Institution: Swansea University

Unit of Assessment: 03 Allied Health Professions, Dentistry, Nursing and Pharmacy

1. Unit Context and Structure, Research and Impact Strategy

1.1. Unit Context and Structure

Swansea University Medical School (**SUMS**) trains tomorrow's biomedical scientists, pharmacists, physician associates and doctors in a supportive and inclusive research environment. This environment gives our researchers freedom to undertake interdisciplinary and collaborative research, develop innovative approaches to health-related problems, and expand the knowledge economy.

SUMS was established in 2004 as a strategic initiative of the Welsh Government and Swansea University, building on the 2001 Clinical School. Since then, we have grown rapidly: within this REF period our research spend has totalled £94m, up 130% from REF2014 and 320% from RAE2008; and research doctorates awarded have totalled 162.5, up 169% from REF2014 and 300% from RAE2008.

Teaching and learning are integrated with our research. In addition to our medicine, genetics, and biochemistry programmes, in this REF period we have launched pharmacy, applied medical sciences, physician associate, medical pharmacology, and population health degrees, each reflecting continued research area expansion.

Research is housed in the **Institute of Life Science** (**ILS**), a collection of buildings on the Singleton campus. More than £100 million has been invested in the **ILS** research environment through the European Funding Office for the **ILS1 Building** in 2008 and the **ILS2 Building** in 2012. In the current REF period, we delivered the third stage, the **Data Science ILS3 Building** (2015, £8m). Together, these buildings provide more than 12,000m^2 of interdisciplinary facilities to support our four core strategic *Research Themes* focusing on fundamental biomedical science and translational medicine: **Biomarkers and Genes**, **Medical Technologies**, **Microbes and Immunity**, and **Patient and Population Health & Informatics** (**PPHI**). Researchers are members of a specific theme but are usually active *across* themes and can achieve this by accessing any of our five core infrastructure *facilities*: the **Secure Anonymised Information Linkage (SAIL) Databank** (previously '*e-health and informatics*'), the **Centre for NanoHealth (CNH)**, **Biomedical Laboratories**, **Clinical Research Facilities** (**CRF**, trials, imaging and patient research), and **Commercial Incubators**.

Within our themes, we have flagship interdisciplinary centres: the **British Heart Foundation Cymru Research Centre**, the **Biorefining Centre of Excellence (BEACON)**, the **Celtic Advanced Life Science Innovation Network (CALIN)**, the **Accelerate Healthcare Technology Centre (HTC)**, and the extensive **Data Science** centres (including the **SAIL Databank**, Farr Institute for Health Informatics, Administrative Data Research UK, Health Data Research UK, and the UK Secure eResearch Platform (UKSeRP).

The **ILS buildings** open directly into one of the major hospitals in the Swansea Bay University Health Board, ensuring strong NHS links. All **ILS** buildings have incubation space for product and technology development. Hence, the NHS and commercial enterprises are co-located within the **ILS**, which continues to mature and build on the early success evidenced in previous assessments.

1.2. Research Objectives

1.2.1. Research Strategy

Each theme is led by a senior academic who reports to a Research Committee, which is focused on delivering the research strategy, and in turn reports to a Senior Leadership Team, which has responsibility for research, internationalisation, commercialisation, and research-led teaching. Longer-term strategy is informed by an external advisory group, chaired by Professor Julian Hopkin CBE, who was appointed School Rector in 2017. Following REF2014, a five-year strategy was published in 2015, and this was reviewed, updated and published in 2020, with a consolidated focus on the four themes.

1.2.2. Review of REF2014 Projections

All key objectives specified in the REF2014 submission were achieved:

Objective 1 Deliver impactful research across all four themes: At least one impact case study (ICS) from each theme has been submitted to REF2021.

Objective 2 Expand e-Health and SAIL capacity: CIPHER (2013-16); the Farr Institute (2015); the ESRC Administrative Data Research Centre (2014-2018), ADR Wales (2018); and a founding centre for Health Data Research UK. In 2015, we built the Data Science Building (projected as 'ILS3' in REF2014). These actions fulfilled our promise to help lead "a *revolution in our ability to answer a host of questions that were previously intractable*" (Professor Paul Boyle, Chief Executive of the ESRC, Oct 2013).

Objective 3 Seek Horizon 2020 funding: SUMS-led H2020 projects including PATROLS (€12.7m, 2018) successfully awarded.

Objective 4 Target EU Convergence Funding: SMART Expertise (£1.2m, 2017) collaboration on therapeutic exosomes; two Sêr Cymru capacity building awards; the Swansea-based Digital Health Care Technology Centre, part of the All-Wales £24m Accelerate HTC (2018); and the CALIN Interreg EU project (£10.7m, 2016).

Objective 5 Build stronger links with the College of Science: The University's Science and Innovation Bay Campus was delivered in 2015. We have strengthened long-standing links in nanotechnology with the Colleges of Science and Engineering. Exemplar new partnerships with the Bay Campus include BHF Centre, rheology, data science and UKRI-supported COVID-19 modelling with mathematics at the £33m Computational Foundry.

Objective 6 Expand our footprint in developing programmes in bio-entrepreneurship, innovation and health informatics: As well as ILS3 (Data Science) further ILS expansion ('ILS4') is continuing as scheduled in sync with the early stages of A Regional Collaboration for Health (ARCH), a partnership with Swansea Bay and Hywel Dda University Health Boards established to improve the health, wealth and wellbeing of the Welsh population.

1.2.3. Current research strategy

Our current research strategy aims to:

1. Develop staff, particularly early career researchers (ECRs), to enable them to excel
2. Secure research income from diverse, private, public, and third-sector sponsors
3. Build critical mass, ensuring sustainability for key research areas
4. Foster interdisciplinary research activity

Successful progress towards these objectives is outlined below:

1. Develop staff, particularly early career researchers (ECRs), to enable them to excel

Two ECRs identified in REF2014 have progressed to Professor level. Professor Shareen Doak leads on the multi-million-pound Horizon 2020 project (PATROLS), directs the interdisciplinary CNH and has authored the Global Nanosafety impact case study (ICS1). Professor Yuqin Wang, now theme lead for Microbes and Immunity, is the recipient of BBSRC funding, and co-authored the sterol analysis impact case study (ICS4).

2. Secure research income from diverse, private, public, and third-sector sponsors

Exemplar achievements within each theme, during the current REF period, include:

In **Biomarkers and Genes**, the British Heart Foundation Sir Thomas Lewis Chair of Cardiovascular Science received £2.3m in funding for a research group focussed on molecular cardiology. A programme of mass spectrometric analysis of lipids and proteins was supported by UKRI for more than £2m.

Building on long established Swansea strengths in genetic toxicology and nanomedicine, researchers in **Medical Technologies** launched the Horizon 2020-funded PATROLS in 2018. PATROLS is a €12.7m global project to address the need for safer and more effective nanomaterial testing. SUMS heads a remarkable 24-institution partnership across 13 countries, from Europe to the USA and Asia.

In **Microbes and Immunity**, the BEACON Biorefining Centre of Excellence was renewed. BEACON is a £12m partnership between Swansea, Aberystwyth and Bangor Universities, working on biomass and biowaste conversion into biofuels, bioplastics and platform chemicals while building strong links with the business community. The project reflects commitment to the green agenda (Swansea University consistently ranks within the top 10 Green League UK Institutions).

In **PPHI**, an exemplar of our strategy and investment success is the evolution of health informatics from pioneering work of the Health Informatics Research Unit in (2006) establishing the SAIL Databank, to the MRC's Centre for Improving Population Health through E-Health Research (CIPHER; 2013-2016); the Farr Institute (2015, £9m); the ESRC Administrative Data Research Centre (£8m, 2014-2018), continued as ADR Wales (2018, £4.3m); and a founding centre for Health Data Research UK (£4.5m with funding from the MRC, EPSRC, ESRC, NIHR). For simplicity in this narrative, we collect these many activities under the broad banner of 'SAIL', the technical facility at the heart of these developments.

3. Build critical mass, ensuring sustainability for key research areas

A number of strategic appointments were made within this REF period. In 2014, Professor Humphrey**,** Professor of Bacteriology and Food Safety, with a strong BBSRC track record, was appointed to strengthen and expand microbiology within Microbes & Immunity. In 2015, Dr Clift**,** an ECR with established links in Switzerland and the wider nanotoxicology community, was appointed to the Medical Technologies theme. In 2015, Professor Fegan was appointed as Director of Swansea Trials Unit. A statistician involved in global health research, he oversaw the registration of the unit, ensuring ongoing capabilities within PPHI. In 2017, Biomarkers and Genes became the host theme for Wales' British Heart Foundation (BHF) group, bringing with it the expertise of Professor George (Molecular Cardiology), thereby expanding SUMS' research portfolio.

4. Foster interdisciplinary research activity

Sustainability in interdisciplinary research can be evidenced by the following theme exemplars (chosen here *in addition* to interdisciplinary projects already mentioned above):

- Biomarkers and Genes: With funding from the Swansea-Grenoble strategic collaboration, researchers in the CNH are investigating the therapeutic potential of selenium in ovarian cancer. The interdisciplinary team of **geoscientists, engineers, physicists and cell biologists** formulate nanoparticles and monitor epigenetic modifications.
- Medical Technologies: The rheology programme based in the CNH (EPSRC funded) brings together **biomedicine, physics, engineering and clinical researchers** for scientific and commercial outputs.
- Microbes and Immunity: Professor Paul Dyson's BBSRC funded work (in the Biomedical Laboratories facility) **combines entomology with genomic techniques** to develop biocide alternatives to pesticides.
- PPHI: through HDRUK and ADRN **computer scientists, clinicians and linguists** are developing innovative natural language processing (NLP) tools to extract and link with the SAIL Databank. SAIL enables interdisciplinary outputs in cardiovascular, pharmaceutical, and genetic studies.

Our major new interdisciplinary partnership is **A Regional Collaboration for Health (ARCH)**, a partnership with Swansea Bay and Hywel Dda University Health Boards established to improve the health, wealth and wellbeing of the Welsh population. **ARCH** is a key strand of the £1.3 billion City Deal for the Swansea Bay region. The aim is to ensure that a diverse, inclusive and rewarding culture is built among researchers, NHS, innovators, educators and their institutions. This culture is essential to meet the challenges of modern healthcare in a low-income region with high health burden and inequality. Our contribution to **ARCH** is focused on big data, clinical trials and biomedical research. The Colleges of Science and Engineering at Swansea University are partners, and Phase 1 of the development has invested in new buildings and staff at Morriston (Science Park) and Singleton (Digital Health Care Technology Centre) hospitals.

Further evidence for commitment to interdisciplinary research is provided by significant partnerships in three additional Swansea University impact case studies: Mitigation of the severe impact of COVID-19 on medical provision, hospitalisations and deaths in Wales through mathematical modelling (with Mathematics, UoA 10); Paying for Plagiarism: Tackling Contract Cheating, Ghost-Writers and Essay Mills in Higher Education (with Social Work and Social Policy, UoA 21); and Translation of Technology into Healthcare via University Spin-out *CanSense Ltd*, Raman Spectroscopy for Colorectal Cancer (with Physics, UoA 9). Such cross-University collaboration is bolstered by interdisciplinary co-supervision of PhD students with Engineering (10), Management (5), Human and Health Sciences (4), Science (6) and Law (1).

1.2.4. Future Research Strategy

Our current strategy runs until 2025, with an interim review in 2022, informed by REF2021 and the new University faculty re-organisation. There will be opportunities from our new programmes in pharmacy, in alignment with UKRI, UK Government, and European priorities. We aim to:

1. Develop new funder relationships to **diversify our funding portfolio** and prevent over-reliance on a single source
2. Maximise **interdisciplinary research opportunities** across the University through engagement with the Morgan Advanced Studies Institute (https://www.swansea.ac.uk/masi/)
3. Develop a **sustainable pipeline of talent** by supporting Early Career Researchers (ECRs) to flourish
4. Focus research activity on **key global health issues** building critical mass to tackle these challenges

Future strategy will also capitalise on opportunities generated by the University faculty structure, to be introduced in 2021, which will bring closer links with the current College of Human and Health

Sciences and the Department of Psychology. Over the next five years, we will continue to invest in established areas of excellence. We will align our strategy to UK and International funder priorities and will promote our expertise on the international stage, an approach that has attracted prestigious research funding. We will attract and retain world-class academic staff at the forefront of their disciplines.

1.3. Impact Strategy

Our strategy is based on early identification and investment in promising projects, adding depth to promising activities, while acknowledging that success may take considerable time. SUMS' investment in impact activity has included seedcorn funding, website development, dissemination materials (videos and animations) and international networking (travel and conference attendance to engage with beneficiaries).

We maintain an idea register and have monitored the progress of > 30 initiatives, from which five of our strongest case studies were selected. Three of our five impact case studies (ICS) were highlighted specifically in a prospective portfolio for impact reported in our REF2014 impact statement. By focusing on pathways to impact in this manner, we have been able to strategically target investment in these case studies, evidenced as follows:

- ICS1: our case study on **Global Nanosafety** builds on many years of strategic investment in genetic toxicology at Swansea and was specifically supported by appointing a new senior lecturer in 2015 (in addition to considerable external funding success, e.g., PATROLS).
- ICS2: the **Azole Antifungals** case study came to fruition after long-term investment in three professorial positions, backed over this period by a full-time appointment of a research assistant, and BEACON funding.
- ICS3: the **PRISMATIC** trial benefited from the priority investment in the SAIL Databank, the academic appointments of an associate professor in health service research and a professor in Statistics, and funding awarded through NIHR**.**

ICS1-3 were highlighted as prospective case studies in our REF2014 impact strategy submission.

- ICS4: on the use of a **Novel Sterol Analysis** for the diagnosis and treatment monitoring of inborn errors of metabolism was supported by strategic refurbishment of a mass spectrometry laboratory in ILS1, the securing of BBSRC and Sêr Cymru awards, the appointment of technical support, and IP licensing assistance.
- ICS5: on **Suicide and Self-Harm Prevention**, resulted from the 2017 appointment of a new chair in public health and psychiatry and benefited greatly from the SAIL Databank facility along with MRC and charitable investments.

Continued impact is overseen by a dedicated SUMS Impact Officer (appointed 2015), and an Impact & Engagement Officer from the University's life science research support hub. Starting at the undergraduate student level, student projects have been designed to understand pathways to, and the development and presentation of, impact using the REF2014 database. Embedding an understanding of impact at all levels of staff and students is achieved through seminars, staff forums and individual support, embedding the University's founding ethos of research as a means to serve society.

Our current prospective impact portfolio includes the following: targeting tumours with bacteria, tissue engineering using 3D bioprinting, the UKSeRP at the SAIL Databank and patient-reported outcome measures in health research (PROMS).

1.4. Research Integrity

1.4.1. Research Ethics

Support for a strong research governance environment begins at our unit-level **SUMS Ethics and Integrity Committee**. This committee was launched (2017) to meet a growing need for specialised support, in particular in biomedical sciences and health data linkage, to support

expansion in research student projects and numbers of professional practice projects. The committee chair coordinates online integrity training for all staff, represents SUMS at the University Institute of Ethics and Law, delivers termly seminars on integrity, and lectures on research ethics and integrity to all research students on induction. The committee reports to the SUMS Research Committee and the wider University Research Ethics and Governance Committee.

SUMS researchers also have close links with NHS Wales Research Ethics Committees 6 and 3 (in particular through the Clinical Research Facilities), contributing long-standing committee members and regular review expertise. A SUMS emeritus professor is chair of the Swansea Bay Health Board Joint Study Review Committee. A research licence from the Human Tissue Authority was awarded in 2016, and we have an Animal Welfare and Ethical Review Process. All staff and PGR students involved with patient-facing research receive training in good clinical practice delivered by HCRW/NIHR to ensure the safeguarding of patients, data, and adverse event recording.

As part of **UKSeRP**, SAIL holds ISO 27001 Information Security Management System (ISMS) and DEA accreditation under the UK STATS Authority, which is externally certified by independent industry assessors, demonstrating SAIL's commitment to legal, physical and technical controls to secure data throughout its lifetime. Additional ethical control and advice on all proposed SAIL projects are provided during a mandatory (internal and external) Information Governance Review Panel application process.

1.4.2. Open Access/ Open Scholarship

All SUMS papers are deposited in the University-maintained **CRONFA** open-access repository, making them discoverable, free to read, downloadable, and searchable by anyone with an internet connection. For **open data** that can be publicly archived, we make regular contributions to the Zenodo data repository maintained by CERN, GenBank databases at PubMed, NCBI, EBI, European Nucleotide Archive, Dryad, and Protein Data Bank. Some major projects have bespoke open data directories; for example, PATROLS complies with the H2020 open access to research data scheme, with all data available through the European Union Observatory for Nanomaterials database.

Critical constraints over the use of personal health data are essential to comply with security requirements and preserve anonymity. Through **SAIL**, we have shaped international standards on the use of such data. We have novel secure protocols that allow access so that *any* bona fide researcher from *anywhere in the world* with a project with potential public benefit can access **SAIL** and work with it easily and remotely. There is no charge for the use of data. It allows researchers to move away from aggregated data to individual linked longitudinal national-scale cohorts, including primary and secondary healthcare records; social services; ambulance services and NHS111; intensive care; pathology services; birth, mortality and census registers from the Office for National Statistics (ONS); pharmacy and dispensing records; cancer registers, screening services, waiting times and national referral schemes; education data from Key Stage 1 to university; fire and rescue services; and a suite of COVID-19 data and other health and administrative data sources. **SAIL** has influenced data-intensive initiatives worldwide. Furthermore, we have **GitLab** open repository software for all **SAIL** research projects to catalogue source codes used in research, along with a data source library that **SAIL** leads as one of the pioneers and alliance members to a UK initiative (https://www.healthdatagateway.org/), exactly as they were used in publications. This allows checking and reproducibility/replicability at later stages (regular code contributions are also made to **GitHub**). **SAIL** has recently opened the **UKSeRP** research cloud specifically designed to support secure use and storage of secondary data (https://serp.ac.uk/).

In the Clinical Research Facilities (CRF), all trials are registered on **ISRCTN** or **clinicaltrials.gov**, and the publication of protocols, including analysis plans, is standard operating procedure. We offer an outstanding environment for study replication, extended follow-up and open scholarship involving clinical trials by embedding data within the **SAIL** system. Newly collected trial data can be brought into the databank, with the added benefit of security, documentation, and accessibility,

and the trial data can be expanded upon in follow-up or retrospectively (subject to ethical approval).

2. People

2.1. Staffing strategy and staff development

The University's Performance and Development Review (PDR) process is based on individual staff key performance indicators (KPIs) related to goals such as grant income, teaching, publication, PGR supervision and achieving impact. Line management structure is aligned with research themes, and PDR meetings take place every six months. The University is committed to the Concordat to Support the Career Development of Researchers and the Vitae Research Development Framework.

2.1.1. Promotions and recruitment in current REF period

All Category A staff have permanent contracts supported by the School Business Plan. Five current Cat A staff moved from fixed term to permanent positions, **eight staff were promoted from lecturer to senior lecturers, 10 were promoted to associate professor and 11 were promoted to professor**. There are currently significant opportunities within the business plan to prioritise investment in multiple junior lectureships within areas of strength. This process began in 2020 with the appointment of two lecturers and two senior lecturers and will continue in 2021.

Recruitment and promotion have strengthened all research themes, with notable effects on outputs and impact:

PPHI	ICS3 was supported by the appointments of **Alan Watkins** in 2014 (with promotion to professor in 2019) and **Alison Porter** as associate professor in 2017 and the promotion of **Hayley Hutchings** to professor in 2016. ICS5 was led by **Ann John**, promoted to professor in 2017. **Kerina Jones** was awarded a chair in 2018, associated with the SAIL expansion. Professor **Greg Fegan** was recruited in 2015, to lead the Swansea Trials Unit.
Biomarkers and Genes	ICS4 was co-led by **Yuqin Wang**, promoted to professor in 2018. The British Heart Foundation team (4 staff members) was welcomed into SUMS in 2017.
Microbes and Immunity	**Cathy Thornton** and **Gwyneth Davies** were appointed to chairs in 2014 and 2018, respectively, both took on deputy head of school roles and have contributed strong outputs to the current REF submission.
Medical Technologies	ICS1 was led by **Shareen Doak**, promoted to professor in 2014, and she has been supported by the recruitment of **Martin Clift** as senior lecturer in 2017, (now promoted to associate professor).

2.1.2. Support mechanisms for staff development

We have two dedicated research support advisers in the University's Life Science Research Hub who identify funding, circulate new call updates and provide assistance with costing. The bid development team hold weekly surgeries to nurture applications from an early stage, encourage best practise and offer training in bid writing skills through a support blog. Our Research Committee and theme leads provide an internal peer-review process for grants prior to submission. Our head of school provides a weekly email update on SUMS activities and takes this

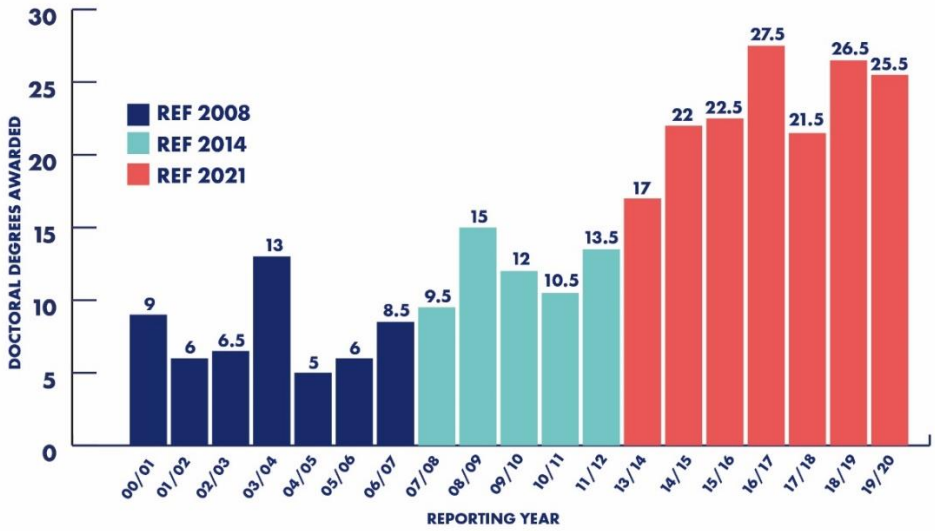
opportunity to highlight staff and student achievements, publications and grant success. We celebrate research achievements at a peer-nominated annual awards ceremony.

Additional support and reward for research is provided through several mechanisms. **Grant overheads are returned** at a rate of 5% to the principal investigator, and a **PGR studentship is awarded** for every £100,000 overhead in awarded income. **SUMS has invested £490K in equipment maintenance**, ensuring continuity of facilities throughout the life span of the projects. The supervision of each student research project is rewarded through an allocation of £150-£750, depending on the programme (BSc/MSc/PhD), plus an additional research allowance for undertaking significant management roles. In 2018, a new lectureship was awarded on the basis of recognising the overall contribution of a team to the wider SUMS environment. Our bid for University PGR studentships is also directed strategically to areas of research strength and ECR potential. We have **underwritten several strategic laboratory refurbishments** (linked to ICS4) and the 50% costs of equipment associated with UKRI awards. Sabbaticals were supported during the period, with host institutions including Cambridge University, Woods Hole Oceanographic Institution and Harvard University.

Specific support for ECRs comes from our own charity, **St David's Medical Foundation** (SMDF), which prioritises annual seedcorn grants (£6000 x4) for ECR projects. We focus on helping ECRs recruit PGR students through our bids for University studentships (17), distribution of doctoral training grants (11 through the ESRC and EPSRC) and 50% funding on Sêr Cymru awards (9). Grant writing support (for all staff) is available from the University's Life Sciences Research Hub, and we support ECRs in leadership training e.g., participation in the Welsh Crucible programme. In SUMS, ECRs are allocated a mentor and a probation supervisor, both of whom assist them in developing and implementing a successful research strategy. In addition, SUMS supports new academic staff to help establish independent research activities by minimising teaching commitments.

2.2. Training and supervision of research students

Our thriving research student community has increased significantly, with 162.5 research degrees awarded in this REF period (average of 23 per year, up from an average of 12 for REF2014 and 8 for RAE2008, see figure below).



NB: Fractional headcount reflects interdisciplinary cross-college PGR supervision (see 1.2.3.)

Of these, 50 were supported through UKRI, NIHR or Health Care Research Wales (HCRW). Notable studentships with significant industrial/international involvement include:

- RCUK Industrial Case Awards

- ESRC Doctoral Training Programme in Data Science, Health and Wellbeing
- BBSRC GW4 Doctoral Training Programme Associate Partner
- Knowledge Economy Skills Scholarships scheme
- Collaborative PhD programmes with the Methodist Hospital Research Institute in Houston, Texas, and Grenoble Alpes have led to 12 PhD studentships

PGR students are recruited following funder guidelines, with EDI considered, and are then treated inclusively as research team members. PGR student facilities include individual workstations; free on-site poster printing/photocopying; a hub in ILS1 with a meeting area and cafe; a hub in ILS2 with digital presentation facilities, a kitchen and respite rooms (for return from maternity leave or return after illness). Students benefit from extended online access to healthcare literature at the adjacent NHS library system. **PGR students contributed as authors to 22% of papers** selected as our REF outputs. Sustainability around PGR recruitment benefits from strong links to our undergraduate and masters programmes, with 36% of the PGR completions being researchers who completed taught study with us.

A new strategy for PGR support was delivered in 2019. Within SUMS, students are supported by a **dedicated PGR office team and PGR Committee**, with progression formally monitored via an initial research proposal (and 'confirmation of candidature' review by two independent researchers at 3 months). A **1st year viva** determines progression from year 1 to year 2, with three academic staff who assess written work, understanding, work plan, supervisor input and student experience. As well as assessment, this serves as practice for their final viva.

All students present at **an annual postgraduate research conference** to develop presentation skills and practise answering (and asking) questions in a friendly, and realistic, conference environment. The conference is entirely organised (advertising/timetabling/plenary speakers/entertainment) by PGR students themselves. Prizes (£500 conference travel) are awarded for talks, posters and 'contributions from the floor'. The conference includes a '3-minute thesis' competition, and winners compete at the University and regional level. PGR students participate in the University's 'Research As Art' competition.

All PGR students attend an induction, including lectures on research conduct, ethics and research integrity, research impact, writing skills, and presentation skills. An in-house statistics and data analysis course, equivalent to a 20-credit master's-level module, is provided. The 1st year viva, PGR conference (including organisation), travel bursary and statistics course were all developed after **requests, consultation and feedback from the research student body.** There is a staff-student consultation committee and two student representative roles on the PGR Committee.

A recent innovation has been led by SAIL researchers, many of whom have technical backgrounds (e.g., in computer science) and are qualified at the undergraduate or master's level. Staff are now offered the opportunity to pursue a research degree, either through part-time study or longer term through PhD by published work. This not only offers significant staff development opportunities but also is a strategy to train a new type of researcher to meet the needs of data science (aligned with UKRI priorities): researchers with the ability to understand routine health data nuances and limitations, combined with statistics, programming, databases, and data visualisation, and who are aware of the biological and clinical plausibility of research questions. Such researchers can be difficult to recruit directly. **Twenty-four staff members have registered as PGR students** and have been **awarded staff bursaries that cover all tuition fees**. This programme is set to expand, and we awarded our first MD by published work in 2018.

A second innovation has arisen from the strong links between SAIL and the informatics teams at Public Health Wales (PHW), where many of the key datasets originate. We currently have two PHW statisticians seconded at SAIL, who deliver priority COVID-19 projects but also are now registered for research degrees. As these are already experienced health data scientists, this programme offers substantial enrichment of both the SAIL and PHW research environments. We believe these initiatives offer a model for how national data linkage projects can work efficiently, and we envisage the programmes expanding, with further potential at the ONS and the NHS

Wales Informatics Service. Two current SAIL staff were also recruited following our **SAIL Summer Internship scheme**.

2.3. Equality and Diversity

In 2020, a **SUMS equality and diversity working group** was established to ensure that key principles are embedded in all policies and practices (chaired by the head of school).

Our commitment to equality is evidenced by long-standing success in the **Athena Swan** (AS) programme. The school achieved a **Silver Award in 2015**, successfully renewed (2019) until April 2023. We have an active AS programme, with an annual culture survey (since 2012) and seminar series (recent topics including bullying and harassment; the health board BAME network; career networks; unconscious bias; the use of social media; and professionalism, equality, diversity and inclusion in science). The AS assessment team is comprised of 20 female and six male staff from both academic and professional services. Notable EDI achievements include:

- Improved gender balance of all committees. All three deputy heads of SUMS are female, enabled by job share.
- Critical AS friend to King's, Exeter, Cardiff and Sydney Universities.
- Member of REF2021 EDAP (A Davies).
- PGR numbers have met gender equity every year (in terms of applications, offers, acceptance and completion rates).
- Data monitoring shows no evidence of vertical segregation in research staff.
- Since 2017, SUMS has offered several places on the **Aurora Leadership Development for Women** programme (five in 2019) to enable engagement with leadership from an early stage. Two participants were promoted to associate professor and one to professor.
- Equity in grant award values. Annually, 30-40% of grant applications are female led (against a background of 23% female CatA staff).
- Progression of female staff to professor has increased over the period and exceeds national benchmark levels (AS renewal award submission).
- Data monitoring previously highlighted a lower than national benchmark level of female clinical academics, making this a focus for improvement. This has required active engagement with NHS partners on recruitment, resulting in reaching equity at the senior lecturer/associate professor level, the appointment of our first two female clinical research professors, and a significantly more gender-balanced researcher community.

SUMS has signed the British Medical Association **BAME Charter** and is represented on University BAME initiatives and the health board BAME network by Honorary Professor Farah Bhatti OBE. In response to the Black Lives Matter movement in 2020, the head of school convened meetings with student representatives to hear concerns. Swansea University takes part in **Stonewell's Workplace Equality Index** and in 2020 was ranked 47th in the league table of *all UK* employers and 6th for *all education* establishments. The school's pride flag is raised for LGBTSTEM Day, and we marked World AIDS Day 2019 with fundraising and seminars. In 2019, we changed pronoun badges and door signs to help create a more inclusive environment. We are represented on the All-Party Parliamentary Group at Westminster on **Diversity and Inclusion in STEM** (British Science Association) by Dr Aiden Seeley (Biomedical Sciences lecturer), who has been **awarded the inaugural British Pharmacological Society's Equality, Diversity and Inclusion Prize** (sponsored by AstraZeneca). In 2016, the University introduced the Mx title in application forms to be inclusive of non-binary and trans staff/students.

We are a **bilingual school** and University, and committed to Welsh Language Standards and compliance with the National Assembly for **Wales Official Languages Act 2012**. One of the deputy heads of SUMS, Professor Gwyneth Davies, is the Welsh Language Lead. Professor Davies sits on the University Welsh Language Strategy Committee and is a Welsh language interviewer and health board liaison. Ten staff are annually engaged with bilingual supervision of

PGR or undergraduate research projects. A dedicated member of our research staff (**Coleg Cymraeg-**funded) facilitates thesis writing, viva preparation and support for funding applications.

A senior researcher with physical disabilities is supported by provision of a dedicated technician to assist with laboratory work and through laboratory modifications. We have also made necessary adjustments for visual impairment at the bench and throughout PGR candidature and examination procedures. Recent adjustments to laboratories through the Accelerate HTC **provide accessible and adjustable bench space**. Annual workshops have focused on living with visual disabilities and mental health.

A new **University wellbeing strategy** was published in 2020. The school operates on flexible working hours and has family-friendly hours. Staff have arranged phased returns after ill health and can work condensed four-day weeks, part-time, and from home. The University has enhanced statutory entitlement; therefore, all pregnant employees are entitled to 52 weeks maternity leave (regardless of service). For researchers , where external funding does not provide coverage, staff may apply to a central University maternity fund allowing principal investigators to employ temporary cover. Mental health initiatives are actively supported by the Head of School Keith Lloyd (professor of psychiatry) who advises on the Health for Health Professionals national scheme, and Deputy Head Ann John (trustee of the Mental Health Foundation), who leads on several MQ funded grants on student wellbeing. In Wales, the **Wellbeing of Future Generations Act (2015)** places specific legal requirements on higher education institutions related to individual wellbeing and the environment. Our ARCH programme was reviewed and repurposed to clarify how this legal requirement will be embedded in work across the region.

In line with the University's Code of Practice and our unit Statement of Intent, the team preparing this submission all received mandatory unconscious bias training, and targeted REF specific training on fair and transparent output selection. The submission comprises the one best-quality output from each Cat A submitted staff member, with the balance made up from the best available pool of eligible outputs. The **selection of outputs in SUMS was blinded** to the identity of the author to whom the output was assigned. The distribution of submitted papers meets the expectation from our staff demographics. We have 23% Cat A female staff members, to whom 25% of our submitted outputs are attributed. Impact case study review was conducted at the University level, anonymously. We note that all our submitted impact case studies are female led (three studies) or female co-led (two studies). Three impact case study leads are female BAME professors. Two of our four theme leads are female. SUMS signed up to, and achieved, a 50:50 female/male representation for our senior leadership committees by 2020 (**Chwarae Teg pledge,** International Women's Day, 2016).

2.4. Staff Support and Working Practices during the Pandemic

In addition to supporting the transition of staff to working from home, our COVID-19 Working Group carried out risk-assessments (June 2020) to support safe access to essential facilities, in particular to the Biomedical Laboratories, CNH, SAIL and CRF. Timetables were organised for research staff and PGR students where working density in laboratories needed to be reduced. It was crucial to allay concerns of PGR students over deadlines, who were also supported with project extensions. **SUMS** staff and research students donated PPE to support our partner health board.

2.5. Integration of Clinical Academics and NHS-Employed Active Researchers

The co-location of our environment with Singleton Hospital and long-term links with nearby Morriston Hospital (expanding significantly with ARCH, see section 1.2.3) enable us to integrate with NHS staff across health professions. Nine of our Cat A staff hold joint NHS appointments, including the director of R&D at Swansea Bay University Health Board (**Bain**) and several members of the School Leadership Team (**John, G Davies**). In addition, **A Davies** is a consultant biomedical microbiologist at the National Cryptosporidium Reference Unit. **Hugtenburg** has a joint appointment as a clinical scientist practising in radiotherapy physics.

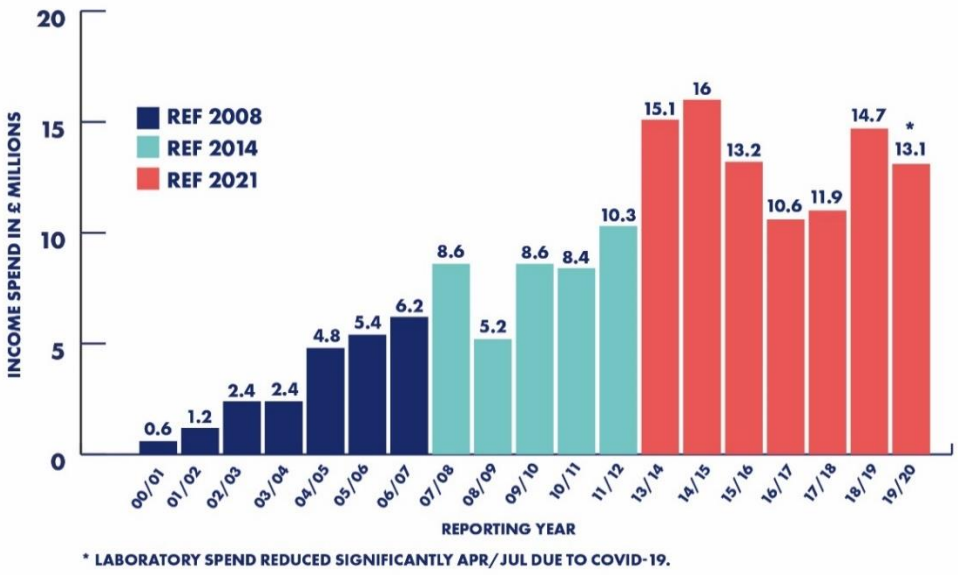
We have built strong links with NHS researchers through honorary contracts, including the chief executive of the Health Board. Exemplars include*: Consultant Physiotherapist* **Battle** was awarded her PhD at SUMS and is now the lead for injuries and emergencies research in Wales for HCRW, with strong links to our clinical trials unit. New research collaborations in *Pharmacy*,

led by four honorary staff, are a target of future expansion, given the opportunities of the new pharmacy undergraduate programme. Colleagues in *Electrophysiology* at Morriston Hospital work closely with our new BHF centre. *Paramedic* **N Rees** is director of R&D for the Wales Ambulance Trust. He studied for his PhD at SUMS and has helped develop the programme leading to impact case studies in both REF2014 and REF2021 (ICS3). We are co-located at Singleton Hospital with *surgeon* **Harris**, who leads a research programme testing for bowel cancer and has full access to our laboratories and expertise in Raman spectroscopy and trials. SUMS also hosts a programme for trainee surgeons whereby they take on a role as clinical lecturers and obtain staff bursaries for MD research. We have also hosted nine prestigious Welsh Clinical Academic Track (WCAT) Fellowships. These fellowships are eight-year (PhD to consultant) positions, with the aim of equipping trainees with the range of skills required to compete as independent investigators and lead research from 'bench to bedside'. WCAT Fellows have focused on biomedical projects involving cell scaffolds, biomarkers and biosensors.

3. Income, Infrastructure and Facilities

3.1. Income

Research spending for the period is shown in the following figure. The annual average (£13.5m) demonstrates growth since the REF2014 (£8.2m per year) and RAE2008 (£3.3m) periods, reflecting sustained success as a research-led school.



SUMS continues to attract awards from a wide range of prestigious funders: the **MRC (50), BBSRC (31), EPSRC (23), NERC (5), ESRC (10), Wellcome Trust (12), H2020 (3), Bill and Melinda Gates Foundation/Microsoft (2), NIHR (10), BHF (7)** and **Royal Society (4)**.

ILS2 houses Saint David's Medical Foundation (SDMF, holdings approximately £750,000), an independent charity that raises funds to support research. Each year, SDMF offers 'seedcorn' research projects through open competition among young postdoctoral investigators (including work that led to a publication in *Nature Communications*).

An exemplar award allocated *as part of large research consortia* is **Health Data Research UK**. As part of the UK Life Sciences Industrial Strategy, the UK Government committed £37.5m to data-driven research in healthcare. The '*One Institute'* strategy has major partners at 31 locations, with that in Wales/NI led by Swansea/Belfast. **PATROLS** is a €12.7m *global Swansea-led* consortia (H2020) of 24 institutions. Large *Innovation and Enterprise*-focused consortia include £12.2m **BEACON,** with Aberystwyth, Bangor, and the University of South Wales; **CALIN**, the £10.7m Ireland-Wales Territorial co-operation project; and **Accelerate** HTC, part of a £33m project that brings together 3 Welsh Universities and Welsh Government.

There is a strong link between our income and high-quality publications, illustrated by the following selected outputs across all four research themes:

- Biomarkers and Genes: Lipidomics (*PNAS*, Griffiths and Wang, BBSRC), Molecular Cardiology (*Circulation Research*, George, BHF)
- Medical Technologies: Nanomaterials (*ACS Nano*, Doak, H2020) and rheology (*Open Heart*, Hawkins and Evans, EPSRC)
- Microbes and Immunity: Asthma genetic epidemiology (*Nature*, G Davies, Asthma UK), *Salmonella* epidemiology (*Nature Genetics*, Humphrey, BBSRC) and T-cell response (*Nature Communications*, N Jones and Thornton, NRN Wales)
- PPHI: Clinical trials (*Lancet*, J Williams, NIHR/Wellcome), alcohol-related harm (*Public Health Research*, Fry, Wellcome/SAIL), and global burden of disease (*Lancet*, Lyons, MRC/SAIL).

Similarly, as discussed in section 1.3, we can demonstrate a strong link between major income capture and all of our five selected impact case studies*:* ICS1:**Global Nanosafety** (H2020); ICS2: **Azole Antifungals** (BEACON/EU, BBSRC, US National Institutes of Health); ICS3: **PRISMATIC** (NIHR, HS&DR); ICS4: **Sterol Analysis** (BBSRC), and **Suicide and Self-Harm Prevention** (MRC, MQ, HCRW).

3.2. Organisational Infrastructure

Our four research themes draw upon *five major facilities*:

- SAIL Databank
- Centre for Nanohealth
- Biomedical Laboratories
- Clinical Research Facilities
- Commercial Incubators

3.2.1. SAIL Databank

A flagship facility is the **SAIL Databank**, a world-leading novel technology that allows routinely collected patient data at the individual level to be used in biomedical research while maintaining the highest standards of patient anonymity. It offers distinct expertise and exceptionally strong infrastructure for the development, storage, access, analysis and commercial development of electronic health records. Currently, there are more than **4.5 billion anonymised person-based events within the SAIL Databank**, and these events can be linked to geographic, educational, social service, transport and environmental data, creating an exceptionally rich international resource. Building on pioneering work at the Health Informatics Research Unit, *CIPHER* (MRC-led, 2013-2016) was one of four e-health research UK Centres of Excellence. Professor Sir John Savill, Chief Executive of the MRC, commented:

"*This is a watershed moment for data research and for the Medical Research Council which I believe will deliver the benefits of e-health research, improving patient care over the coming years. The way in which the partner organisations have come together to invest in e-health underpins its importance and will help establish the UK as a world leader in this field.*"

UKRI invested an additional £20m in the *Farr Institute for Health Informatics*, with one of the four centres based at SUMS. This investment enabled the completion of the **ILS Data Science Building** in 2015. The ESRC investment of £8m in the Administrative Data Research allowed our e-Health and informatics expertise to include social science and economic data. In 2018 there was a further £4.5m UKRI investment in *Health Data Research UK* (HDRUK), and a new innovation, **UKSeRP**, an important development in open scholarship. **UKSeRP** is a research cloud trusted research environment (TRE), pushing the horizons on 'health informatics' to include omics, imaging, NLP, and GIS. **UKSeRP**-hosted research programmes include the £7.5m MRC Dementia Research Platform UK. The impact of CIPHER, the Farr Institute, HDRUK and **UKSeRP** is supported by many international testimonials:

*"**SAIL**'s approach to data science and their success in linking data has been an inspiration and model for our efforts to bring together social services and health data in Ontario, Canada*" (Michael Hillmer, Ministry of Health and Long-Term Care, Canada)

*"If you want to know what data linkage in the UK might look like in future decades, take a look at where **SAIL** is currently"* (Dr Dermot O'Reilly, Director of ADRC-Northern Ireland, Queen's University Belfast).

3.2.2. Biomedical Laboratories

This is one of the largest and most diverse of the **ILS facilities**, based over three buildings, offering custom-designed laboratory bench space, including extensive Biosafety Level 2 laboratory space, tissue culture facilities, microscopy (confocal, fluorescent, laser capture), flow cytometry and cell sorting facilities. Recent additions include XF^e24 and XF^e96 extracellular flux analysers, a Bruker BioScope Catalyst (on Nikon Eclipse), Illumina MiSeq benchtop sequencing, a NanoString nCounter, a BD Rhapsody system, a 10x Genomics Chromium Controller and the only CytoViva microscope in the UK. Recent investments in mass spectrometry facilities have expanded our capabilities in lipidomics, building on the long-standing (30 years) UKRI Mass Spectrometry Facility, which has now evolved from a service facility into a research facility (supporting the lipid metabolomics team and one of our impact case studies). Other recent refurbishments include investment in the Accelerate HTC laboratory, flow cytometry, functional genomics, two electrophysiology laboratories, and a re-fitted diabetes laboratory. A linked facility (based within the Emergency Department of Morriston Hospital) is the Clinical Haemostasis and Biomarker Research Unit. A new entomology culture lab (established in 2019) in the ILS1 building supports novel symbiont siRNA development.

3.2.3. Clinical Research Facilities (CRF)

Three linked SUMS units, supporting biomedical research, form the **CRF*:***

The **Swansea Trials Unit (STU)** is one of approximately 50 groups undertaking clinical trials registered (2015) by the UK's Clinical Research Collaboration. The STU has a current portfolio of 20 trials, and key strengths in the methodological development of patient-reported outcome measures, public and patient involvement in the co-production of research, and utilising anonymised routine data repositories such as **SAIL**.

The **Joint Clinical Research Facility (JCRF)** is a self-funding **SUMS**/Health Board partnership, with units in **ILS2** and Morriston Hospital and a track record of being first to recruit globally and first in the UK. Since 2014, the JCRF has undertaken 171 studies, supporting 135 multi-centre trials, with over 5,000 participants ranging from early Phase I to Phase IV. The JCRF has seen 24 trial interventions bought to market, with investigators being a chief investigator for 48 trials and overseeing the recruitment for 30.

The **Medical Imaging** unit includes a Siemens 3T Magnetom Skyra, a Siemens Somatom computed tomography (CT) scanner and a Syngio Viao image processing server, plus contrast injection systems for magnetic resonance imaging (MRI) and CT, a cannulation suite, an image processing/reporting room, an interview room and accessible changing facilities. Conventional and advanced fields of medical imaging are available, requiring custom-designed imaging protocols.

3.2.4. Centre for Nanohealth

A joint interdisciplinary initiative between SUMS and the Colleges of Engineering and Science, **CNH** has evolved, with renewed emphasis on medical technology and advanced therapeutics. Located in ILS2, **CNH** offers state-of-the-art, cross-discipline fabrication facilities (nanogrowth, chemical functionalisation, tissue engineering, and molecular biology) alongside downstream characterisation tools (nano-/micro-rheology and biological-atomic force, scanning electron, tunnelling electron, scanning near field, nuclear magnetic resonance and precision fluorescence microscopy). This complements a bio-suite tailored for nanotoxicology and biosafety evaluation (class 100/1000 clean room), informing advanced diagnostics, therapeutics and 3D disease models. With direct access to the JCRF, medical imaging, ILS1 laboratories and clinical, biomedical, and engineering staff, **CNH** leads industry-sponsored research (PATROLS, CALIN,

BHF, as well as the Cluster for Epigenetics and ADC Therapeutics (CEAT)) garnering commercial support for translation.

3.2.5. Commercial Incubators

Close links with industry are maintained through the co-location of ILS researchers, academics with small- and medium-sized enterprises (SMEs). ILS1 and ILS2 have **dedicated business zones** for company activities. Since 2014, there have been 20 full-tenant companies (with seven 'graduated') and 15 resident affiliate companies with desk space. In addition, 412 companies were assisted in R&D collaborations, 37 new companies were created, 44 new patents were registered and increased turnover in companies assisted totalled £51.9M. Exemplar research-focused commercial activities include the following:

- **BUCANIER (2017-2021):** The aim of BUCANIER was to support small businesses on the Irish Sea Border in key growth areas of life sciences and renewable energy, with a budget of €2.9M 132 enterprises engaged, 15 FTE jobs created, 22 new-to-market products, and 62 new-to-firm products.
- **CALIN (2016-2023)**: The €19M **CALIN**, an Ireland-Wales Programme uniting six universities, has provided more than 3500 hours of support to 146 SMEs, with 200 products launched onto the life science market, 20 new jobs in the sector and an inward investment of over €10M.
- **Accelerate HTC (2018-2022)**: The HCTC is hosted by SUMS and partnered with the Welsh Government's Life Science Hub, University of Wales Trinity Saint David and Cardiff University to the £24m Pan-Wales **Accelerate** programme funded by the Welsh Government and European Regional Development Fund. The HCTC has partnered locally in 20 research and innovation projects, with 15 dedicated staff and a network reaching throughout industry, the NHS and the third sector.

3.3. Operational and Scholarly Infrastructure

Our biomedical research environment is supported by SUMS through **sustained investment in a thriving cohort of permanent staff** which include research technicians, research officers, data analysts, statisticians, and administrative staff, all employed to support the ongoing research activities of the school. In addition, our life sciences research hub (comprising six core staff with additional support from peripatetic staff) supports bid writing, project and financial management with close links to the University Research Engagement and Innovation Services team to provide additional infrastructure, with particular expertise in European and UKRI projects and IP/Commercialisation. In addition, there is a School Enterprise and Innovation team (three staff).

SUMS accesses a range of central infrastructure across other HEI, such as **high-performance computing at Supercomputing Wales** (epidemiology, bioinformatics), the **European Synchotron Radiation Facility at Grenoble** (nanotoxicity), **CERN** (clinical radiation physics), **Texas Medical Centre** (*in vivo* models, cardio pump devices), **Wales Gene Park** (functional genomics, epidemiology), **UK Biobank** (mental health), **Baby Biobank** at UCL and Imperial College (maternal and child health), **Wales Cancer Bank** (genetic toxicology, biomarkers), **Woods Hole Research Center** (cytochrome P450), **NIH facilities at the University of Florida** (fertility), and **Scotland's Rural College** (microbial genomics). SUMS reciprocates by housing its **own major central HEI facility**, the **SAIL** Databank, which is accessed by many institutions worldwide.

HCRW has a vibrant programme of research networks and structures. Our researchers are particularly engaged with **HCRW research centres** (mental health, population health and wellbeing, cancer research, cardiovascular research, and primary and emergency care) and **HCRW research units** (diabetes and brain repair and intracranial neurotherapeutics). SUMS also leads one of the three **HCRW Clinical Trials Units** and one of three **HCRW major infrastructure support groups** (SAIL).

The interdisciplinary relationships built up through our research activities have resulted in *major benefits in kind*, aiding our growing research environment and that of our partners. The ILS laboratories house specialist equipment jointly acquired with the College of Engineering

(rheometers, transmission electron microscope). The reopening of the neighbouring Department of Chemistry which has received significant start-up investment has stimulated new joint research activities. Similarly, we access to **entomology and zebrafish facilities** in the School of Biosciences. The largest health board hospital, Morriston Hospital, provides a full ward for our CRF. Equipment secured through our income is also housed in two major laboratories at Morriston Hospital (rheology, regenerative medicine), and we have access to the Singleton Hospital pathology laboratory. ILS2 houses the health board R&D office and the Wales Ambulance Service research office. NHS colleagues provided **Raman spectroscopy equipment**, leading to significant collaborations between SUMS and the Department of Physics. Equipment has also been donated by industrial collaborators Unilever (high-performance liquid chromatography) and GE Healthcare (imaging, microscopy).

4. Collaboration and Contribution to the Research Base, Economy and Society

Our vitality is evidenced through leadership and engagement with many international initiatives and the international reputations of our researchers. Our sustainability can be seen in the contributions made across many disciplines and career stages. The following table summarises our activities undertaken in the census period by Cat A staff only (55.7 FTE). The subsequent sections present highlighted contributions of named individuals.

Indicators of collaboration/contribution	Count
Formal visiting positions at other universities/institutions	39
Journal editorial board memberships	44
Membership of the boards of external advisory bodies	118
Conference organisation	61
Plenary and keynote lectures	161
Invited lectures	237
Other conference presentations	669
Personal fellowships awarded competitively	11

4.1. Support for Effective Collaborations, Networks and Partnerships

SUMS staff are involved with leading several ***initiatives to promote research collaboration at the national and international levels*:**

Jenkins is President of UK Environmental Mutagen Society. **Johnson** is President of the European Environmental Mutagenesis and Genomics Society. **Hawkins** serves as Secretary of the British Society of Rheology and Director of the Institute of Non-Newtonian Fluid Mechanics. **Lyons** is Chair of the International Collaborative Effort on Injury Statistics and Methods for US Centers for Disease Control and past chair of the 110,000 UK Birth Cohort Study Record Linkage Group. **Van Keulen** is Chair of the Prokaryotic Division of the Microbiology Society. **Lloyd** and **John** co-chair the Cochrane Foundation Satellite for suicide and self-harm prevention. **Bain** is Clinical Director of the Academic Health Science Collaboration. **Weston** was Clinical Director of the Myocardial Ischaemia National Audit Project (MINAP). **Doak** is steering board member of the International Genetic Toxicology Technical Committee (and Nanomaterials Team co-Chair). **Ford** is Deputy Director of the Wales and Northern Ireland Health Data Research UK. **Dyson** is Scientific Advisor for the International Foundation for Science. **Pallister** is Vice-President of AO UK&I Foundation for musculoskeletal injury and disease. **Williams** is Founding Director of the Royal College of Physicians Health Informatics Unit. **G Davies** is Wales Respiratory Specialty lead for NIHR. **George** is Chair of the Wales National Cardiovascular Network. **Thornton** serves on the High Council for Evaluation of Research and Higher Education (HCERES), France. **Evans**

is Senior UK and Overseas Examiner for the Royal College of Emergency Medicine. **Wagstaff** has been Director of Wales Cancer Trials Network and a Member of the UK National Cancer Research Network. SUMS has formal partnerships with Union Hospital Wuhan and Tongji Medical College of Huazhong University of Science and Technology, Grenoble Alps University, Soochow University in China, Monash University in Australia, the Methodist Hospital Research Institute in Houston, the University of Pennsylvania School of Medicine, Rice University, and Texas A&M University.

SUMS *senior roles on advisory bodies* include the following**:**

Stephens is Wales' lead on the Diabetes UK Council of Health Care Professionals and contributed to the WHO Global Report on Diabetes. **Bain** is a Royal College of Physicians Specialty representative for diabetes and endocrinology, Adviser to the National Institute of Clinical Excellence, and a former member of the UK Human Genetics Commission and National DNA database. **Roberts** and **Williams** served on the Lancet Commission into Liver Disease. **K Lewis** is a member of the European Respiratory Society Tobacco Taskforce. **Jenkins and Doak** sit on the Expert Panel, UK Government's Committee on Mutagenicity. **Tan** leads the Eating Disorder Service Review for the Welsh Government. **Griffiths** serves on the Lipid Maps Advisory Board. **Humphrey** is a member of the UK Advisory Committee on the Microbial Safety of Food and the Steering Group for the BBSRC Animal Health Club. **Doak** is expert advisor to the OECD Panel on Genotoxicity of Nanomaterials and the European Commission Scientific Committee on Consumer Safety.

4.2. Interaction with Key Research Users, Beneficiaries and Audiences, and Wider Contribution to the Economy and Society

Many of our impact focused activities have been covered already in the previous sections (impact case studies, SAIL, UKSeRP, ILS, CNH, CALIN, PATROLS, BEACON). Other notable wider contributions include the following: partnership in the BBSRC CampAttack consortium on host pathogen interactions (**Wilkinson**) and BREATHE, the Health Data Research Hub for Respiratory Health (SAIL, **Ford**, **G Davies**). More mature projects that are already delivering wider impact (in addition to our 5 case studies) include Calon Cardio-Technology, a mini-heart pump company housed in the ILS, which demonstrates both economic impact and research outputs through funded collaborations with **Thornton** and **Kanamarlapudi** focused on inflammatory responses to the implants. PROMS (**Hutchings**, **J Williams**) is focused on a firm evidence base for treatment based on the experience of the patient to better refine interventions across a range of conditions. **Snooks** has evaluated new protocols for paramedics to assist older people after falls (SAFER2) and evidence for a survival advantage in myocardial infarction patients if given a prehospital electrocardiogram (ECG). **Roberts'** work on gastroenterological disorders has had an impact on service provision across Europe. **Ford** is the chair of the academic advisory group for the Court Reform Evaluation Panel at the Ministry of Justice and director of the UK Multiple Sclerosis Register, in partnership with the MS Society. **Brophy** leads the Primary School Network in Wales, bringing together schools, the third sector, public health clinicians, and health and education researchers to evaluate wellbeing in schools, with a focus on those with chronic conditions.

4.3. Community and Diverse Community Engagement

Fegan has long-standing involvement with global health initiatives in low- to middle-income countries. He is external examiner at the Muhimbili Christian Medical Centre in Tanzania and initiated R statistics training programmes in Kenya. **Snooks** is project lead for Welsh Government Policy Implementation Guidance on *Health Expectations of Asylum Seekers and Refugees*. We have a recent MOU with the Medical College and Genetics Department at Dhaka, Bangladesh, with research training and collaboration provided to new clinical and science fellows in DNA mutation, gastroenterology and clinical trials/statistics. **D Kelly** has supported numerous institutions on AS initiatives. **Doak** was keynote speaker at NRN Diversity in Science and Engineering 2017 and co-organised Richness in Diversity: Academic Careers in STEM. **Lyons** served on the First Minister's COVID-19 Advisory Group on BAME issues. **Howell** has hosted MS Society patient information days and fundraising events. Our Biomedical Laboratories annually hosts laboratory placements for children from low-income families through the Nuffield Future

Researchers Scheme. **Owens** established the national retinopathy screening initiative in Mauritius and Trinidad and Tobago.

Public engagement events have included: 32 articles in ***The Conversation***; active involvement in ***Soapbox Science, Pint of Science***, and research animation outreach on YouTube; and hosting the ***British Science Festival*** at Swansea (2016). Many staff engaged with public outreach during the pandemic (*BBC television and radio*, *Channel 4*, *Time Magazine*, *Washington Post*, *National Eisteddfod* 'Cyfraniad Cymru i guro COVID-19', and *The Conversation*).

4.4. Wider Influence on the Research Base

4.4.1. Selected Journal Editor Roles (out of 44)

Founding Editor-in-Chief	*International Journal of Population Data Science* (**K Jones**)
Editor-in-Chief	*Mutagenesis* (**Doak**); *Fibres* (**Clift**); *Applied Radiation and Isotopes* (**Hugtenburg**)
Deputy Editor-in-Chief	*International Maritime Health* (**Roberts**)
Senior Editor	*British Journal of Pharmacology* (**George**); *Mutagenesis* (**Jenkins**).
Full Editor	*Drug Resistance Updates* (**S Kelly**); *Royal Society Biology Letters* (**Gravenor**); *Cardiovascular Research*; *Frontiers in Physiolo*gy; *Artery Research* (**George**); *Journal of NanoBiotechnology* (**Clift**); *Health Technology Assessment* (**Snooks**); *Mutation Research* (**Jenkins**); *International Journal of Molecular Sciences* (**Lamb**)

4.4.2. Notable Fellowships and Awards

Sheldon won the Schofield Prize and Medal awarded by the University of Guelph, Canada, and was awarded FRCVS for Meritorious Contributions. **Bhatti** was appointed OBE. **Kanamarlapudi** was awarded the Association of Biotechnology and Pharmacy (ABAP) India Senior Scientist Award. **Conlan** won the i3S-Hovione Capital Health Innovation Prize. **S Kelly** won the George Schroepfer Medal from the American Oil Chemists Society (Salt Lake City) and shared the RegioStars Prize for EDRF projects (for BEACON) with **D Kelly** and colleagues at Aberystwyth and Bangor. Staff have won numerous MediWales Innovation and Industry Collaboration Awards.

Prestigious research fellowships include: The British Heart Foundation Sir Thomas Lewis Chair of Cardiovascular Science (**A Williams**), Four Health and Care Research Wales Senior Fellowships (**Lyons, J Williams, Snooks, Lloyd**), Fellow of the Royal Society of Biology (**Conlan, S Kelly**), Fellowship of the Royal Society of Chemistry and Institute for Welsh Affairs (**S Kelly**), Bronze Clinical Excellence Award (**G Davies,** 2019**; Lewis,** 2018), Silver Clinical Excellence Award **(Stephens,** 2018; **Lloyd**, 2016; **Weston**, 2015**),** Gold Clinical Excellence Award (**Bain**, 2016), **D Kelly, S Kelly, M Rees, John, Lloyd, Lyons, Doak, Snooks**, and **Kanamarlapudi** were elected to the Learned Society of Wales.

4.4.3. Notable Visiting Positions (out of 39)

Distinguished Chair as Professor, Xian Jao Tong University, China; and Senior Affiliate Member of the Methodist Hospital Institute, Texas (**Conlan**). Visiting Professor, Department of Biochemistry, Vanderbilt University, USA (**Lamb**). Honorary Professorial Research Fellow, Faculty of Medicine, Imperial College (**A Williams**). First Distinguished Visiting Professor to the University of Tennessee (**S Kelly**). Visiting Professor, Chinese Academy of Sciences, and Universidade Federal de Fluminense, Niteroi, Rio de Janeiro, Brazil (**Dyson**). Adjunct Professor, Monash University, Australia (**Lyons**). Honorary Professor in the School of Chemistry and Physics, University of KwaZulu-Natal, South Africa (**Douglas**). Distinguished Lecturer, Animal Molecular and Cell Biology Graduate Program, University of Florida, USA (**Sheldon**). Fulbright Scholarships **(Lamb,** Woods Hole**; Jessop,** Harvard University**)** and Royal Society Visiting Fellowship (**Lamb**).

4.4.4. Notable Roles on Major Grant-Awarding Bodies

Chair BBSRC GCRF Translation Panel, Chair BBSRC iFLIP Panel, Chair BBSRC DTP Awarding Panel, Chair NERC/BBSRC/AHRC Policy Internship Panel, and Deputy Chair Committee E (**Sheldon**). Deputy Chair of NC3R grant assessment panel (**George**). BBSRC Committee D (**Wang**, **Kanamarlapudi**). MRC Populations and Systems Medicine, ESRC Research Methods, and international reviewer for Health Research Board for Ireland (**Brophy**). EPSRC Healthcare Technologies (**Evans**). CRUK review panel (**Jenkins**). Vice-Chair of the British Heart Foundation Fellowships (**A Williams**). BBSRC Technology Development Fund Panel (**Conlan**). European Developing Countries Clinical Trials Partnership (**Fegan**). Foulkes Foundation Advisory Committee (**J Williams**). Senior Scientific Advisor NIHR Health Services and Delivery Programme (**Snooks**). Welcome Trust Science Interview Panel (**Lyons**). Wellcome/BBSRC/EPSRC/NIHR/MRC/Diabetes UK Pool of Experts (**Hawkins**, **Wang**, **D Kelly**, **S Kelly, Hutchings, Watkins, Fegan, Stephens**). Future Leader Fellowship panel, UKRI (**John**).

4.4.5. Notable Invited Conference Roles (all at invited plenary/keynote level*)*

Schofield Memorial Lecture, University of Ontario, Canada; Opening Expert at RCUK Newton Fund Meeting Brazil; and Endometritis, Gdansk, Poland (**Sheldon**). International Biometric Society, Uganda (**Fegan**). International Symposium on Solid-state Dosimetry, Zacatecas (**Hugtenburg**). International Conference and Asian Congress on Environmental Mutagens, Seoul (**Johnson**). MRC Council at Bristol; Sanda Macara BMA Memorial Lecture; National Network of Public Health Institutes, Atlanta (**Lyons**). eCells and Materials Conference, Davos, Switzerland (**Khan**). European Society of Cardiology, Nice; Royal Society Kavli Meeting, Cambridge; and British Heart Foundation, Cambridge (**George**). European Lipidomics Meeting, Graz, Austria (**Griffiths**). American Diabetes Association Meeting (**Bain**). Asian Pacific Society of Cardiology Congress (**Stephens**). Yeast Lipid Conference, Ghent (**S Kelly**). British Orthopaedic Research Society (**Pallister**). International Conference on Eating Disorders, New York (**Tan**). Environmental Mutagenesis Society of India, Lucknow (**Jenkins**). Academy of Medical Sciences and Informatics for Health, Manchester (**Ford**).

Selected roles in ***international conference organisation***:

Hosted at Swansea	30th Anniversary RCUK Mass Spectrometry Centre Celebration (**S Kelly**). European Lipidomic Meeting (**Wang**, **Griffiths**). 3rd Symposium of the European Network for Oxysterol Research (**Wang**, **Griffiths**). International Population Data Linkage conference, (**Ford**), British Yeast Group Conference (**S Kelly**),
Organising committee	European Nanomedicine Meeting, UK (**Conlan**). Institute of Non-Newtonian Fluid Mechanics Meeting, UK (**Hawkins**). European Study Group on Cardiovascular Oscillations, UK (**Edwards**). Symposium of the European Network for Oxysterol Research, France (**Griffiths**). Administrative Data Research, UK (**Ford**). European Society for Artificial Organs, UK (**Thornton**). Annual (since 1993) Symposia on Cytochrome P450 Biodiversity and Biotechnology, international (**S Kelly**). UKEMS, UK (**Jenkins**). International Particle Toxicology Conference; British Society of Nanomedicine Early Researcher Conference; NanoToxicology (**Clift**). World Buiatrics Congress, Japan (**Sheldon**). Annual 999 EMS Research Forum, online (**Snooks**).

4.4.6. Selected Roles in PGR Student Initiatives

SUMS hosts the ESRC Data Science DTP and is a partner on BBSRC GW4 DTP. **Fry** is a HDRUK International Population Data Linkage Network summer school member. **G Davies** leads the Asthma UK PGR Training Programme. **Thornton** was awarded recognised research supervisor status in the inaugural UKCGE assessment and acts as reviewer for the scheme. **A Davies** was elected Vice-President for Learning at the Royal College of Pathologists, with a role to adapt

postgraduate training to secure workforce continuity. Strategic collaborations with Grenoble, Texas and Wuhan have resulted in 12 international collaborative PGR projects.

4.5. Contribution of Cat C Staff

In section 2.5 we highlighted strong research links with NHS staff. This is reflected in many honorary (Cat C) staff, who make a significant contribution to our environment through their contributions to the research base, economy and society. Our expanding efforts in pharmacy involves input to our cardiology HDRUK team (**Daniel Harris,** Welsh Government cross-party stroke campaign); the Director of the Royal Pharmaceutical Society for Wales (**M Davies**); and Head of Nuclear Medicine at Singleton Hospital (**Hartman**). Physiotherapist **C Battle** was awarded an Advanced Research Fellowship with HCRW. SAIL maintains strong links with former SUMS professor **S Rodgers** at Liverpool through current NIHR/MRC projects; and neurologist **O Pickrell**. In Radiology, we benefit from imaging expertise from our neighbouring Medical Physics NHS Department through shared ILS facilities (R **Evans**/J **Phillips**). The **ARCH** project includes **Richard Evans**, Medical Director of Swansea Bay University Health Board, and **Phil Kloer**, Medical Director of Hywel Dda.

Our environment is enriched by artist, and Cat C staff member, **Karen Ingham**, e.g., the MRC/ESRC-funded **'***Be Seen': an arts-led participatory approach to understanding 'big data' in young people's mental health and use of images by young people.*

4.6. Research Efforts Focused on Reproducibility

The importance of reproducible and replicable research is recognised in the SAIL infrastructure, which not only allows code, protocol and data storage/access (through UKSeRP) but also offers considerable opportunity for reproducing research and follow-up replication studies. Examples include **Lyons**' publications on health index external validation, **Fry's** papers on alcohol exposure and **Robert's** papers on liver disease mortality. Clinical trial data embedding in SAIL allows trial outcomes to be re-visited and enriched in a longitudinal manner (publications by **Gravenor** on asthma risk in children and **Hutchings** on health status scores and patient-reported outcomes). **Conlan** has published on issues of transparency and reproducibility in nanomedicine. Staff contribute to the Swansea University branch of the UK Reproducibility Network.

4.7. Contributions from Cat A Staff at Early Career Stages

Evidence for the future sustainability and success of our development strategy is provided by exemplar contributions from researchers who began this REF cycle as ECRs: **Cronin** was a Royal Society Parliamentarian Pairing Scheme member, IMPACKT (www.impackt.org.uk) co-founder, and coordinated the British Council UK-Brazil 'Researcher Links' programme. **Francis** held an adjunct professor position at Rice University, a Derek Brewer visiting fellowship at Emmanuel College Cambridge, and invited visiting positions at Houston Methodist Hospital Research Institute and the New Zealand Institute of Plant and Food Research. **Bodger** is statistical consultant at Swansea Bay and Hywel Dda Health Boards. **Whitten** delivered plenary lectures at the Royal Society of Biology; International Molecular Plant Protection Congress, Turkey; and International Meeting of Biological, Biotechnological & Health Science, Brazil. **Johnson** won the EEMGS young scientist award in 2014. **Clift** was chair of the UK In Vitro Toxicology Society; member of the Expert Panel for NC3Rs UK on Nanotoxicology; an EU QualityNano Expert Group member, and won the British Toxicology Society 'Early Career Researcher' Award 2019 (Lecture at British Toxicology Society/UKEMS Joint Annual Conference, Oxford).

We have included 10 current ECRs in our submission. Notable achievements include **Fry's** membership of the SAGE COVID-19 sub-group on Care Homes. **Webber** was awarded a 5-year Prostate Cancer UK Career Development Fellowship. **L Thomas** was awarded a HCRW Research Fellowship. **N Jones** was lead author on a *Nature Communications* publication. **Chapman** won the 2016 Lush Prize awarded for contributions to animal replacements. **Theofilopoulos** and **Angelini** were awarded 5-year Sêr Cymru II Rising Star Fellowships. **Jessop** held a Fulbright Research Scholarship at Harvard. **Zallot** was awarded a Marie Skłodowska-Curie Actions Individual Fellowship. **Obaid** is simulator training lead for the Welsh Cardiovascular Society.

4.8. Contributions to the Pandemic Response

Welsh Government emergency scientific advice was led by the Technical Advisory Cell (TAC), with **Gravenor**, **John** and **Lyons** as members. **John** chaired the behavioural TAC sub-group and was a member of UK SPI-B, the *Independent Scientific Pandemic Insights Group on Behaviours*. **Gravenor** was a leading contributor to the TAC Modelling sub-group, and member of UK SPI-M (*Scientific Pandemic Influenza Group on Modelling*).

Numerous **SUMS** staff were members of UK consortia, including BREATHE (HDRUK Hub for Respiratory Health), COVIDENCE (longitudinal risk) and CVD-COVID-UK (cardiovascular impact). **A Davies**, as HCRW Specialty Lead in Infection, supported recruitment for 65 COVID-19 trials, including RECOVERY, which demonstrated dexamethasone efficacy.

Showcasing the global importance of data processing and dissemination, **SAIL** took a leading role on data and infrastructure for national and international initiatives, including the 'One-Wales' response (https://popdatasci.swan.ac.uk/news/one-wales/, the Data and Connectivity and Longitudinal Health themes of the National Core Studies initiative (UK Government), the CO-CONNECT serology data initiative, the COVID-19 Clinical Information Network, and the International COVID-19 Alliance and Workbench. As the partner Trusted Research Environment (TRE), **SAIL** provided access to >100 researchers to analyse the **Zoe Symptom tracker** for whole-UK coverage. **SAIL** responded to 180 COVID-19 data requests (e.g. from NICE, NHS Tower Hamlets, the Bradford Teaching Hospital Foundation Trust, Liverpool University, the Joint Biosecurity Centre, the Welsh Government, SPI-M and SAGE).

As the most extensively linked secure platform in the Four Nations, **SAIL** had considerable influence as an exemplar for TRE development worldwide. On 6th July 2020 an open letter was published in the BMJ, "**Reducing barriers to data access for research in the public interest – lessons from covid-19**". The following recommendation was made, signed by 374 cross-disciplinary researchers:

"Independent, accredited data providers should be created, with expert processing and disseminating capacity, knowledge of how data are used in research and understanding of how best to prepare and deliver datasets to researchers, emulating the successful SAIL Databank *in Wales"*

In 2019, SUMS celebrated its 15th anniversary. Over this period, we have rapidly established a vibrant research environment in which staff are valued, supported and make significant contributions to their research base. Our environment is well placed to ensure the future success, growth and sustainability of our research.