wellbeing cross-council initiative. Boyd and Conway are trustees of Medical Research Scotland; S. Pyne - member of the Tenovus Advisory Board; Lawrence – member of the Finnish National Academy Review Board.

Other Research Advisory Roles: Black – member of the Institute of Physics & Engineering in Medicine Publications Committee. Cohen – chair of the Royal College of Speech & Language Therapists Special Interest Group (Scotland) Voice. Connolly – chair of Royal Society of Edinburgh Engineering Section Committee, member of the advisory board of NanoMetNet, Scottish Medtech Steering Group and the NHS-led Scottish Health Technologies Group Industry Users Forum. In 2012, she was invited to join the international advisory panel for Biomedical Engineering at Hong Kong Polytechnic University. Conway, in 2013, was invited to join the University of Cambridge International Visitor Committee to advise on the development of bioengineering research at Cambridge. Gourlay – chair of the Health Technology KTN, Cardiovascular Specialist Interest Group and since 2012 advisor to the National Institute for Health & Clinical Excellence (NICE), Medical Technologies Evaluation Program. Grant – member of the MHRA Expert Group on the long-term safety of metal orthopaedic implants. Lowit – member of Ataxia UK advisory board for practice guidelines and national advisor on Foreign Accent Syndrome. MacKenzie – professional advisor to the Stroke Association and the Stroke Managed Clinical Network, NHS GG&C. D Rowe – member of the expert panel on Objective Measurements of Physical Activity. P. Rowe – member of Executive Committee, International Society of Biomechanics. Reilly – member of the WHO Department of Maternal, Infant, Child & Adolescent Working Group; member of the NIH Objective Monitoring of Physical Activity Working Group. In the REF period, Conway and Gourlay have been elected committee members of the Bioengineering Society.

(iii) Support for Journals and International Conferences

Editorial Activity (Journals) examples: Alexander *Infection and Immunity and Microbes and Infection*; Black *Medical Engineering and Physics* (Editor-in-Chief); Connolly *Biosensors* and *Proceedings of the IMechE, Part H: Journal of Engineering in Medicine*; D. Rowe *Measurement in Physical Education & Exercise Science; Journal of Physical Activity & Health*; Edrada-Ebel *Marine Drugs*; Grant *Toxicology in-vitro* and *The Scientific World Journal* ; Harnett *Parasitology*; Hoskisson *Microbiology Today* (Editor-in-Chief); Houslay *Cell Signalling* (Editor-in-chief); Kennedy *British Journal of Pharmacology*; Kirk *Nutrition, Metabolism & Cardiovascular Disease*; Reilly *Pediatric Obesity*; Kumar *Journal of Biomedical Nanotechnology* (Editor-in-Chief); *Cancer Nanotechnology*; MacKenzie *Aphasiology*; N. Pyne *Cellular Signaling* (Deputy Editor-in-Chief); P. Rowe *Journal of Bioengineering & Biomedical Sciences* and *OMICS*; Roberts *Parasite Immunology*; S. Pyne *British Journal of Pharmacology* and *Cellular Signaling* (Co-editor); Thomson *Journal of Antimicrobial Chemotherapy.*

Conference committees/organisation examples: Alexander *Immunobiology of Health and Disease* (2008) and *Royal Society/NRF Workshop Program on Parasitic Infection and Chronic Inflammation* (2011), both Cape Town; Ferro *Adjuvant* (2010) and *Vaccipharma* (2012) both Cuba; Florence *4th European Congress for Crystal Growth* Glasgow 2012 ans *APS PharmSci Conference* Edinburgh 2013; Hoskisson *16th International Symposium on the Biology of Actinomycetes* Vallarta Mexico; Lawrence (Meetings Secretary) *British Society for Parasitology Meeting* Strathclyde, 2012; McCarron *9th (Australia; 2008) and 10th (Denmark; 2011) International Symposia on Resistance Arteries*; McConnell *European Light Microscopy Initiative Conference* Glasgow 2009; N. Pyne *Gordon Research Conference, Phosphodiesterases* Ciocco Italy 2008; S. Pyne *8th International Sphingolipid Meeting* Glasgow; Roberts *10th International Toxoplasma Conference* Roiduc Netherlands 2009; Watson (awarded in competition) *2013 Meeting of the Metabolomics Society* Glasgow; Gourlay *40th meeting of European Society for Artificial Organs and Bioengineering* Glasgow 2013; P. Rowe *12th Annual Meeting of Clinical Movement Analysis Society, 22nd Annual Meeting of the European Society for Movement Analysis in Adults & Children* (both Glasgow, 2013) and with Riches, local organisers of the *25th Biennial Congress for the International Society of Biomechanics* Glasgow 2015; Grant *Eurotox 2014 (International meeting of European Toxicology Society* Edinburgh.

(iv) Other marks of research esteem

International Co-authorship, invited review commissions and keynotes, fellowships & prizes: Publications represent key evidence of successful collaborations and our researchers have published joint research papers with colleagues throughout the world. As examples, from Europe: Germany (Wiese), Italy (Bushell, Lakany, Riches), Denmark, Switzerland, Netherlands (Conway), Ireland (Riches), Spain (N. & S. Pyne), France and Turkey (Gourlay); from North America: USA (N. & S. Pyne, Conway, Harnett, Roberts, Wiese, Winn), Canada (Conway, Harnett); from South America: Brazil (Winn); from Africa: South Africa (Alexander, Roberts); from Asia: Bangladesh (Ferro) and Japan (Flint); and from Australia (N. Pyne, Riches).

Further evidence of standing and influence are the increasing numbers of invited review articles for high impact journals and prestigious invitations to lecture. During the REF period, each of N. Pyne, S. Pyne, Harnett and Pratt were invited to write reviews for the Nature series of journals; Kumar was invited to submit a review to Chemical Reviews (impact factor, 40) and N and S Pyne were invited to publish a commentary in Cancer Cell (impact factor 26). N. Pyne delivered the closing Special Symposium lecture at the 49th (2008) meeting on Advances in Enzyme Regulation in Normal and Hyperplastic Cells (Hans Krebs lecture) and each of N. Pyne (2012), S. Pyne (2010) and Flint (2012) spoke at a Gordon Conference. FASEB International Conferences invited S. Pyne to deliver keynotes at 2 events and N. Pyne at 1 event.

Harnett was a plenary speaker at Keystone Symposia in 2009 and 2011, and McConnell was an invited speaker at SPIE Photonics West, San Francisco in 2013. In addition, Conway spoke at the motor control satellite symposia for the Federation of European Neurosciences (FENS 2010) and was invited to contribute to the North American Clinical Trials Network, Task Force on Assessment in Spinal Cord Injury in association with the Christopher Reeve Foundation.

Fellowships and prizes: Chamberlain and McConnell held prestigious MRC Senior and RCUK Fellowships, respectively. We hosted 2 Royal Society of Edinburgh Enterprise Fellows; SIPBS in collaboration with NHS GG&C won a Chief Scientist Fellowship in pharmacoepidemiology (2013). Other society fellowships awarded since 2008 are: L Harvey, Pratt, Winn – Society of Biology; Kennedy – British Pharmacological Society; Winn – Association of Psychological Sciences (USA); MacKenzie – Royal College of Speech and Language Therapists; McNeill – Institute of Chemical Engineers. In 2012, Houslay received the Joshua Lederberg Award from Celgene for contributions to drug discovery. Maclean and Anderson's work on light based decontamination technologies won The Times Higher Research Project of the year award in 2011. Kumar received the RPSGB British Pharmaceutical Conference Science Medal in 2012, and P Rowe in 2013 won the RCUK advisory group of experts on aging "Translating Research Award" for his work in stroke rehabilitation.