Institution: Newcastle University

Unit of Assessment: 8

1. Unit context and structure, research and impact strategy

a. Overview

Chemistry at Newcastle University (NU) is a thriving discipline of 36 academics, a positive trajectory and ambitious vision for the future. It delivers meaningful impact, from new medicines that revolutionise the treatment of ovarian cancer to pioneering the ability to perform remote access crystallography experiments, and from new technologies for energy capture and storage to enzymes which promote deep cleaning. Its progress is underpinned by fundamental chemical research including, new synthetic approaches and methodologies for understanding chemical reactivity, which catalyses the applied research across our research themes. Research is strongly aligned with UOA8 but extends beyond this through interdisciplinary expertise and collaborations into the life sciences, materials science, engineering and physics. This has been supported by the 2017 realignment of the Faculty of Science, Agriculture and Engineering leading to the creation of the School of Natural and Environmental Sciences (SNES). Bringing Chemistry into closer collaboration with Agriculture, Biology, Environmental Sciences, Geoscience and Marine Science providing further opportunities to develop research applied to high priority societal goals.

In Chemistry, we push the boundaries of understanding by building from our underpinning research themes. This is translated to achieve broad impact by our integration with other academic disciplines and links to external stakeholders (See Figure 1). In line with NU's research strategy, we aim to be internationally leading in our key strengths that contribute to Health and Ageing, through Medicinal Chemistry and Chemical Biology, and in Sustainability and Energy through our Advanced Materials Expertise. In both, we strongly contribute to and enhance research areas across the University to achieve real impact by the translation of basic research through to the market.

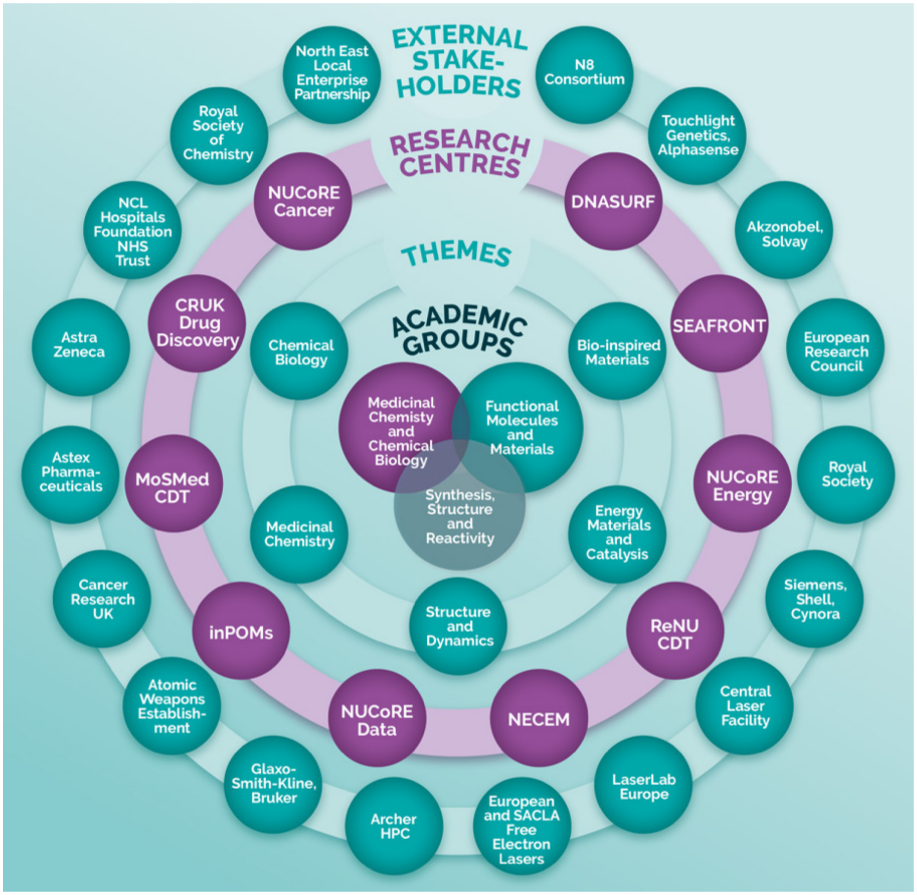

Figure 1 The research structure of Chemistry at NU including academic groups which are responsible for concurrently managing research and teaching, our core research themes and collaborations with institutional, and external partners. NUCore: Newcastle University Centre of Research Excellence, CRUK: Cancer Research UK, MoSMed CDT: Molecular Sciences for Medicine CDT, inPOMs: International Network on Polyoxometalate Science, NECEM: North East Centre for Energy Materials, ReNU CDT: Renewable Energy Northern Universities CDT, DNASURF: Molecular diagnostics through DNA modification and interfacial engineering.

Chemistry consists of a research community of 7 Professors, 8 Readers, 12 Senior Lecturers, 3 Lecturers, 4 University Research Fellows and 2 Emeritus Professors. This is a >10 FTE increase compared to REF2014 and results from strategic investment in new academic staff and development of existing researchers in our areas of established strength.

To support our objective of research-led teaching and its innovative delivery, Chemistry has 4 Teaching and Scholarship Lecturers. NU holds a TEF gold award and teaching within Chemistry is coordinated through inorganic, organic, physical and medicinal sections. We teach >500 undergraduates, across 10 chemistry courses, with 47% of these students on Masters level courses. We develop our undergraduates' awareness of research and impact through our research-led teaching programmes, school- and university-level entrepreneurship programmes. This includes undergraduate-led research seminars, skills training integrated into core modules and entrepreneurship activities embedded within our degree programmes. The effectiveness of this is evidenced at institutional level by NU being in the top 3 for UK graduate start-ups.

Chemistry is based within the Bedson building on the main city university campus and is co-located with complementary research groups in Biology, Engineering and Physics. The building is shared with industrial partners, including NewChem Technologies, Indicatrix Crystallography Ltd, NunaBio Ltd and QuantumDX. The estate has received £2.5M investment during the REF2021 period reflecting the growth of Chemistry at NU since REF2014 and a priority to support world-class infrastructure. In a broader setting, Chemistry benefits from:

- Helix venture, NU's £350 million flagship project bringing together academia, public sector, local communities, business and industry.
- £58 million Urban Sciences building, which considers energy research in an urban setting. The development also includes a low carbon energy centre and unique £2 million grid-connected energy storage testbed well aligned with our energy material research.
- £2 million Drummond Building OnePlanet facility including shared earth sciences resources for geology, geosciences, archaeology, chemistry and biology.
- The International Centre for Life, a joint venture with the NHS, which includes the Biosphere (90,000 sq. ft of state-of-the-art laboratories) on the Helix site, home to two spin outs from chemistry, NewChem Technologies and BiBerChem.

b. Research Strategy

Overview

Our research strategy is based upon our vision and objectives for Chemistry and significantly extends those laid out in REF2014. It is implemented coherently through our underlying research structure which supports progress in our research culture, objectives and vision (see subsections below). Our objectives during the REF2021 period have been to establish a positive trajectory in research and impact, develop distinct research strengths and ensure a critical mass in these areas and nurture newly appointed staff. This has resulted in an improvement of over 60 places in the QS subject World Rankings, built primarily on improvements in academic reputation. Our success is also highlighted by:

- **A significant increase in research intensity** as shown by £8.5M of funding being awarded between March 2020- February 2021 (£236K per FTE), a total of £23.3M awarded over the present REF2021 period, 70% increase in the size of postgraduate cohort and 140% increase in PDRA cohort since 2014, an annual increase in research expenditure including an overall 11% increase in total research expenditure compared to REF2014.
- **Expanded our internationally leading research strength in Medicinal Chemistry**, including renewal of the Cancer Research UK Newcastle Drug Discovery Unit, the successful translation of our core academic research in this area to the clinic (see impact section and case studies) and the establishment of a Centre for Doctoral Training. This is enhanced by full integration with the NU Centre for Cancer.
- **Developed a research strength in Energy Materials** supported by the North East Centre for Energy Materials (NECEM, EP/R021503/1), the International Network on Polyoxometalate Science for Advanced Functional Materials (EP/S031170/1) and Centre for Doctoral Training (EP/S023836/1) which works alongside the NU Centre of Research Excellence in Energy facilitating a multi-scale and interdisciplinary research across the university.
- **Significant growth of our research profile in Chemical Biology**, enhancing links between core chemistry and Medicinal Chemistry research with the appointment of 2 Chairs (**Sargent**

and **Kawamura**), and the construction of state-of-the-art Chemical Biology laboratories and facilities. Recent successes include an ERC Consolidator Award (**Kawamura**, 2020, £1.8M).

- **Establishing two EPSRC Centres for Doctoral Training** in Molecular Sciences for Medicine (MoSMed, EP/S022791/1) and Renewable Energy North East Universities (ReNU, EP/S023836/1).
- **Development of Computational Chemistry** expertise through the recruitment of 5 computational and theoretical staff (**Hofer**, **Penfold**, **Bronowska**, **Cole** and **Dawson**), responsible for >£3M external research funding and a number of high-quality research outputs.
- **Recruitment and promotion of new academic staff** (see section 2) with a 10 FTE increase compared to REF2014, including ECRs transitioning to independence, mid-career staff developing leadership and the appointment of established career academic leaders.

Research Structure

Research is coordinated through 3 interdisciplinary academic groupings, Medicinal Chemistry and Chemical Biology, Functional Molecules and Materials and Synthesis, Structure and Reactivity. These ensure the coherent and transparent management of research and teaching. Every member of academic staff is associated as a primary member of a group. Many staff have secondary group affiliations reflecting the inter-disciplinarity of the research. The academic groups develop 5 main research themes: Medicinal Chemistry, Chemical Biology, Bioinspired Materials, Energy Materials and Catalysis and Structure and Dynamics (see below). These groupings interact strongly with each other, other departments, research centres within NU and external institutions nationally and internationally (Figure 1).

Research themes and activities are supported by the Chemistry research committee composed of the Head of Chemistry (**Penfold**), three academic group leads, and the School's Research and Impact manager. Broader strategy including multi- and inter-disciplinary opportunities are assessed at the SNES research committee. This feeds into the School Executive Board and the Faculty Research Committee, all of which have representation from Chemistry.

Medicinal Chemistry (**Waring**, **Cano**, **Hardcastle**, **Cole**, **Bronowska**, **Golding**, **Carroll**, **Knight**, **Madden**) is a recognised and long-standing strength at NU. It has a strong track record of drug discovery and has progressed three projects to clinical candidates including the marketed PARP inhibitor Rucaparib and inhibitors of DNA-PK and MDM2-p53 which are progressing in clinical trials. This represents an unrivalled level of success for an academic drug discovery group of this size. The central research focus is cancer drug discovery, centred on the CRUK Drug Discovery Unit, but in line with the objectives of REF2014 this has been expanded to include infectious diseases, new approaches to drug discovery, computational modelling, radiochemistry and imaging. In the next five years this will be expanded to other disease areas with the recruitment of new research fellows (i3 grant from Research England). Radiochemistry and imaging will be further developed to establish new disease application for diagnostics and therapies.

This expansion of Medicinal Chemistry will be driven in close collaboration with Chemical Biology (**Kawamura**, **Sargent**, **Hall**, **Higham**, **Stach**). Chemistry has invested significantly in this area during the REF2021 period with the appointment of 2 Chairs in Chemical Biology and the development of state-of-the-art Chemical Biology facilities (described below). Research focuses on understanding the molecular mechanisms of epigenetic processes, development of cyclic peptide discovery platform, chemical probes development, bacterial bioenergetics, biologically active natural products, bioimaging and sensing. The aim in the next 5 years is to establish this as a core strength within Chemistry and a focal point for providing strong interdisciplinary links throughout Chemistry, SNES and the Faculty of Medical Science.

Collaborations with established academics groupings within Chemistry will be initiated through the Bio-inspired Materials (**Fulton**, **Houlton**, **Horrocks**, **Pike**, **Tuite**) theme. This theme focuses upon the application and control of DNA- and protein-based materials for a wide variety of potential applications, such as sensors for aberrant genes associated with diseases such as cancer. Future work will focus on the development of protein-based gels for use in cartilage and bone regeneration. Collaborations across chemistry are enhanced through work focusing upon

the fundamental understanding of DNA-templating to introduce long-range electrical conduction forming nanowires. These are used to assemble electrical circuits and fabricate sensing devices. This approach is complemented by our innovation that allows the integration of well-defined coordination polymer motifs into DNA. An objective during the next 5 years is to integrate and manipulate novel opto-electronic properties into these materials as a bottom up device assembly methodology, which will strongly complement our research in Energy Materials and Catalysis (**Stimming**, **Cucinotta**, **Gibson**, **Freitag**, **Dawson**, **Errington**, **Doherty**, **Benniston**).

Energy research is a rapidly emerging strength at NU and in Chemistry. Research in this theme focuses upon the development, understanding and application of novel materials to enable the low-carbon transition both in the UK and internationally to become reality. It includes expertise in electrochemistry, photochemistry/physics and catalysis and also incorporates strong applied perspectives, underpinned by fundamental research. In a functional context our materials have been used in photovoltaics, photocatalysts, batteries and organic light emitting diodes (OLEDs). Collaborations across disciplines including physics and engineering enable a molecule-to-system perspective. Fundamental understanding of functional materials will remain a key focus of the group, but our aim in the next 5 years is to expand our interaction with industry and the translations of this research into practical applications supported by the experience of the Medicinal Chemistry theme.

Energy research is complemented by expertise in spectroscopy, computational analysis and the bespoke synthesis of exotic materials within the Structure and Dynamics theme (**Probert**, **Clegg**, **Walker**, **Izod**, **Knight, Carruthers**, **Lu**, **Penfold**, **Hofer**). The challenges addressed focus upon understanding atomic scale structure, bonding and reactivity. Research involves the development and use of sophisticated and globally unique instruments (e.g. microwave spectroscopy and X-ray diffraction facilities, see section 3) to enable the measurement of matter to an increased level of detail. It also includes a broad range of computational and theoretical research and bespoke synthesis of unique chemical compounds stretching the boundaries of chemical knowledge and understanding. Our aim in the next 5 years is to enhance the connection between detailed fundamental studies into structure and dynamics with more applied research fields, e.g. Medicinal Chemistry and Energy Materials.

Research Objectives and Vision

Our vision for the next 5-10 years is to build upon the strong foundation by expanding excellence across each of the research themes while enhancing a strong and supportive research culture. Specific goals and actions for the next 5-10 years to achieve this include:

- **Nurturing excellence in research and innovation** that is based upon expanding the boundaries of fundamental knowledge that can be applied to address societal and global needs, support sustainability and promote health and well-being. Targeted actions will:
  - Strengthen our core underpinning expertise in *innovative synthesis of organic and inorganic* materials through the appointment of new staff and development of the present infrastructure providing the solid foundation for applied research.
  - Consolidate and expand *research expertise in energy materials*, with a particular aim of addressing the climate action development goals, achieved by an increased focus upon integration of emerging technologies into energy systems by strengthening links with Engineering, NU Helix site and external partners such as Net Zero Teesside.
  - Enhance *interactions with national institutes*, e.g. the Turing, Diamond Light Source, Rosalind Franklin and Francis Crick Institutes and engagement with NU's *Global Challenges Academy* aligned with UN sustainable development goals.
  - Nurture and grow the emerging strength in *computational and theoretical chemistry* by supporting recently appointed early career academics and developing strong collaborations with regional, national and international institutions.
  - Consolidate and continue to develop our *strengths in Medicinal Chemistry and Chemical Biology*, to deliver innovation, translational discovery and impact in biology and medicine.
  - Design and deliver a *flexible and world-leading infrastructure* for physical sciences with co-location with industrial stakeholders and complementary research groups across the sciences, engineering and social sciences to encourage inter-disciplinary research excellence.

- Capitalise on opportunities arising through *alignment with NU strategic goals* including Healthcare, Aging and Data.

- **Supporting staff and students at all career stages** to develop skills enabling them to achieve their objective for research in the academic, commercial and public sectors. Specific targeted actions include:
  - Development of our research-led teaching to provide *enhanced training for undergraduate students* to prepare them for research careers in both academia and industry.
  - Expand and develop our successful model of *industry-academia doctoral training and student cohorts* through initiatives with industry, RCUK and EU funders. Ensure a bespoke, personalised and supportive training programme is provided to all PGRs.
  - *Transition to independence*: The REF2021 period has seen the appointment of many ECRs and an increase in Postdoctoral Research Associates. Through tailored individual development plans, we will support the progress of all of these appointments to enable their careers to meet personal objectives.
  - *From mid-career to leadership*: Through bespoke training and mentorship, in collaborations with the NU Academies (Policy, Global Challenges, Enterprise and Skills), develop and deliver enhanced training for staff seeking to transition career stage.

- **Fostering inter-disciplinary approaches and partnerships** with businesses and external stakeholders that extend our reach and impact. Specific targeted actions will include:
  - Developing *international partnerships*, and increase the number of undergraduates, postgraduates and postdoctoral researchers who have an international research stay of 1 month or greater during their studies. This will be achieved by exploiting the strategic academic partnerships of the university including Monash University; Xiamen University; the RENKEI Network; University of Groningen; National University of Singapore; Cornell University; Indian Institute of Technology Delhi.
  - Maintain and expand *key partnerships across academia and industry* through our industrial advisory board and strategic research investments (e.g. CDTs).

Research Culture and Integrity

Our research culture is focused upon four main pillars; openness, multi-disciplinarity, collaboration and creativity. We follow the Researcher Development Concordat, of which NU became a signatory in 2019. We actively encourage the use of responsible metrics and have implemented a school wide workload contribution model (WCM), which is used as one component to inform management decisions. We focus upon the collective performance rather than individual, through the process of annual group performance development reviews (PDR) which seek to optimise the performance of the group across all relevant areas (teaching, research and impact and administration). Research culture is supported by an active seminar series within the school attracting >30 external speakers each year. We manage internal funding in an open and transparent manner, with an objective of promoting multi-disciplinarity and creativity. We encourage openness in research by celebrating success through regular newsletters and staff meetings, but also encouraging an open discussion of challenges and continually work to remove all barriers to collaboration.

Open Research Environment

We strongly support and enact the institution-level policy of encouraging all staff and students to discuss their work with other researchers and the wider public. 86% of all papers published within the REF2021 period meet the open access criteria. Where research is deemed confidential, we act to define this as narrowly as practicable. We promote the open access of *all* published work via an on-line publications management system (MyImpact) in which the author's accepted manuscript in its final submitted is openly accessible. In addition, an institutional open access team manages UKRI and COAF block grants to support Gold Access for original, peer-reviewed research and where green open access is not offered by the publisher. Open-access software is also strongly encouraged within our computational groups.

We also encourage data sharing to enhance our research impact and visibility, using an institution-level open data repository for documenting, archiving and publishing datasets. The repository enables creating data management plans for project grants and adopts the philosophy that archived data are *FAIR* (Findable, Accessible, Interoperable and Re-useable).

Research Integrity
Training in the context of research integrity is begun at undergraduate level, especially during the research projects in 4th year. All research proposals (externally and internally funded) are subject to initial ethics screening via an on-line ethics form that helps identify whether a proposal is 'high risk' and requires formal ethical review by a Research Ethics Committee. All researchers are made aware of the University Code of Good Practice in Research, which in addition to ethics and openness, clarifies expectations relating to integrity and honesty, research misconduct, leadership and cooperation, and professional standards and advice. An example of leadership in research integrity is provided by **Probert's** contribution to the author's development of the CheckCIF program (See page 7).

c. Impact Strategy
Overview
Chemistry has a strong history of research which is translated into products, tools or policy that impact society. This is aligned with an institutional strength illustrated by the University being ranked in the world's top 25 in the Times Higher Education impact rankings. Our engagement and alignment with the goals of industry, at undergraduate, postgraduate and research levels are supported by our industrial advisory board containing representatives from local, national and international business, which meets quarterly. Progress in this area is managed through the Chemistry research committee supported by dedicated impact and business development manager, and research and impact manager. We seek to facilitate the achievement of impact through four main channels:

- Knowledge generation**:** Underpinning all impact is the generation of new knowledge through research excellence. Increasingly multi- and interdisciplinary work has been encouraged, e.g. through the formation of SNES and the co-location of research facilities. Funding for interdisciplinary projects has been provided by the university, e.g. through the Research Excellence Academy (£14.6M, 2014-19) and Research Investment Fund (£30M, 2014-21). A key focus has been placed upon supporting fundamental work such as the pioneering of remote access use of beamline I19 at Diamond Light Source (**Probert** and **Clegg**, *Crystals* 2017, **7**:360). This mode of operation has now been rolled out nationally and our staff have been running remote access workshops to increase user uptake. In addition, **Waring** has established a national collaboration with Diamond Light Source, Astex Pharmaceuticals and York to progress FragLites, an approach to fragment-based lead generation. This work was recently used to identify a potential therapeutic approach to COVID-19 (Nature Comm. 11:5047 (2020)). The translation of knowledge generation to other forms of impact, such as Economical is supported by EPSRC Impact acceleration accounts, CASE studentships and knowledge transfer partnerships. This is managed through the School's Business Partnerships Manager. Mentorship for academics with less experience in this area is provided.

- Economy: Chemistry's largest contribution to the economy through the REF2021 period has been through the delivery of PARP inhibitor rucaparib to treat ovarian cancer. Medicinal chemistry research at Newcastle discovered the first potent inhibitors of the DNA repair enzyme poly (ADP-ribose) polymerase 1 (PARP-1). During the REF2021 period, Rucaparib has received approval for clinical use in ovarian cancer in the USA, Europe and the UK. Net product revenue totalled >£217M for 2019. Sustained delivery of impact through drug discovery is demonstrated by two candidates, MDM2-p53 inhibitor (with Astex Pharmaceuticals) and DNA-PK inhibitor (with AstraZeneca) progressing to clinical trials during the REF2021 period. Our continued contribution to economic impact is secured by our staff generating 22 patents during the REF2021 period. At a local level, interaction is supported by engagement with North East Local Enterprise Partnership (NELEP). Additional examples include research in chemistry (**Golding**) that initiated two spin-out companies, NewChem (founded 2002) and BiBerChem

(founded 2017), which provide molecular design, synthetic and analytical services for the pharma/chemical industry and academia worldwide. During the REF2021 period, NewChem has employed > 100 FTEs and achieved sales exceeding £3M. Both companies are based in the Biosphere, which provides state-of-the-art laboratories within the newly built NU Helix site. **Tuite** and **Pike** patent on an enhanced DNA-sensing platform technology (P246026GB) has led to £310k of funding to develop a company, NunaBio Ltd, that will apply this technology in many market sectors that require increased confidence in the sensitive detection of target DNA sequences. **Stimming** in collaboration with Siemens has 6 patents (WO2019025190A1, WO2019020351A1, WO2018206593A1, EP3439092A1, EP3432402A1, EP3446351A1) on the redox flow batteries, which are currently being developed into a spin-out company. **Probert** and **Hall** have a patent (GB1908349.2) on approaches to robotic crystallisation, which has been developed into a spin-out company, Indicatrix Crystallography Ltd and was shortlisted for RSC Emerging Technologies Prize 2020.

- People: Besides employment, the impact on people arises primarily from the training and career development we provide to all staff. This begins at undergraduate level with research challenges and skills developments achieved through dedicated course modules and 'Skills Week' where local and national companies set research challenges for our students. Dedicated training is provided for early and mid-career staff, while leadership training is given by NU for experienced staff with potential and interest in this direction. Broader training is provided at institutional level through Policy Academy-fostered engagement with policymakers, Enterprise Academy, Skills Academy, and the Global Challenges Academy. Staff are all encourage to broaden their skills and enhance reach through contributions to the community, including activities such as professional bodies, e.g. Faraday Council, RSC Chemistry Degree Programme Accreditor (**Higham**) and journal editorial boards. Our transparent workload contribution model is used to support colleagues with significant research time committed through grants, but also optimise teaching and administrative loads to maximise time for research activities.

- Society: Chemistry has a strong outreach programme, delivering a wide range of quality outreach activities including laboratory sessions, spectroscopy visits, presentations, revision workshops and science showcases (See Page 16-17). This is focused upon National STEM learning and the local area. Strong engagement with learned societies, such as the Royal Society of Chemistry and the Royal Society, as well as local museums such as the Great North Museum and the Centre for Life, help provide access to a wider audience. Internationally, this is achieved through engagement with the Global Challenges Research Fund (e.g. **Gibson** with Peru and India) and the British Council (e.g. **Walker**-India). An example of a significant contribution to the research society is provided by **Probert** who led a report to the International Union of Crystallography about the ease of mechanisms to create believable fraudulent diffraction data. He also proposed solutions to identify malpractice automatically and the result of these reports are routines which are now implemented into the *checkCIF* program and used globally to validate all crystallographic refinements that enter the public domain through publication in peer reviewed journals. **Golding** contributed to the Parliamentary Office of Science and Technology rapid response to COVID-19 report.

Impact Objectives and Vision

Our objective for the next 5-10 years is to build upon the impact of our work. It will be supported by the School's dedicated impact manager, who provides training and support in identifying, maximising and conveying the impact of our research to a wider range of audiences. This will also be driven by ensuring that all colleagues have the opportunity and support to explore higher-risk impact opportunities when they arise. Targeted actions to achieve our goals will include:

- Through *emphasis upon the collective* rather than individual achievement, support academics seeking high-risk high-reward opportunities. This will be achieved through the Group Progress Development Review (PDR) process and will help provide the time for our academics to explore high-risk routes for exploiting research and generating impact.
- Building upon the *high-quality outreach* provided by Chemistry, with a particular focus upon the local areas aligned with the ethos of a civic university. Targeted actions include

extending our successful Partner School summer events and increasing and supporting larger scale coordinated outreach events.

- To support the *sustainability of the discipline*, we will also encourage increased interaction with learned societies, e.g. Royal Society of Chemistry and the Royal Society. **Walker** sits on the Council of the RSC Faraday division and RSC local section (North East) committee.
- By *enhancing interaction with our industrial advisory board*, increase industry funding and the connection between basic research and industrial impact.
- Develop training at all levels, i.e. undergraduate to established career level to *support and encourage open research data.*
- Expand our work in supporting the development of a *strong, sustainable and supportive research culture,* and integrity in the development of impact.
- Catalyse impact by *increased engagement with cross-cutting Centres of Research Excellence* (NUCoREs, see Ref5a 2.2.1), including those focused on Energy and Cancer (Figure 1).

2. People

a. Staffing strategy and staff development

Our staffing and support strategy develops and extends that laid out in REF2014, which was to invest in our areas of strength and free-up staff to perform research. An important development has been the strategic appointment of teaching and scholarship staff who focus upon laboratory teaching and pedagogical research making a significant contribution to undergraduate teaching. During REF2021 we have also made appointments to develop and grow new areas of expertise (Computational and Theoretical Chemistry, Chemical Biology and Energy Materials). We are focused upon retaining, developing and rewarding our staff to ensure all reach their potential.

In line with the university strategy we intend to increase our research power by 20% between 2021-25 through strategic T&R appointments. We will maintain a balanced demographic of leadership and early career researchers. Proleptic appointments will be made at a junior level when staff retire. Senior members of staff will be replaced by internal promotions where appropriate, reflecting our positive mentorship. Strategic senior appointments will be made if required. Staff recruitment will be supplemented through external fellowships and Newcastle University's Academic Track (NuACT) scheme (see Ref5a 3.2.4). The only Category A staff in Chemistry on fixed-term contracts are the NuACT fellows, but importantly the university has guaranteed an open-ended contract for every fellow in the scheme, activated upon successful completion of the fellowship which is based upon criteria co-created between the fellow, line manager and NuACT director at the start of the fellowship.

Academic Leadership: Through the REF2021 period, Chemistry has invested in the development of academic leadership in key strategic areas: Medicinal Chemistry and Chemical Biology, Energy Materials and Computational Chemistry. 5 Professors aligned with these areas namely, **Waring**, **Kawamura**, **Sargent**, **Stimming** and **Hofer** have been appointed, leading to a total investment in leadership during the REF2021 period, of £3.7M. In addition, investment in the Chemistry estate, to boost facilities and infrastructure accessible to all staff has been £2.5M.

Academic Appointments*:* As part of our growth strategy and to develop the key strategic areas, 16 new academic positions have been appointed. Progressive Equality, Diversity and Inclusion (EDI) recruitment strategies has also increased the diversity in our staff.

- Energy Materials: 7 (6 ECRs, 1 Prof.) academic staff have been appointed: **Stimming** (Prof., 2014), **Gibson** (2014), **Cucinotta** (2014), **Penfold** (2015), **Lu** (2019), **Dawson** (2020) and **Freitag** (2020). **Gibson** has been awarded an ERC starting grant and promoted to Reader, **Lu, Dawson** and **Freitag** received a highly competitive NuACT fellowship. **Freitag** has also been awarded a Royal Society University Research Fellowship. **Dawson**, **Penfold** and **Cucinotta** have been awarded EPSRC First grants**.**
- Medicinal Chemistry: 4 (3 ECRs, 1 Prof.) The appointments in this area are: **Waring** (Prof., 2015), **Knight** (2018), **Cole** (2016), **Bronowska** (2016), **Madden** (2020). **Cole** has been awarded his EPSRC First Grant and a UKRI Future Leaders Fellowship.

- Chemical Biology: 3 (1 ECR, 2 Profs) appointments have been made to bridge Medicinal Chemistry and Chemistry research: **Sargent** (Prof, 2018) and **Kawamura** (Prof, 2019) and **Stach** (2016).
- Computational and Theoretical Chemistry: 5 (4 ECRs, 1 Prof.) members of staff have been appointed in this area: **Hofer** (Prof., 2014), **Penfold** (2015), **Cole** (2016), **Bronowska** (2016) and **Dawson** (2020). 3 of the ECRs have been promoted (**Penfold, Bronowska, Cole**). This research grouping has achieved >£3M research funding during the REF2021 period.

Staff Development*:* During the REF2021 period, 9 members of staff have been promoted: **Cano**, **Horrocks**, **Penfold** and **Gibson** to Reader, and **Pike**, **Cole**, **Hall**, **Probert** and **Bronowska** to Senior Lecturer. Support for staff progression is achieved by identifying challenging but realistic targets to enable staff to achieve their full potential. All newly appointed members of staff are appointed a mentor to ensure smooth transition into their new role, provided with a PhD studentship, a start-up budget to purchase equipment or travel and given one year of no teaching or administration. In addition, all staff receive an annual budget that can be used for equipment or travel. NuACT Fellows (**Dawson**, **Freitag**, **Lu, Madden**) are provided a personalised bespoke training and support programme, including research leadership skills, workshops and bespoke activities tailored to fellows' needs. These are developed through one-to-one meetings with dedicated research funding managers. As this is a new programme, we are in the process of developing similar approaches to development for all staff. All staff are offered the opportunity to take part in teaching awards (CASAP) which enable them to become fellows of the Higher Education Academy. All members of academic staff participate in a supportive internal peer review policy prior to the submission of proposals. A sabbatical policy has been developed in line with our objective of REF2014. To date, 3 members of staff have taken sabbatical and increasing this is a major goal of the next 5 years.

Postdoctoral Researchers: Chemistry recognises the unique challenges that exists for postdoctoral researchers and the need for mentorship and time to focus on research before assuming the broader responsibilities of an independent academic post. A PDR process, analogous to that for academic members of staff is implemented for postdoctoral researchers, with a strong focus upon career development. NU is committed to the Concordat to Support the Career Development of Researchers and was one of the first to be awarded a HR Excellence in Research Award by Vitae in 2010 (renewed twice during this REF cycle). Peer-peer mentorship is facilitated by a postdoctoral society organised at faculty level and an annual postdoctoral conference. A postdoctoral network has also been established within SNES and which contains chemistry representation. Workshops such as grant-writing, teaching and science communications training are also available. This support has led to successful future employment of our PDRAs, with >90% of our PDRAs progressing to high value roles in industry and academia.

Technical Support and Workshop Staff*:* Research is supported by a senior chemical and biology laboratory technician and dedicated staff in mechanical (3), and electronics (3) workshops. A further 5 members of our technical team provide support in purchasing, safety, waste-disposal and building management. During the present REF period £1.5M has been invested to improve all workshop facilities. A dedicated member of technical staff manages and runs the NMR facility. We have separated Technical Management from Health and Safety Management with School Safety Officers forming a pragmatic conduit to the University's Safety Office and providing a proactive approach to health and safety whilst allowing the technical team to focus on directly supporting research, teaching and engagement. Their excellence and vital support for the research environment is highlighted by their presence on >50 research papers published during this REF period. To support career development, technical staff are encouraged to learn new skill sets and undertake apprenticeship programmes at various levels, covering scientific and management training. During the REF period 8 technical colleagues have undertaken apprenticeships. Technical colleagues also regularly undertake university development programmes ('Chameleon' and the Professional Services Development Programme)), as well as many of the workshops offered through Organisational Development.

b. Research students

The total number of postgraduate students enrolled on doctoral (PhD) programmes in Chemistry has increased from 60 in September 2014 to >110 in September 2020. This will continue to rise with the development of the two CDT programs. The CDTs, alongside CASE studentships, DTP awards, EU funding and Industry represent the main source of studentships.

Postgraduate Recruitment

Postgraduate positions within Chemistry are in demand from in-house and external graduates and international students illustrated by average PGR applications of >200 per annum. Adverts, checked for unconscious bias, are provided on the faculties PG website and advertised at PG Open Days. We have a high completion rate of >95%, illustrating the supportive environment within the cohort. Our objective in the next 5-10 years is to recruit 30-40 postgraduate students a year ensuring a cohort of approximately 150 PGR students, while creating a supportive and stimulating environment whereby all our students can achieve their potential.

Postgraduate Experience

Upon starting all students are given a comprehensive induction by SNES and Chemistry. This includes research ethics and health and safety. Each student is also responsible for their own consumables budget throughout their research to ensure that they develop research management skills. Our PhD students are in high demand after completing their studies. Destinations of Leavers from Higher Education (DLHE) shows >93% of our postgraduates are in employment within 6 months of graduating, many of these in postdoctoral and academic positions at universities around the world.

We also strongly encourage and support our postgraduates to achieve beyond the immediate objectives of their thesis. This is highlighted by the many awards won by our PhDs (e.g. conference poster and talk prizes), a specific example includes the prestigious STEM for Britain award at the Houses of Parliament by Dr Yvonne Choo. Other examples include participation in the Brilliant Club (teaching secondary school and sixth form pupils with university style tutorials), science communication blogs and active engagement of PGRs in the research culture of the group through student organised events such as the Women's Global Breakfast, Cancer Research UK funding events.

Training and Support, and Academic and Personal Progress

The training within the PGR programme offers a diverse range of subject-focused lectures on research skills, ethics and safety, augmented with interdisciplinary programme of seminars. All students are allocated an independent progression panel who monitor and approve their progression through their PhD. The progression panel consists of a subject specialist and a pastoral member, also usually a subject specialist. This panel monitors progress annually throughout their studies and also provides impartial academic and pastoral support. Progress monitoring includes the preparation of an annual report which is discussed during a meeting with the student. All PhD students must undertake an additional 100 credits of formal PhD training during their first 2 years of study. In total ~120 courses are available to students and each research students are encouraged to undertake a training programme tailored to their needs.

c. Research Culture

Career progression for part-time and fixed-term staff

Chemistry supports staff on fixed term contracts in line with the Concordat Action plan. We perform an annual PDR process for all research staff, provide mentorship and inductions, include research staff on Chemistry Committees, hold researcher forums (e.g. Wynne Jones Research Day) and use redeployment register for all staff within six months of redundancy giving them priority access to job vacancies at the University. Chemistry supports staff who wish to work part-time, adjusting workloads and expectations accordingly. All meetings and seminars are held within core hours of 10am-4pm and for important meetings the days for which part-time staff are least likely to work is taken into account before organising them.

Health and Safety (H&S)
This is managed through the Chemistry H&S committee which reports into the H&S committee of SNES. Chemistry is represented by **Benniston** who Chairs the Chemistry H&S group and SNES. Both meet monthly. The Chemistry group includes representation from all academic groups, technical, PGR and postdoctoral researchers. All research laboratories perform weekly inspections, and this is supplemented by quarterly inspections by research technicians and the school health and safety manager. To support the integration of H&S as a core element across all activities within Chemistry it is a standing item on meeting agendas.

Equality, Diversity and Inclusion
Chemistry has a strong commitment to ED&I and holds Athena Swan Bronze award. The university has staff groups for disabled, LGBT+ and minority ethnic staff, which are promoted to staff at induction and via the intranet. Chemistry has increased the number of female staff during this REF period with 5 Teaching and Research academic appointments being female (**Gibson**, **Bronowska, Kawamura, Freitag, Madden**) leading to 21% representation, similar to the national average and significantly larger than REF2014 (10%). 50% of Teaching and Scholarship appointments have been female. All of these provide academic leadership and are visible role models. Throughout the REF2021 period, the average number of funding applications (2.5 *vs.* 2.2) and success rates (37% *vs.* 37%) per FTE has been slightly higher or equivalent for female staff. Throughout the REF2021 period, parity of gender representation has been observed at UG, PG and PDRA levels. BAME and International representation of staff is 3% and 20%, respectively both of which are slightly below the national average. Support for diversity of socio-economic background is focused at UG levels especially through extensive outreach activities with Partner Schools. Equality in learning is also supported by providing each UG with a Tablet for learning and each PG with a laptop. Throughout the REF2021 period, the School alongside the local RSC has organised a range of Women in Science events, and in 2019 **Golding** organised a BAME researchers day.

Support for submission of funding applications, access to internal funds, research-related promotion and reward procedures, recruitment for research-related leadership roles, conference attendance, sabbaticals and training can be provided on an individual basis taking into account all professional and personal circumstance. This is managed through the head of Chemistry (**Penfold**), the academic group leads (**Probert**, **Houlton** and **Cano**) and ratified by the Chemistry Research Committee.

Through conference attendance (RSC, Joliot-Curie), network meetings (e.g. Celebrating Diversity in Chemistry Meeting 2019, Global Women's Breakfast), ED&I seminars, e.g. Rt. Hon. Chi Onwurah (MP for Newcastle Central), and training (e.g. unconscious bias), Chemistry has supported and highlighted the importance of ED&I. Chemistry have implemented a number of core policies to support this, including a transparent workload contribution model for all staff, a detailed return to work policy for all long-term absentees including sick, parental and adoption leave and a childcare fund to support academics who incur additional costs when travelling to conferences with children.

In evaluating individual research performance, Chemistry follows the institution lead (see Ref5a 3.2.7) as signatories of the San Francisco Declaration on Research Assessment (DORA), including not considering any internal or external output quality assessments carried out for REF.

Key achievements through the REF2021 period include:

- Implementation of a *return to work policy for long term absence* (e.g. parental and adoption leave, ill health, managing long-term illness, or with caring responsibilities), within the SNES. This includes the management of workloads and support to maintain research.
- We provide *support for all staff and students with protected characteristics* making changes in infrastructure and procedures to enable all staff and students to reach their potential.
- Development of a fund to support additional expenses incurred for those with *caring responsibilities to travel to conferences*.
- *Implementation of a sabbatical policy* in line with our objective from REF2014.

- To support flexible working all key events, including research seminars are held between *core-hours of 10am-4pm*. All staff are able to work off site when required.

Chemistry at NU continues to recognise the work required to ensure an equal and diverse workforce which is optimum for a strong research community. It will form a major role of the development in chemistry in next 5-10 years and will focus upon the support for all staff to ensure each can reach their potential. Key objectives include:

- *Visibility of diverse role models and mentorship*: Beginning from undergraduate students we will ensure that we will promote visible role models and leadership from diverse backgrounds.
- Deliver *enhanced reporting mechanisms* to ensure a supportive research community throughout chemistry.
- *Enhanced support and awareness of mental health*: Train mental health first aiders throughout Chemistry to work alongside first aiders.
- *Encourage virtual conferences*: To support staff unable to travel to conferences, Chemistry will encourage and support the delivery of virtual conference.

3. Income, infrastructure and facilities

Research Grant Expenditure*:* The focus of the REF2021 period has been to increase and diversify research expenditure, which declined through the REF2014 period. This trend has been reversed in REF2021, supported by the award of a number of major grants including: Cancer Research UK Drug Discovery Programme (£5M), Astex Drug Discovery Alliance (£3M), ERC Starting Grant (**Gibson**, £1.3M), UKRI Future Leaders Fellowship (**Cole**, £1.3M) ERC Consolidator (**Kawamura**, £1.8M), North East Centre for Energy Materials (£1.8M) and the International Network on Polyoxometalate Science for Advanced Functional Materials (£0.9M). Our increasing research spend has been accompanied by a diversification of this income, which in the previous REF period was dominated by Research Councils and Charites. In particular the total income from industry (£2.0M) is an increase of 230% from the previous REF period. Early career staff joining Chemistry in the REF window have also been particularly successful, with **Penfold, Dawson, Cucinotta** and **Cole** winning *EPSRC First Grants.* **Freitag** has been awarded a Royal Society University Research Fellowship. **Errington** has led an EU COST Action CM1203 Polyoxometalate Chemistry for Molecular Nanoscience (PoCheMoN), which has since developed into the International Network on Polyoxometalate Science for Advanced Functional Materials with collaborations across the EU and Japan.

Doctoral Training Centres*:* In 2019 Chemistry were awarded two Centres for Doctoral Training (CDT). The Centre for Doctoral Training in Molecular Sciences for Medicine (£7.2M), led from Chemistry by **Waring** (PI and Director) and partnered with Durham University. All projects are based in both molecular and medical sciences and will focus on unmet medical needs, such as understanding of disease biology, identification of new therapeutic targets, and novel approaches to discovery and development of therapies. The Centre for Doctoral Training in Renewable Energy Northeast Universities (£5.4M), led by Northumbria University and partnered with Chemistry (**Gibson**, Co-Director) and Durham University. It is driven by the industry and market needs for an unprecedented growth in renewable and distributed energy to 2050.

Research Facility Awards: Chemistry staff have also made extensive use of national and international facilities for X-rays (Diamond Light Source, SACLA Free Electron Laser, European X-ray Free Electron Laser), Lasers (Laserlabs Europe and Central Laser Facility). Access has been obtained through competitive peer review systems. A total of >100 days have been awarded throughout the present REF period. Additional access to High performance computing (ARCHER HPC, JADE HPC, EPSRC tier-2 facilities and HPC-Europa) facilities have been awarded.

Infrastructure and facilities: NU and Chemistry has invested significantly in research facilities. The total investment in the Chemistry estate amounts to £2.5M. This includes extensive

refurbishment of the underpinning facilities, but also investment in new research laboratories associated with emerging themes in Energy Materials and Chemical Biology. Chemistry collaborates with the NEXUS X-ray photoelectron facility that contains a comprehensive range of XPS instruments and the Photon Science Laboratory (Psi-Lab) which represents a £1M investment to produce a world class laser facility and which incorporate techniques well aligned for the Energy Materials. Chemistry also benefits from strong collaboration with Engineering and the Medical Faculty – as illustrated by collaboration on DNA-templated nanowires which led to the successful cross-Faculty bid to BBSRC for (>£1M) CryoTEM (**Horrocks**) and work closely with partners in the N8 research intensive universities to develop and implement best-practice for infrastructure sharing. Within Chemistry highlighted facilities include:

NMR facilities: These received a £1.3M refurbishment, delivering one of our infrastructural objectives of REF2014. It now hosts four state-of-the-art instruments ranging from 300 MHz to 700 MHz. The 700 MHz spectrometer is equipped with a nitrogen-cooled cryoprobe to give very high sensitivity and is especially suited to biological samples and samples of low concentration. Solid state NMR facilities and a triplet resonance probe are also available.

Single crystal (SXRD) and powder diffraction (PXRD) facilities: These received over £0.5M investment and include two unique single-crystal X-ray diffractometer, one optimised for ultra-low temperature (2-290 K) and the other optimized for pressure (0.5 to >200kbar). All experiments can be performed with in-situ sample irradiation with laser light of various wavelengths (400 – 660 nm).

HPC facilities have been transformed by investment in Rocket (more than 5000 cores, 112 nodes, InfiniBand connection, 500TB of storage). This represents a £2.0M investment by the university to foster a pervasive HPC-culture and boost modelling and simulation. This investment has been crucial to support the emerging strength of computational chemistry.

Mass Spectrometry in Chemistry has received £0.5M investment and is comprised of three machines each offering high sensitivity and sub ppm mass accuracy, with flexibility to study biomarker discovery, oligonucleotides, small molecules and polymers**.**

Microwave Spectroscopy: The unique microwave instrumentation is used to determine high precision molecular structures and intra-molecular interactions. Unique capabilities include the ability to probe non-volatile molecules and the chemistry of plasmas, with direct implications for astrochemistry, and distinguish molecular chirality. The capabilities of this setup have led to 6 academic visitors from around the world with research stays >1 month.

Chemical Biology and Radiochemistry: These facilities have received £1.0M investment in infrastructural improvements and £1.1M in equipment committed to underpin one of our primary objectives of growing this area of research. The labs are well equipped for all aspects of chemical biology, including molecular biology, protein production, biochemical and biophysical analysis, facilities for synthesis and preclinical in vivo evaluation of radiopharmaceuticals, peptide synthesis as well as a dedicated cell culture facility.

Infrastructure and facilities strategy*:* The chemistry estate has witnessed a significant expansion and improvement during REF2021 period as outlined above. Our objectives over the next five years are to:

- Expand capabilities in materials characterisation and ensure the *long-term sustainability* for all equipment.
- Consolidate existing equipment and *promote equipment sharing* to maximise the investments.
- Ensure *high quality training and career progression* prospects for technical staff who maintain and manage equipment.
- Continue to improve *core laboratory facilities in conjunction with an increase in flexibility* of shared space to facilitate most efficient use with fluctuation sizes of research groups.
- Extend *strategic co-habitation of Chemistry* with other disciplines related to our core research strengths to enhance transdisciplinary research.
- Develop *stronger links with industry including shared services* to increase interactions and the collaborations leading to impact.

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

Throughout the REF2021 period Chemistry has had over 150 international visitors. Our staff also make substantial contributions across a wide range of areas and work extensively across different disciplines both within NU, regionally, nationally and internationally. The following is illustrative rather than exhaustive:

Academic Collaborations

- **NU**: Chemistry has long standing and hugely successful interdisciplinary collaborations with the Faculty of Medical Science (FMS) through the Cancer Research UK Drug Discovery Unit, which forms a fully integrated, cross-faculty research group and is a full member of the national CRUK Drug Discovery Network. Research in the group has led to an internationally recognized reputation for medicinal chemistry and drug discovery with a track record of successful delivery including two marketed cancer treatments (rucaparib and erdaftinib). Chemistry also interacts with Chemical and Mechanical Engineering through projects such as the North East Centre for Energy Materials (NECEM). Collaborations between the electrical power group in Engineering and Chemistry are contributing to a Faraday Challenge project on the battery degradation. **Freitag** and **Stimming** collaborate with the School of Computing Science with an objective of linking advanced materials for sensors with the internet of things and data science.

- **Regional**: Newcastle Chemistry interacts strongly with neighbouring institutions (especially Durham and Northumbria) as highlighted through collaboration in key strategic funding including North East Centre for Energy Materials and two CDTs. This is also supported by over 35 papers published with either Durham or Northumbria University in this REF period. We strongly interact with the N8 partnership; for example, **Houlton**, through the METRC scheme, has established collaborations with AkzoNobel's Marine and Coating Business. **Penfold** with Monkman (Durham) have collaborated extensively on thermally activated delayed fluorescence leading to 3 EPSRC grants (EP/P012388/1, EP/N025811/1, EP/T022442/1) and 1 REF output.

- **UK:** Collaborations include the NECEM project led by **Stimming** which interacts strongly with 5 other centres (St Andrew, Edinburgh, Cambridge, UCL, Oxford) across the UK to establish a UK Network for Advanced Materials. **Stimming** also participates in a Faraday Challenge consortium entitled "*Towards a Comprehensive Understanding of Degradation Processes in EV Batteries*" which involves Cambridge, University College London, Sheffield, Warwick, Southampton, Manchester and Liverpool. **Kawamura** has strong collaborations with Oxford University including acting as co-director for a CRUK programme grant. Other examples include: **Penfold** and **Probert** with Diamond Light source resulting in EPSRC funding (EP/S022058/1), **Probert** and Brechin (Edinburgh) on molecular magnetism leading to EPSRC funding (EP/N01331X/1) and 1 REF output. **Penfold** with Brechin and Johannson (Edinburgh) on molecular photomagnets leading to EPSRC funding (EP/V010573/1) and 1 REF output. **Houlton** with Turberfield (Oxford) on DNA-based coordination polymers resulting in EPSRC Funding (EP/S015310/1).

- **International: Errington** led the European COST Action "Polyoxometalate Chemistry for Molecular Nanoscience" (PoCheMoN) which coordinated research across 22 European countries and Russia and Australia. This has been developed into the International Network on Polyoxometalate Science for Advanced Functional Energy Materials (EP/S031170/1) led by Newcastle Chemistry, which is a collaboration between over 50 researchers across UK-Japan-Germany and France. **Kawamura** was a management committee member on the COST action on Epigenetics (EPICHEMBIO). Additional International collaborations supported by EU Horizon2020 Marie Sklodowska-Curie Actions include the £0.5M RISE project DNASURF led by **Tuite** which includes partners across the EU, Israel, USA, Australia, Singapore, and Japan. The £7.5M EU funded industry-led international SEAFRONT project involving **Fulton**, **Horrocks** and **Houlton** to develop next-generation anti-biofouling coatings industry-led international collaboration, involving 19 academic and industrial partners.

Additional collaborations include **Cole** with Jorgensen (Yale) and the OpenFF initiative on the development of first-principles high accuracy force-fields for classical molecular dynamics leading to 1 REF output. **Walker** with Arunan (Indian Institute of Science, Bangalore)

on the nature of hydrogen bonding in H_2O and H_2S leading to 1 REF output. **Lu** and **Hofer** with the Chinese academy of Sciences. **Kawamura** with Suga (University of Tokyo) on screening of cyclic peptide libraries resulting the award of a visiting fellowship to Japan.

Non-Academic Collaborations

Waring, **Cano** and **Hardcastle** have longstanding and fruitful collaborations with Cancer Research UK (C2115/A21421, £5M) and Astex Drug Discovery Alliance (£3M). **Probert** and **Clegg** also have a >10 years partnership with GlaxoSmithKline. **Stimming** with Siemens (£0.6M) are developing new high performing redox flow batteries. **Penfold** with Cynora (£0.3M) have investigated the molecular properties required to deliver high-performing molecules in Organic Light Emitting Diodes. Chemistry has received >20 industry funded PhD students during the REF2021 period. Non-Academic collaboration within Chemistry are increasing linked to CDTs and strategic research grants held. While many of these are early stages, support from within the school will be provided to help support and grow these. Chemistry staff also maintain 9 consultancy contracts including: Glythera, Genentech, InTray Ltd, Astex Pharmaceuticals, Janssen, Citadel, GlaxoSmithKlein and NovoNordisk.

Leadership, Awards and Esteem

Awards for contributions to the discipline include:

- UK: **Golding** (Robert Robertson Prize, 2019), **Waring** (Malcolm Campbell Medal, 2017)
- International: **Waring** (ACS Heroes of Chemistry, 2018)
- Named Lectureships and Visiting Professorships: **Hofer** (Distinguished Visiting Professorship of Physics at University of Chinese Academy of Sciences), **Stimming** (Shanghai Jiao Tong University, Shanghai, China and Technical University Munich, Visiting Professor at the University of Porto), **Waring** (inaugural RSC Biological and Medicinal Chemistry Lectureship, 2014-2015), **Clegg** (Lonsdale Lecture, British Crystallographic Association, 2018).

Chemistry Community Contributions

- *Plenary and Keynote Conference Lectures*: All staff returned have presented their research at international conferences during the REF period. In total >150 invited keynote and plenary lectures have been given at major conferences world-wide. These activities have been supplemented with a large number of contributions to national and regional meetings.

- *Conference Organisation:* Chemistry staff have been involved in organizing >50 conferences during the REF2021 period. The annual Chemical Nanoscience Symposium conference is now in its 10^{th} year and attracted high quality national and international speakers each year. Additional examples include: the European Federation for Medicinal Chemistry young medicinal Chemistry symposium (2016, Manchester UK, organised and chaired by **Waring**, Mastering Medicinal Chemistry (2020, hosted by Newcastle), the International Conference for Energy Materials (2019), The 2017 Biannual RSC Photophysics and Photochemistry Special interest group meeting (**Cucinotta**, **Tuite**) CARISMA (2017), CECAM Workshop: Nonadiabatic Quantum Dynamics: From Theory to Experiment (2018), CONEXS International Conference on X-ray Spectroscopy (2020), UK Energy Storage (2019), Annual Northern Universities Meeting on Chemical Physics (2018), Annual Northern Universities Meeting on Chemical Physics (2017), Droplets (2019), ChemBiox (2019) a student-led chemical biology conference and RSC Scientific Discussions Meeting on 'Frontiers in Epigenetics Chemical Biology' (2017), RSC Prize Symposium (2019) to celebrate the International Year of the Periodic Table, featuring 3 RSC prize winners namely, Prof. Polly Arnold, Prof. Jose Goicoechea and Prof. Debbie Kay, CCPBioSim 2020.

We have also organised numerous PhD+ training events including two (2018, 2019) summer schools on X-ray science for materials characterisation and another one (2019) on NMR and EPR spectroscopy. These summer school also include specialist wider academic training including Equality, Diversity and Inclusion, publishing, patents, interacting with parliament. We have also taught international PhD+ level training schools in Powder Diffraction and Rietveld refinement and single crystal diffraction methods every year during the REF period; these have trained ~500 students from around the world.

• *Editorships/International Advisory Boards/Panels:* Many academics are members of the EPSRC peer review college and have served on panels. **Stimming** is Editor-in-chief of the scientific journal "*Fuel Cells-From Fundamentals to Systems",* **Hofer** is Editor of the Elsevier journal Surfaces and Interfaces *and* Associate Editor-in-Chief of Frontiers of Physics. Our academics are also assistant editors or advisory board members on a number of journals including; RSC Medicinal Chemistry (**Waring**), Journal of Materials Chemistry C and Materials Horizon (**Penfold**), Crystals (**Probert**), Sustainable Energy & Fuels and Chemical Science (**Gibson**) and Communications Chemistry (**Kawamura**) and Organometallics (**Izod**). **Gibson** is an invited Advisory Board Member of the UK Solar Fuels Research Network. **Sargent** has been senior editor of Microbiology and an editor for the Biochemical Journal.

We contribute to many external panels. Examples include the Royal Society Newton Fellowship (**Houlton, Fulton**), Royal Society Fellowship Research Grants Award Panel (**Sargent**) and the Daphne Jackson Trust Fellowship (**Kawamura**), Chair of Panel 7 (**Probert**) at Diamond Light Source, Cancer Therapeutics CRUK (**Waring**) and the Association of British Spectroscopists (**Walker**). **Tuite** and **Stimming** sit on evaluation panels of the European Research Council (ERC) and **Stimming** is a Member of the Visiting Committee for CEA - Alternative Energies and Atomic Energy Commission. **Benniston** serves on the funding panel for the National funding body of Finland. **Bronowska** sits on the Irish research council panel. **Walker** sits on the Council member of the RSC Faraday division and RSC local section (North East) committee, **Kawamura** is an RSC Chemistry Biology Interface Division Council member. **Sargent** has been panel member of the Norway Research Council FRIMEDBIO Panel.

Outreach and Science Communication

Outreach and engagement are vital components for a continued pipeline of STEM students. A dedicated member of staff, Dr Peter Hoare, delivers an extensive outreach programme with an extensive network of 30+ regional Schools with a focus upon increasing engagement from low participation neighbourhoods. Chemistry runs an annual Partners summer school, welcoming over 50 16-18 years olds per annum from low participation areas.

In addition, Chemistry has been represented at a large number of public events promoting our research and subject in general. These include the Royal Society Summer Exhibition Events (2018), "Light for Life" exhibit at the Great North Museum (**Gibson, Cucuinotta** and **Benniston**), and a permanent exhibit of our Energy Materials research and climate change at the Great North Museum during Dippy the Dinosaur exhibition seen by over 10,000 visitors. **Gibson** also acts as UK STEM ambassador (STEMNET), which includes giving lectures on her research to local schools (e.g. Discovery School, Newcastle College). **Carruthers**, **Bronowska, Tuite** and **Gibson** all regularly present at the Soapbox Science events at NU aimed at increasing the visibility of female scientists in STEM subjects. In collaboration with the Royal Society of Chemistry, **Walker** promoted the Lighting up Chemistry Week for the international year of the periodic table 2019 (https://www.youtube.com/watch?v=c0DI2YcAneQ). The medicinal chemistry group regularly engages with the cancer community including patients, survivors and fundraisers through events including the NU Centre for Cancer open days, talks at Race for Life and public lectures at the Great Exhibition of the North (**Waring**).