Institution: University of Greenwich

Unit of Assessment: 8 - Chemistry

1. Unit context and structure, research, and impact strategy

a) Overview

Chemistry is a core constituent of the School of Science (SoS), part of the Faculty of Engineering and Science (FES), which also comprises Medway School of Pharmacy (MSoP), Natural Resources Institute (NRI) and School of Engineering (SoE). Greenwich returned under Chemistry (UoA8) for the first time in 2014, reflecting the expanding role chemistry plays across all the activities within the SoS. Importantly, chemical sciences underpin much of the Faculty's research activity spanning several subject disciplines, supporting interdisciplinarity and broader impact, as reflected in its staff being returned in UoAs 3, 6 and 8.

We have improved performance since 2014 measured against common key metrics of research excellence (Table 1).

Table 1: Improved performance in research excellence over the REF period.

Metric	% Increase over 2014 (2021 figure)
Scholarly outputs	78% (345)
Field weighted citation impact	14%
Outputs in the top 10% citation percentile (field-weighted, %)	35%
PhD completions	8.5% (47)
Research income	370% (£6.09M)
Increase in research active staff under UoA8	16.3% (17.2)

Chemistry recruited 2 new research-active staff who are part of this submission and invested £2.13M in core analytical testing facilities and general infrastructure. Of particular note, is the near four-fold increased research income over the period, much of which is collaborative in nature. Several colleagues are active in multi-national consortia projects reflecting the unique contribution they bring to that research. To highlight this, in the following narrative, such activity will be presented in terms of total project values as well as that element retained at Greenwich. The total value of the entire research and enterprise project portfolio that UoA8 staff are engaged in is close to £15M.

Our two impact case studies (ICS) (i) '*Carbonation as a Circular Economic Solution: Innovating the waste management and the construction sectors through commercialisation of carbon-negative building aggregate*' (ICS-1) and (ii) '*Pheromone Traps: Providing New Tools Across Europe for the Prevention of Spread of Pine Wood Nematode, an Invasive Disease of Pine Forests*' (ICS-2) show the significance of our chemistry research and its broad applications in areas of strategic national and global importance. Both ICS have received national recognition awards: ICS-1 was recognised in 2017 by the '*Queen's Award for Enterprise*: *Innovation*'; while ICS-2 was part of the submission awarded the '*Queen's Anniversary Prize for Higher and Further Education*' in 2019/20.

Research continues to be organised through 3 research groups: (i) **Pharmaceutical and Materials Sciences** (ii) **Biological, Medicinal and Synthetic Chemistry; and** (iii) **Chemometrics and Analysis**. These have expanded over the REF period, creating a vibrant interdisciplinary environment spanning the interface of core (*organic, analytical, physical, inorganic*) and applied (*pharmaceutical/materials science, computational modelling, medicinal*) chemistry research, supported by well-equipped analytical and material characterisation laboratories. Within each of these 3 overarching groups, there are also cognate research sub-disciplines, which collectively has resulted in a wide spectrum of activities reflected in research

income, international collaborations, highly cited Q1 research articles, PhD supervisions, and impactful research with international reach and recognition.

b) Research Strategy – progress since 2014

The University's Strategic Plan aims to "*Enhance Science and Society Through Inspiring Research and Enterprise*". Based on this, the Faculty and Unit-level strategies set out several key objectives over this REF period including:

- develop the research staff base, such that more than 80% of staff with significant responsibility for research (SRR) were publishing at a minimum of 3* (based on annual internal reviews of outputs in preparation for REF).
- grow and expand our research groups, doubling research and enterprise income.
- substantially strengthen our links with industry, as a vehicle to drive impact.
- increase the number of registered postgraduate research (PGR) students and successful completions.

Evidence of achieving these goals is:

- net growth in the unit size, through strategic new appointments at early and mid-career stages to ensure sustainability and promotions based on research excellence at associate professor/full professorial levels to drive research leadership.
- significant improvements in impact pathways in an academic sense - the quality and volume of output generation with outputs in journals such as 'Angewandte Chemie', 'Carbon', 'Nature Catalysis' and 'Green Chemistry', textbooks - as well as granted patents.
- implementing strategic, impact-orientated, collaborations against global challenge-orientated themes allied to relevant stakeholders and target groups, most succinctly evidenced by the portfolio of commercial partners *e.g.* Infineum, Unilever, Santas, Chevron, Shell, Pfizer, Akzonobel, AstraZeneca, GlaxoSmithKline, GALVmed, Curadev, Mylan, Merck and agro-chemical companies resulting in research income >£5M, a significant proportion of the total research & enterprise income.
- developing interdisciplinary impact through pursuance of chemistry-based research through strategic collaborations and/or consortia internally and with other universities at international and national levels (section 4).
- investments in studentships through VC scholarships, strategic allocation of HEIF/QR funding and membership of the University Alliance Doctoral Training Alliance (UADTA) and the London Interdisciplinary Doctoral Programme (LIDO) to boost our PGR student numbers. Total HEIF and QR investment into UoA8 was £1.55M.

Organisation

Members being submitted to UoA8 for REF 2021 are placed into one of three professorially-led core research groups (group leader underlined), with several members working at the interface of more than one group. Furthermore, to reflect the breadth of interdisciplinary research themes and enhance the international and national reach/impact of our research, the three groups have

specialist sub-disciplines, centres of excellence and spin-out (consultancy) companies, most of which are industry facing.

1. Pharmaceutical and Materials Sciences: *Alexander*, *Antonijevic*, *Boateng*, *Coleman*, *Douroumis*, *Griffiths*, *Hills*, *Mitchell*, *Snowden*.

Research focuses on (i) pharmaceutical pre-formulation, advanced drug delivery systems (formulations and devices), pharmaceutical process engineering and analytical technologies, biomaterials for tissue regeneration and (ii) use of carbonation systems for land remediation. The group has won external grant income >£5M over the REF period.

Preformulation, Process Engineering and Analytical Technology and Quality by Design

Douroumis develops secondary continuous manufacturing using hot melt extrusion (HME) coupled with process analytical technology (PAT) tools and resulted in a recent KTP award (section 4) with Cubic Pharmaceuticals. He is also involved in developing targeted anticancer drug delivery systems and 3D printing technologies for medical devices (*e.g.* microneedles/stents) and personalised medicines, resulting in 2 granted patents and 2 submitted. As Director of the Centre for Innovative Processing Engineering and Research (CIPER), ***Douroumis*** has extensive collaborations with industry/other universities funded by the EU and pharmaceutical companies such as Pfizer and Celgene (£754K, with overall total project value >£3M). ***Douroumis*** was among the top 2% (around top 100K) across all scientists and scientific disciplines globally, based on composite citation index. ***Griffiths'*** research employs spectroscopic and neutron scattering methodologies to quantify complex structure-property relationships in commodity formulations (funded by Unilever and Infineum-£440K) and in drug delivery contexts (*e.g*. an €8.1M FP7 funded project with18 partners (academia/industry) spread over 11 EU countries entitled "*Mucus Permeating Nanoparticulate Drug Delivery Systems*" (Greenwich allocation-€472K). ***Mitchell*** - internationally recognised expert in pre-formulation sciences and Head of Medway Sciences (an early spin-out from SoS) – has generated significant income (£4.3M) through contract research undertaken for major pharmaceutical companies, including Mylan, Merck, Pfizer, and GSK. ***Snowden*** has research interests in the chemistry of microgels and their pharmaceutical applications and has industry-funded research in collaboration with ***Mitchell***.

Advanced Drug Delivery Systems and Biomaterials Linked with Tissue Regeneration

Boateng researches (i) buccal delivery of large and small molecules to improve compliance in paediatric/geriatric patients, which resulted in a DFID funded (£18K) postdoctoral research project on formulations for treating malaria in children (<5 years) in line with UN Millennium/ Sustainable Development Goals; (ii) developing nanocarriers for mucosal vaccines. Seven of his outputs in these areas are among the top 10% most cited publications in the field worldwide (SciVal); (iii) nanocarriers for optimising cellular output of complement regulators in hereditary angioedema (new VC scholarship collaboration between UoA8 and UoA3). Further work includes ***Boateng's*** research in advanced biomaterial-based wound healing technologies for delivering actives (*e.g.* honey and growth factors) to wounds and 3D printing/bioprinting of bioactive scaffolds for tissue regeneration. These resulted in an invitation by Wiley to edit "*Therapeutic Dressings and Wound Healing Applications*" (February 2020). Six of his wound healing articles are in the top 10% most cited publications in this field worldwide, with 2 of these in the top 1% most cited (SciVal). ***Coleman*** applies inorganic expertise to biomaterials applications, including artificial cements for bone and teeth regeneration and prosthesis (gum and dental implants) and attracted funding (£55K) through collaborations with industry.

Materials Science Engineering Linked to Land Remediation

Carbonation research initially developed in SoS resulted in the formation of a spin-out company Carbon 8 Systems (C8S), (ICS-1). C8S novel CO_2 mineralisation technology is world-leading and recognised in 2017 with '*Queen's Award for Enterprise*: *Innovation*'. They were funded (€860K) by the EU for an INTERREG project "*Sustainable Aggregate Production with Imbibed Carbon Dioxide* (SAPICO2)" (2013-2015). C8S expanded to involve multi-disciplinary collaborations with the SoE and the founding of a new spin-out company, Carbon 8 Aggregates (C8A). In 2019, C8A became fully independent, operating under license from C8S and rebranded as OCO. The group is led by ***Hills*****,** Director for the Centre for Contaminated Land Remediation and he is also a non-executive Research and Development Director of C8S.

2. Biological, Medicinal and Synthetic Chemistry: *Boateng*, *Dobbs*, *Everett*, *Farman*, *Lam* (**new staff**), *Leach*, *Mitchell*, *Pang*

Research focuses on the application of synthesised/natural molecules in agriculture, disease diagnosis, targeting, prediction and therapy and won grants totalling £650K.

Biological Chemistry

Metabonomics, Microbiome and Predicting Disease

Everett - an internationally recognised expert in metabonomics, having co-conceived and co-defined the term with Nicholson (Murdoch University, formerly at Imperial College) - leads the Medway Metabonomics Unit with members from MSoP and other colleagues within SoS. The group has established high-profile collaborations, including NTU (Singapore), Murdoch University (Australia), Imperial College & UCL; he won £297K from various sources, including Wellcome Trust. A key output during the period concerned phenotype of a knockout mouse. Follow-on studies in collaboration with UCL led to the discovery of an anti-obesogenic agent (patent filing-2019), and the University is currently seeking to commercialise this compound. A second key output describes the discovery of the final biosynthetic step to taurine in humans.

Computational Chemistry, Drug Targeting/Discovery

Research focuses on the molecular mechanisms for disease and developing relevant therapies and achieved key outputs (patents, Q1 papers, strategic international/national collaborations), important for our future strategic plans. ***Leach***, who specialises in the biochemical basis of neurological and immune-related diseases, is co-inventor of Pleneva (BGC20-0134; BTG International), which has reached Phase II clinical trials for multiple sclerosis. Research into the medical uses of triazine derivatives resulted in 12 patents, including: "*HK1170726 (A1)2017-06-02 Cyclic triazo sodium channel blockers*" (2017); and "*Triazine derivatives as interferon gamma inhibitors*" (2018). ***Pang's*** computational chemistry research aims to elucidate fundamental mechanisms of enzyme activity and has gained EPSRC National Computational Facility access, and her expertise interfaces with other members, *e.g.* PhD supervision with ***Alexander*** and ***Dobbs***.

Medicinal and Synthetic Chemistry

This is led by ***Dobbs*** and strengthened by the recent strategic appointment of ***Lam***, which has resulted in excellent synergy between novel asymmetric synthesis and electrosynthetic chemistry respectively, coupled with the refurbishment of a new synthetic lab (£157K) equipped with modern facilities (section 3). Sustainability of the group has been reinforced by the recent appointment of two new ECR's (Gale and Honey). ***Dobbs*** is a leading heterocyclic chemist with >£200K in grants for developing new synthetic methodologies. Other areas include novel nitro-containing heteroaromatics as potential anti-parasitic agents and developing anti-mesothelioma compounds funded by June Hancock Mesothelioma Research Fund (JHMRF) and British Lung Foundation (BLF). ***Lam's*** research (activation of organic molecules using electrochemistry, medicinal electrochemistry, and electrocatalysed reduction of carbon dioxide) has demonstrated

rare interdisciplinarity and made significant contributions to disparate fields including catalysis and oncology with funding from EPSRC (Electrochemical generation of oxygen and nitrogen centred radicals) and Wellcome Trust (£300K).

3. Chemometrics and Analysis: *Alexander*, *Antonijevic*, *Everett*, *Farman*, *Griffiths*, *Pang*, *Wray*, *Zand, Zeinalipour-Yazdi*

Research covers critical fields of current social importance, including environment and sustainable global food security as outlined below:

Petrochemical, Geochemical and Environmental Analyses

Highlights in this area are exemplified by the work of ***Wray***, founder and Technical Manager of the ISO 17025 accredited Analytical Services Laboratory (ASL) housed within the SoS, which offers advanced analytical facilities. Research focuses on inorganic elemental, isotopic and mineral analysis by ICP- and X-ray-based techniques for solving geochemical, forensic, and environmental challenges with an annual turnover of £200K. Over many years, research work has formed the basis for international collaborations with industry, most derived from the oil and gas industry, through a long-standing technology transfer collaboration with Hafren Scientific. Examples include mineral provenance studies using automated Raman spectroscopy and Pb-U isotope chronology of zircons in East Africa (Apache/BG/Shell-US$100K); NW Shelf of Australia (Apache Quadrant/Santas-US$400K); Greater Grand Banks of the North Atlantic (Hafren- £1M), which has established the largest source to sink mineral provenance database in the world for this active area of exploration and new development. ASL has also provided mineralogical, chemical, and rock evaluation studies to shale gas projects in the Permian Basin of Texas (USA) for clients including Chevron, Oxy, EOG (US$300K). These collaborations have also resulted in publications, *e.g.* implications for the paleoenvironmental conditions leading up to the Late Devonian Mass Extinction in terms of ocean chemistry and a co-funded PhD. A significant geochemical output involving national/international collaborators from Oxford, University of Washington, Curtin, Utrecht & Milan Universities presented and interpreted data from a globally important Late Cretaceous succession in which the rock record is interpreted to show elevated global temperatures, high sea levels and likely reduced oceanic circulation. ***Wray*** generated and interpreted the inorganic and rock evaluation chemical data.

Renewable Energy, Catalysis, Sensors and Green Chemistry

Work in this area is typified by ***Alexander*** and ***Zeinalipour-Yazdi's*** research, in collaboration with the computational chemistry sub-group. ***Alexander*'s** research covers solar energy conversion, photocatalysis/renewable fuels, computational chemistry, modified surfaces for micro-array sensors and spectroscopic analysis of geological samples and been funded (£270K) and involved strategic collaborations with ***Wray*** and internationally recognised researchers in other fields. A key output resulted from collaboration with Australian and UK researchers, focusing on how the structure of a key peptide involved in Alzheimer disease and diabetes is influenced by interaction with nanomaterials' surfaces, with clear societal impact. ***Zeinalipour-Yazdi's*** research has resulted in important outputs, *e.g.* a *Nature* group paper demonstrating the ability of combined operando spectroscopy and density functional theory calculations to characterise a previously unidentified PdNx species, and how Pd catalysts support catalytic oxidation of NH_3 to N_2.

Pharmaceutical Quality Control, Consumer Product Development and Analysis

Antonijevic's research using thermal (TSC, DSC, TGA) analytical techniques to study pharmaceutically important molecules has resulted in strategic collaborations with industry. His collaboration with Dermal Laboratories, who have a unit within SoS, has brought in approximately £714K in enterprise research income.

Global Food Security and Nutrition

This involves strategic collaborations with the NRI, an internationally recognised centre of excellence. ***Farman*** undertakes pheromone chemistry research for agricultural purposes (ICS-2), with significant external funding (£500K), from various sources such as Gates and McKnight Foundations. ***Farman's*** research provided the first evidence that plant chemicals confer resistance to sweet potato weevils, and segregate with insect resistance based on field and laboratory studies. Plant chemicals can therefore be used as markers for resistance in potato for the first time and will accelerate the development of improved varieties in breeding programmes. This has substantial impact on improving food production in Africa and highly relevant to sweet potato production in the USA and worldwide. ***Zand's*** research focuses on nutritional chemistry and developing new protocols for analytical based optimisations for nutritional quality of new food products. Her work is referenced in Public Health England advice documents on infant nutrition standards.

c) Research Culture

The Unit actively contributes to FES weekly research seminars with both internal and external speakers. All PGR students, postdoctoral fellows and Unit members are required to attend to keep up to date with current developments in their respective fields. Furthermore, to ensure strategic interdisciplinary research with other Units, our members participate in MSoP, and NRI seminar series and members have active collaborations with both entities, including joint supervision of PGR students and postdoctoral fellows. Each PGR supervisor holds regular research group meetings comprising academics, PGR students and postdoctoral fellows where each presents and answers questions about their research. This is supplemented by training and Three Minutes Thesis (3MT) competition implemented by the Greenwich Research and Enterprise Training Institute (RETI). The ECR forum within FES allows ECRs to discuss research and highlight for senior management, areas where further external training input and support are required. Research groups hold regular meetings to review research progress including evaluating targets/milestones set for internally allocated research funding, exploiting grant opportunities and growing our research impact, allowing a vibrant environment within the Unit and sustains vitality. We also contribute to the FES Public Lectures named 'GREat Medway Talks' and 'Pint of Science' which are designed to expose the surrounding Kent townships to the excellent research undertaken by UoA8 members and other FES researchers. In addition to supporting open access publication using allocated research group funds, we strictly adhere to open access requirements. All published work and PhD theses are deposited to our institutional literature archive and are freely available after the embargo periods. All ethical matters are initially scrutinised by Faculty Research Ethics Committee which can approve straightforward applications, while more complex applications are forwarded to the Central University Ethics Committee

d) Impact Strategy

The strategy to derive impact from UoA8 research has several connected threads;

- profile raising both at the level of the individual academic within- and of- an institution with ambitions to achieve a more research intensive environment.
- consolidation/diversification of external partnerships with a focus on addressing industry/societal problems and opportunities.
- an increased focus on the practical nature of our research and its ability to address global challenges,
- Patenting and licencing of knowledge and technologies, and where appropriate

- Developing impact pathways for key research portfolios including investment in knowledge exchange activities to support translation of research into impact e.g. appointment of a new Enterprise Business Manager.

There is evidence of significant success in this strategy on which the UoA can build *e.g.* the level of funding from strategic partnerships with industry etc. (>£5 million); the work with GALVmed supporting overcoming livestock diseases in low and middle income countries, and the importance of licencing technologies in the impact pathways of the two case studies submitted partners.

e) Specific Objectives for the Next REF Period

The research strategy of the SoS and UoA8 is developed in tandem with the Faculty and University Research & Enterprise Committees. The Faculty committee is also guided by an external industrially-focused Advisory Board. Chemistry has ambitious targets and objectives:

- consolidate and expand the existing research groups and specialist centres including enhancing interdisciplinary collaborative research across FES and wider university.

- expand international collaborations - our international outlook informs the practical nature of our research and seeks to address global challenges that affect particular regions of the world *e.g*. (i) ***Dobbs'*** synthesis of novel drugs to treat leishmania common in developing countries, (ii) ***Boateng's*** DFID-funded collaboration with Ghanaian researchers that significantly improves compliance with antimalarial medication in African children (<5 years) to reduce fatalities. These fulfil UN Sustainable Development Goals, and we will expand this approach to other areas.

- develop researchers at all career stages in an inclusive and nurturing environment for sustainability of research capability and ensure succession planning (*e.g.* ***Lam*** has been supported with VC PhD studentships to help delivery on his EPSRC First Grant).

- exploit our research outputs and commercially supported projects to drive grant submissions in our core research themes and sub-groups.

- pursue an active programme of infrastructure enhancement, through laboratory refurbishment and a rolling programme of replacing capital equipment.

- drive research quality, interdisciplinarity and knowledge through the evolution of the groups into a cross-faculty impact-focussed Institute, in alignment with the University's new strategy (2021-2030).

2. People

i*) Staffing Strategy and Staff Development*

Staffing strategy within the SoS is structured to achieve equality and diversity of research themes/groups and protected characteristics and balance between ECRs and experienced researchers for effective succession planning and sustainability of the Unit. Subsequently, strategic academic appointments have been made to support, broaden, and enhance the key research areas in line with FES philosophy of '*learning by doing*' and rewarding research excellence. The underlying theme of our staffing strategy has been the recruitment and development of well-rounded academics that recognise opportunities in research, research informed training/teaching and enterprise. In addition, it provides a supportive, and enabling environment for existing members to progress their research careers. This includes targeted

research training and development and well-defined career progression through the Research Career Pathway.

Staff undergo annual appraisals to celebrate achievement and facilitate career development and discuss individuals' needs, including adjustments to workload *via* the Greenwich Balanced Academic Workload model. All academic staff with a minimum 20% allocation in their workload model are designated as having SRR. Appraisals help to evaluate and identify researchers for promotion, with several Unit members benefiting from this approach. The School was involved in Erasmus exchange scheme for all researchers during the REF period, offering the opportunity for knowledge exchange and seminars at partner institutions. The 'Outside Inside' inter-university scheme offers researchers the opportunity to gain work experience by undertaking a shadowing placement at a partner institution. Some examples of our staffing strategy and staff development are outlined below:
Lam (Reader/Associate Professor: electrosynthetic chemistry); Castilla (Senior Lecturer: pharmaceutical sciences); Gonzo, Honey and ***Zeinalipour-Yazdi*** were recent appointments to strengthen our research environment and boost outputs (grant income/publications). Castilla, Gonzo, and ***Lam*** have been supported with VC PhD studentships to progress their research and mentoring support provided by ***Boateng*** and ***Dobbs***.

ii) Early Career Researchers and New Academic Staff

Greenwich is a nurturing environment for early career appointees, as evidenced by a good record of successful awards in EPSRC First Grants. During the REF period, all eligible UoA8 staff (4) were able to submit their EPSRC First Grant with 2 successful outcomes (Szilagyi 2015; ***Lam*** 2019). The School has been successful in attracting its first Marie Curie Individual Fellowship (Mittapalli) and has 3 additional independent research fellows, one of whom contributed towards our ICS-1. New and early career staff undergo a structured probation (1 year) and supported in career development by the appointment of mentors, provision of PhD studentships and start-up funds, low teaching and administration loads for the first two years and meet with the Head of School every 4 months. RETI provides regular staff development to academic researchers; indeed, all research active staff are required to undertake refresher courses every three years. All academics and researchers new to supervision must attend the "*Essential Training for Research Staff*" courses to acquire the skills and knowledge required to effectively function as PGR supervisors. They also receive guidance on obtaining research funding, writing grant applications and publications.

The SoS actively encourages career progression of all its researchers through effective mentoring. Several members who started their Greenwich careers as ECRs at AC2 have all progressed significantly through the mentoring system [***Alexander*** (*AC4*)***, Antonijevic*** (*AC4*)***, Boateng*** (*AC5*)***, Coleman*** (*AC3*), ***Douroumis*** (*AC5*), ***Wray*** (*AC5*), ***Zand*** (*AC4*)]. The Unit strategically allocates PhD supervision roles and funded VC PhD scholarships (***Alexander, Antonijevic***, ***Boateng***, ***Coleman***, ***Dobbs***, ***Douroumis***, ***Everett, Griffiths, Lam, Pang, Zand***), Research Group Funded PhDs (***Boateng***, ***Douroumis, Hills, Lam***) as well as DTA PhD allocations (***Dobbs, Lam***). We organise these roles to enable ECRs to act as First Supervisor while experienced researchers act as co-supervisor and mentor. ECRs can also act as second supervisor on other PGR projects, observing effective supervision from experienced supervisors.

To further strengthen our research staff base and provide more opportunities for ECRs, UoA8 has successfully bid for internal (REF and HEIF) and external grants to recruit postdoctoral fellows who undertake specific programmes of research and provide day to day oversight for research teams led by Unit members. This includes being on supervisory teams for PGR students, contributing to a diverse and vibrant research environment. For example, 6 postdoctoral fellows have supported ***Boateng*** and ***Douroumis*** to run CIPER and delivering important externally funded research projects (see below).

iii) Research Students

An important aim of the REF 2014 strategy was to increase the number of doctoral students. In addition to various externally funded scholarships (RCUK, EU, industry, charities) Greenwich provided annual VC Scholarships (fees and maintenance) on a competitive basis (Table 2). Greenwich joined the UADTA which supports PhD students in two schemes (Biosciences and Energy), benefitting the School with additional PhD students. The Head of SoS (***Dobbs***) is also Director of the UADTA in Biosciences (2019-date). Greenwich has signed up to the new UADTA and was also invited to join the recently renewed BBSRC-funded Doctoral Programme (LIDO), which will provide additional students for the next REF period. These schemes mean high quality students continue to be recruited with many coming through our MChem and MSc Pharmaceutical Science /Formulation Science programmes. Since REF 2014, Chemistry has increased its overall number of PGR students with completion rates increasing by 8.5% from 43 in 2014 to 47 (Table 2).

Another key infrastructural change was the establishment of RETI, which oversees all aspects of PGR recruitment, supervision, PGR training, and progression, aided by the Faculty Research Degrees Committee (FRDC), chaired by ***Wray***. All PGR students undergo a formal interview with a minimum of two research active academics, to determine their suitability for research at PhD level. Each student has a 1st and 2nd supervisor and in many interdisciplinary projects there is a 3rd external (academic or industrial) supervisor. Student progress is carefully monitored by FRDC *via* a series of report forms (6, 12, 24, 36 months). All students submit a transfer report and undertake an MPhil-PhD oral *viva* within 18 months, assessed by two research active academics independent of the supervisory team.

Table 2: Total VC/DTA PGR Students and PhD Completions August 2013 – July 2020

Year	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	Total
VC/DTA	2	5	-	2	5	2	1	17
Completions	6	7	11	2	5	6	10	47

All 47 PhD graduates have either become successful academic researchers in several UK (*e.g.* Queens University Belfast, University of Strathclyde, Imperial College, De Montfort) and international (*e.g.* University of Texas at Austin, Kwame Nkrumah University of Science and Technology (KNUST), Ghana, University of Napoli, Modern University of Science & Arts, Cairo) universities, or gone into research careers in industry (*e.g.* AstraZeneca, Pfizer, Bristol Myers Squib, Almac, Infineum and Novartis).

The School funds one UK and one international conference for all PGR students, conditional on presenting at the meeting. UADTA students get additional training and placement opportunities provided by the UA and partner academic and industrial organisations. PGR students are represented on the Faculty Board. In addition, there are two dedicated Programme Leaders for MPhil/PhD (***Lam***) and MRes (Bartlett) students. ***Lam*** represents PGR students' interests at FRDC, while ***Wray*** is the FES Representative on the University R&E Committee.

iv) Equality and Diversity

Greenwich is a signatory to the Concordat to support the career development of researchers. The SoS operates under Greenwich's Equality and Diversity Policy, covering all aspects of university work, including appointments and promotions. This is aptly reflected in the SoS leadership team comprising Head of School (M), Deputy Head of School (F), 4 women (Teaching Leads (x2), Director of Enterprise (BAME), & Director of Admissions & Outreach) and Director of Research (M). Of the 18 staff being submitted to Chemistry, 3 are women, 3 are developing-country nationals, and 2 are British of BAME background. ***Boateng*** (BAME) is also Joint Lead (with the Head of Science) for UoA8 REF 2021 submission. Greenwich was awarded an Athena Swan Bronze award in 2013 and the Head of SoS is a former Chair of the University Athena Swan Committee. Greenwich also runs the Aurora programme for female staff considering future leadership roles. More female [Pecorino (2019), Bartlett (2020)] and BAME

(***Boateng***-2020) staff have been proactively encouraged and supported to apply for promotion to full Professorship and have been successful.

All appointment panels for research fellows and academics with research roles, include members of both sexes and an external panel member, and have all undertaken EDI training. All senior staff undergo training concerning legal requirements around maternity/paternity/adoption leave and staff are made aware, via HR, of what leave is available. PGR supervision cover for members on maternity/adoption leave and paid 'Keeping in Touch' days are provided. The SoS also encourages continued research activity by Senior Emeritus staff, who have contributed >60 papers, 5 PhD completions and raised over £489K research income during the REF period. Finally, staff are allowed working at home arrangements for writing grant applications and significant publications, which is particularly convenient for those with parental responsibilities.

UoA8 has welcomed PGR students and postdoctoral fellows from all continents which has provided a rich diverse cultural environment. Of the 47 successful PhD completions, 38 (81%) were of BAME origin and 24 (51%) were female, reflecting the inclusive, international outlook and widening participation ethos of Greenwich which has enormously enhanced our research environment.

3. Income, infrastructure and facilities

i) Research Income

The Unit won external grants with total project value around £15M (Greenwich allocation £6.09M, during the period, representing a significant (370%) increase over REF 2014 income (see Table 3 for selected highlights). To maintain a sustainable chemistry Unit, the School has acknowledged and adapted to changes in the funding landscape. Funding sources have been diversified, including EU, EPSRC, BBSRC, Innovate UK, DFID, industry (*e.g.* Pfizer, Merck, Celgene) and charities (*e.g.* Leverhulme, Wellcome Trust). The applied nature of most of our research has resulted in high levels of success with development, industry and enterprise grant income.

Table 3: UoA8 Income (Greenwich Allocation) Based on Relevant HESA Categories Accrued (2020) from Different Funding Sources Compared to 2014

Income Source	Total Income REF 2021	Increase over REF 2014
UK-based charities (open competitive process)	£1.59M	£145K
UK central government//local, health & hospital authority	£107K	£14K
UK industry, commerce, public corporations	£1.24M	£578K
EU government bodies	£1.17M	£981K
Non-EU Industry, commerce & Public corps	£102K	£92K
Non-EU Other	£798K	£797K
Research income-in-kind	£827K	£554K

Selected highlights of external income are outlined below:

Alexander has been funded to the tune of £270K including a KTP (£130K) with Chemostrat, involving automated analysis of heavy minerals for the oil industry and self-cleaning coatings in collaboration with ***Wray*** as part of technology transfer into the company. ***Alexander*** was granted beamtime at the ISIS Neutron beam for soft matter analysis and consultancy income from Raman microscopy analysis of heavy minerals. ***Dobbs*** received £178K for Marie Curie Postdoctoral Research Fellow (FP7-PEOPLE-IEF Scheme:2016-2018). ***Everett*** achieved grant income (£297K) including Wellcome Trust Pathfinder Award and Horizon Discovery. ***Antonijevic*** brought in industry-based income (£714K), involving characterisation of topical formulations for clinical effectiveness and user acceptance. ***Douroumis*** obtained funding from the EU and

pharmaceutical companies (£754K) *e.g.* "*3D Printing Platform*" (Celgene Corporation, US); "*Innovative MulticOmponent Drug dEsign*INTERREG-2018; "*Transdermal Microneedles for Insulin Delivery*" (Science without Borders, Brazil). ***Boateng/Douroumis*** won an Innovate UK, KTP Award (£158K) in collaboration with Cubic Pharmaceuticals (Kent). ***Farman*** obtained research income including BBSRC (£146K), Agriculture and Horticulture Development Board (£175K) and DEFRA (£112K). ***Griffiths*** received external research funding approximating £440K, predominantly from major companies such as Akzonobel, GSK, Unilever and Infineum in addition to EU FP7 grant (€472K) noted in section 1 above. ***Hills*** accrued £192K in research and enterprise income including "*Investigation of the Treatment of Incinerator Bottom Ash Fines by Accelerated Carbonation*". ***Lam*** obtained EPSRC funding (£260K) on '*Electrochemical Generation of O and N Centred Radicals*' while ***Dobbs, Lam*** have won 3 UA Doctoral Training Alliance–PhD Scholarships (£130K). ***Mitchell, Snowden*** have obtained significant income £4.3M) through contract research for various pharmaceutical companies including Merck (£556K); GALVmed (£1.69M); Pfizer (£64K); Curadev (£100K); Mylan (£114K); and Merial Inc/BI (£1.8M). ***Wray***, through ASL obtained £993K over the REF period, providing chemical and mineralogical data derived from advanced instrumental techniques to clients across petroleum, environmental and geotechnical disciplines based in the USA, Australia, UK, Africa and the Middle East. ***Zand***, obtained income of £167K including: Innovate UK Smart Grant 2020, PhD research grants and consultancy projects.

ii) Infrastructure and facilities

The SoS and UoA8 infrastructure has benefitted from external grants and strategic investment from Greenwich to conduct cutting edge chemistry research, reflecting a research-intensive School. Since 2014, the University has spent a total of £2.13M on capital equipment (£1.75M) and infrastructure (£389K) projects in SoS.

a) Core facilities

The core facilities have been maintained and enhanced during the period. There is significant NMR provision (500MHz, 2 x 400MHz, 300MHz) for solution and solid-state studies with one 400MHz machine replaced in 2020 (£325K) funded by the University. We have a mass spectrometry centre of excellence, containing 11 mass spectrometers, including single quadrupole, ion-trap, triple quadrupoles and MALDI-TOF machines and an Orbi-trap HRMS. The total investment in new equipment for the mass spectrometry centre during the period was £520K. A trace metal analysis facility comprising a WD- and ED-XRF, 2 ICP-OES and 2 ICP-MS instruments, one of which is coupled to a 213nm laser ablation solid sample introduction system forms are key components for our ISO 17025 accredited ASL. Others include benchtop IR, UV, circular dichroism, fluorescence and vibrational (Raman mapping/SERS) spectroscopies; and for interdisciplinary projects; X-ray diffraction, atomic force and electron microscopy (AFM, SEM). The SoS's high quality research environment is supported by highly skilled and dedicated team of technicians (21 FTE), 5 of whom have PhD, who maintain all equipment and provide interpretation expertise.

The SoS is supported by excellent library facilities, and Greenwich has supported UoA8 with increased investment (£2.12M) in facilities, including access to all the major chemistry related journal publishers (Science Direct, RSC Gold, Wiley) and databases (Reaxys, Scopus, Web of Science), supplemented with IT provision including statistical tools such as MATLAB, SPSS, Origin and Sigma Plot and a ChemDraw site licence.

b) Research group specific facilities

Pharmaceutical/Materials Sciences: Specialised facilities for pharmaceutical/materials analyses, include LC-MS/GC-MS, HPLC (9 instruments) and GC (5 instruments) laboratories; two Nanosurf EasyScan atomic force microscopes, two Malvern Zetasizer Nano ZS for measuring size and zeta potential of colloids and nanoparticles/proteins. The group hosts CIPER which has extensive international collaborations through EU funded projects (*e.g.* AMPTEC and

IMODE (INTERREG 2 seas). CIPER houses advanced state of the art formulation technologies including hot melt extruders (x2), freeze-dryers (x3), spray dryer, texture analysers (x2), 3D printers/bioprinters (x13), Franz cells and automated industrial tabletting machine. Others (flow through USP dissolution baths, powder testing machine and a rheometer) were donations from Colorcon (Darford) through their collaboration with ***Boateng***. ***Griffiths*** uses scattering and spectroscopy to characterise hierarchically organised materials and has access to a 400 MHz NMR spectrometer customised for conducting electrophoretic mobility and diffusion measurements, and a prototype solvent relaxation benchtop NMR spectrometer which are deployed in combination with the world-class neutron scattering facilities through STFC (ISIS and ILL) (£720K in-kind contribution).

Biological and Medicinal Chemistry: A new synthetic chemistry lab (£157K) was developed in 2018 (***Dobbs***, ***Lam***). This is fully equipped with all the tools for synthetic chemistry, including, a glove box, ultrahigh speed potentiostat, CombiFlash automatic chromatographic purification system (x2), and Microwave reactor. In 2019, IKA provided electrochemical/electrosynthesis suite of equipment containing 10xElectrsyn 2.0 (£39K) and associated electrodes. The group has unrestricted access to a state-of-the-art LSM880 confocal microscope with airyscan and a Tutting edge electrophysiology rig, which was a £400K capital investment by Greenwich with further benefit for other members (***Boateng***, ***Douroumis***), resulting in significant outputs, and impactful externally funded collaborative research with other Units (UoA3, UoA6). Key areas include '*Printing of Tissue Engineered Scaffolds for Wound Healing and Skin Regeneration*', and '*Microneedles in Drug Delivery Through Skin Cells*'. The 'tissue culture and parasitology research laboratory, funded by FES is the only CAT 2 laboratory at Greenwich, equipped with an Accuri C6+ Flow cytometer for cell analyses and an ultramicrotome for preparing biological samples for SEM, and serves various research groups within UoA8 (***Boateng***, ***Dobbs***, ***Douroumis***, ***Lam***).

Chemometrics and Analysis: Greenwich strongly supports computational research (***Alexander***, ***Pang***, ***Zeinalipour-Yazdi***) through the provision of a local High Performance Computing (HPC) facility (*ca* £400K) based on a 64-bit Centos 7 Linux operating system, comprising 1150 processing cores, including 48 compute nodes, each with 20 CPU cores (2.4GHz, 128GB DDR4 RAM) for molecular modelling research. The group also has DSC, HSM, TGA, cone and plate rheometers (x2), and advanced FTIR/Raman mapping capabilities, which serves collaborative research with the Pharmaceutical/Material Sciences research group.

iii) Future investments

The secure financial position within the Faculty and University means that a future funding strategy will build on enhancing our research infrastructure and facilities over the next period, complimented by external capital grant income. These include continuing the rolling programme of laboratory refurbishments (3-5 years); an update of at least one of the ageing core analytical instruments *e.g.* plans for one new NMR machine and Research England World Class Laboratory Fund from which SoS will gain £94K to part fund a triple quad ICP-MS.

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

Greenwich's core research vision (section 1) is embedded through all our research activities.

(i) Collaborations

The SoS has been designed to remove barriers and to facilitate interdisciplinary research. UoA8 demonstrates excellent collaborations with international, national and local partners alongside demonstratable impact/pathways to impact. This is clearly evidenced by the number (1011) of collaborative articles (Table 4) over the REF period, involving industrial, academic and clinical partnerships as well collaborative grant income (section 3).

Table 4: **Number of *Co-authored Publications 2014-20 by Research Group and Collaboration Type***

Research Group	***International***	***National***	***Institutional***
Pharmaceutical/Materials Sciences	178	162	172
Biological and Medicinal Chemistry	67	72	22
Chemometrics and Analysis	161	103	74

Key and impactful collaborations of UoA8 are briefly outlined below.

Pharmaceutical/Materials Sciences

Boateng's collaborations with Ayensu, (KNUST, Ghana), on '*Novel Antimalarial Paediatric Formulations*' resulted in a DFID-funded postdoctoral fellowship (2018) and being progressed for phase 1 clinical trials in collaboration with the School of Medical Sciences, KNUST and a Ghanaian pharmaceutical company. Collaboration on '*Antimicrobial Dressings for Wound Healing and Tackling Biofilms in wounds*' with Debrah (University of Ghana), resulted in a 2019 article. ***Coleman's*** collaboration with FORZA Industries Ltd on food supplements and medical devices resulted in external income (£55K). ***Douroumis'*** collaboration with Uddin (BRAC University, Bangladesh) and Lamprou (Queens University Belfast) resulted in a key output on intradermal insulin delivery. ***Boateng*** and ***Douroumis*** collaboration with Lille 1&2 University and Lamprou resulted in a second article on insulin skin delivery while their collaboration with Cubic Pharmaceuticals resulted in an Innovate UK KTP (see above). ***Hills*** is a Director of the University spin-out company Carbon8Systems. ***Mitchell*** and ***Snowden's*** collaborations with world leading pharmaceutical industries resulted in significant research income (section 3), publications, patents, and commercial products.

Biological and Medicinal Chemistry

Dobbs hosted a CASE award with AstraZeneca and fully funded postdoctoral research fellow from GSK on butylrubber oligomers. He collaborates with Szlosarek (Bart's Hospital) investigating anti-mesothelioma compounds funded by JHMRF and BLF. ***Everett*** collaborates with Nicholson (Murdoch University), yielding several patents and publication [(*e.g. on* Metabolic Phenotyping. His collaboration with Shephard (UCL), on therapeutics for lowering plasma cholesterol and weight gain, resulted in Wellcome Trust Pathfinder and UCL TAS Fund Awards. ***Farman*** works extensively with partners in the horticulture sector. ***Lam's*** collaborations with several universities have resulted in significant publications: (i) Zaitsev**,** Moscow State University on aryl oligogermanes; (ii) Geiger, University of Vermont (USA) on ethynylferrocene; (iii) Hilton UCL on electrochemical methoxymethylation. ***Lam*** actively collaborates with GSK, Johnson & Johnson (Belgium, Spain) developing novel electrosynthesis methodologies for drug synthesis. ***Pang*** has several international and national collaborations including Lange, Alborg University, Denmark employing molecular dynamics simulations.

Chemometrics and Analysis

Alexander has significant publications from collaborating with Stephens, a Biomedical Materials Scientist (Imperial College London), Taillefumier (Universite Blaise Pascal), Hjelmgaard (Technical Unitesrity Denmark) and Guilliano Sgiligardi (Diamond Light Source). ***Antonijevic's*** collaboration with Dermal Laboratories on formulation product design resulted in key open access publication and research income (£714K) as noted above. ***Griffiths*** has an extensive network of collaborators including funding industries outlined above and hosted 3-5 Erasmus researchers annually. ***Wray's*** international collaborations with several petrochemical companies and universities (*e.g.* Oxford University) has resulted in significant income (sections 1 and 3) and research outputs. ***Zand*** is a Member of the Joint Research organisation of NHS

South East Trust and developed strategic collaborations around healthy baby foods especially in Kent, illustrating the social impact of our research.

ii) Leadership and Recognition in the Academic Community

Research achievements of staff have been recognised by the award of prizes, invitations, election to leadership roles (nationally/internationally) and other indicators of esteem as summarised in Table 5 below and supported by selected highlights.

a) Exemplars of leadership positions in learned societies/professional bodies/international committees

Antonijevic (Vice Chair, RSC Thermal Methods Group; ***Boateng*** (Evaluator Panel Member, *Czech Academy of Sciences-2020,* the Czech equivalent of REF); ***Dobbs*** (Secretary & Treasurer RSC Heterocyclic & Synthesis Group (2011-15), RSC Organic Division Council (2013) & RSC Admissions Committee (2016-2022); Committee Member International Society of Heterocyclic Chemistry (2019-2022); ***Douroumis*** (Member, Board of Academy of Pharmaceutical Sciences (APS) of GB and Ireland (2014-2015), ***Everett*** **(**Member, Metabolite Identification Working Group and served on Innovative Medicines Initiative (IMI) expert panels deciding on grant awards approximating €44M); ***Griffiths*** (Chairperson, Society of Chemical Industry Rideal Trust and ISIS Faculty Access Panel 8 (SANS); ***Leach*** (Member, Royal Society of Medicine's Clinical Neuroscience section); ***Pang*** (Committee Member Molecular Graphics and Modelling Society); ***Wray*** (Custodian Trustee-2017-date and, Vice President (appointed 2020) of the Mineralogical Society of GB and Ireland); ***Zand*** (Member, Research Award Board of Coeliac UK).

Table 5: Summary of Members' Recognition

	Count
Exemplars of leadership in the academic community, learned societies, professional bodies	>20
Conferences organised or chaired	>13
Plenary/invited keynote lectures	>100
Fellowships	>20
Journal editorial advisory board membership, national and international advisory boards/committees	>20
Refereeing academic publications or research proposals	>200

b) Prizes/Awards

Dobbs, (RSC Inspirational Member Prize Award 2015); ***Douroumis*** (APS Outstanding Scientific Contribution Award 2017); AAPS Pharmaceutical Research Meritorious Manuscript Award (2020); ***Lam*** (Thieme Journals Award 2019).

c) Organisation of major international scientific meetings

Examples include: ***Douroumis***, ***Mitchell***, ***Snowden*** (10th APS PharmSci Conference, Greenwich 2019); ***Snowden*** was elected Science Chair for the 11th APS Conference in 2020. ***Boateng*** (Organising Committee Member-International Conference and Exhibition on Pharmaceutics and Nanotechnology, London 2018); ***Dobbs*** (Organising Secretary and Chairperson, 22nd RSC Grasmere Heterocyclic Chemistry Symposium 2015); ***Griffiths*** (UK Colloids 2017, 2021); ***Pang*** (MGMS Young Modellers Forum 2015-date)

d) Invited/plenary lectures/session chair roles

The Unit's members have given over 100 invited/plenary lectures over the REF period at international conferences and taken chairing roles (>20) in conferences including:

Boateng (International Conference on Pharmaceutics and Nanotechnology, London, 2018); ***Coleman*** (ICDP Surtsey Workshop, Iceland, 2014); Dobbs (>10 plenaries, *e.g. International Society of Heterocyclic Chemistry Conference, Japan 2019*); ***Douroumis*** (chaired over 5 sessions and delivered more than 30 plenaries/keynotes *e.g.* Controlled Release Society Annual Meeting, Seattle, USA 2016); ***Everett*** (20 keynotes, *e.g.* "R & D Innovation Leaders Forum, Next Level Life Sciences, Basel, Switzerland 2020); ***Lam***, delivered over 20 plenaries/keynotes *e.g.* (ACS Meeting San in Francisco 2020, GSK meeting on Electrosynthesis for Drug Discovery 2019, Stevenage, UK); ***Pang***, (EPSRC UK National Service for Computational Chemistry Software (NSCCS) user meetings (2014-2015); ***Zand*** (Food Innovation Asia Conference, Bangkok 2018), Chaired session at Food Matters Lives, London 2014).

e) Visiting professorships

Many staff have had visiting academic positions during the period, including ***Antonijevic*** (Faculty of Pharmacy, University Business Academy, Novi Sad, Serbia); ***Boateng*** [KNUST (2014-date) and University of Ghana (2013-2014), both in Ghana)], ***Everett*** (Imperial College and NTU, Singapore). These have achieved social impact, through research capacity building especially in developing countries, thus fulfilling UN sustainable and millennium development goals.

f) Editorial roles

Members act as journal editors or editorial board members and exemplars include: ***Alexander*** (*Journal of Chemistry*); ***Antonijevic*** (*Journal of Mining and Metallurgy*); **Boateng** (*Journal of Pharmaceutical Sciences; Polymers*), ***Coleman*** (*Prosthesis; Crystals, Journal of Composites Science*), ***Dobbs*** (Molecules); ***Douroumis*** (*Advances in Pharmaceutical Technology*; *Journal of Nanomedicine and Nanotechnology*); ***Everett*** (*Metabolites*); ***Griffiths*** (*Polymers*); ***Pang*** (*Journal of Algorithms and Computational Technology*; *Journal Frontiers in Chemistry*); ***Zand*** (*Journal of Pharmacy and Nutrition*).

(g) Refereeing academic publications or research proposals

The international profile of our members is shown by reviewing for high profile scientific journals and major funding bodies, with selected highlights of reviewing for funding bodies outlined below.
Alexander **(**Polish National Science Foundation); ***Boateng*** (BBSRC, EPSRC, MRC, Danish & Polish Science Foundations); ***Dobbs*** (EPSRC); ***Coleman*** (Estonian Research Council); ***Douroumis*** (BBSRC, EPSRC, MRC, UKRI, Deutsche Forschungsgemeinschaft); ***Lam*** (EPSRC, UKRI, French & Austrian Ministries of Science); ***Pang*** (BBSRC, EPSRC).

(h) Fellowships

Antonijevic, ***Alexander***, ***Coleman***, ***Dobbs***, ***Everett, Griffiths, Hills, Pang, Wray*** (Fellows of the RSC); ***Boateng***, ***Mitchell*** (Fellows) & ***Douroumis***, ***Snowden*** (Eminent Fellows) of APS; ***Leach*** (Fellow, Royal Society of Medicine); ***Hills, Wray*** (Fellow, Geological Society of London); ***Zand*** is Fellow, Institute of Food Science & Technology and has listed chartered status. The SoS also has two Principal Fellows (including ***Snowden***) and three Senior Fellows of the Higher Education Academy.

(i) Co-operation and collaborative arrangements for PGR training

Antonijevic has been funded extensively to provide research capacity building to several universities in Serbia including training of PGR students; ***Boateng's*** Visiting Professorship at KNUST and University of Ghana provides direct PhD supervision, training and expert advice on developing effective PGR programmes. Four PGRs have successfully graduated and another postdoctoral research fellow successfully trained and co-supervised 2 other PGR students at KNUST; ***Boateng*** received DFID development funding for: "*Novel Antimalarial Formulations for Paediatric Patients in Ghana*" (£18K) and "*Testing of Phosphonium Salts*" with ***Dobbs*** (£27K) in collaboration with KNUST. ***Boateng***, ***Dobbs***, *Getti's* collaboration with KNUST researchers resulted in a prestigious Royal Society Exchange Grant in 2018 (£27K) to expand PGR training and setting up of a drug testing laboratory in Ghana, resulting in an externally funded DTA PhD studentship (2018). ***Dobbs*** is Director of the UADTA in Applied Biosciences; ***Everett*** is Visiting Professor at Imperial College School of Medicine (2014-date) and Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore (2016-2019), supporting PGR training and development.

(iii) Relationships with research users, beneficiaries of our research, audiences

UoA8 maintains active relationships with key research users and beneficiaries including patients, and chemical/pharmaceutical companies. Selected highlights are outlined below. ***Antonijevic*** works extensively with Dermal Laboratories as consultant and resulted in rebranding formulation improvement which is currently on the market. ***Boateng*** provided consultancy (£10K) expertise to NDR Ltd, helping to develop and optimise a sublingual delivery system for their proprietary peptide for subsequent clinical trials. CIPER, through ***Boateng***, ***Douroumis'*** research is a key partner in interdisciplinary networks in pharmaceutical materials sciences, pharmaceutical processing engineering and biomedical sciences and makes significant contribution to international priorities such as "*Technological & Social Innovation*" including marketed products. For example, relationship with Cubic Pharmaceuticals resulted in a KTP Award (£158K) (2019) to support the transfer and embedding of CIPER generated research knowledge, within the company over 18–24 months. CIPER provides consultancy and support for other pharmaceutical companies, including Celgene, Fuji Chemicals and Pfizer. ***Boateng***, ***Douroumis*** also supervise an employee of Gamlen Ltd (tabletting machine company) for a PhD, to enhance the company's skills base for expansion. ***Everett*** was Acting Director of the Singapore Phenome Centre at Lee Kong Chian School of Medicine, Nanyang Technological University-NTU (2016-2018) and generated significant outputs including (i) Virus-induced cancer: translational oncology research and Immunology Consortium-VICTORY, with NTU, Singapore) for OF-LCG May 2017 Grant Call, £200K (2018); (ii) Precision Medicine in Hepatocellular Carcinoma, Singapore Clinician Scientist Award - National Medical Research Council, £484K (2017). ***Griffiths*** undertakes research for various companies (*e.g.* Akzonobel, GSK, Unilever and Infineum); ***Mitchell*** and ***Snowden*** undertake contract research and product development for various companies including Merck, GSK, GALVmed, Mylan and Pfizer; ***Wray*** through ASL has provided geochemical input into oil and gas projects from the Middle East, SE Asia, Norway, and Africa. Clients include PDO, BG, BHP, Chevron, Murphy, Shell, CNNOC, Husky, COP, Oxy, Santas, Beach. ***Zand*** is Food Standard Agency registered specialist and frequently contributed to several food-related projects, including "*Good Food in Greenwich (GFIG)*", "*Eating Well: First Year of Life Practical Guide*", published by the Caroline Walker Trust and "*Baby Food in the UK*".