

Institution: Queen's University Belfast

Unit of Assessment: UOA8

1. Unit context and structure, research and impact strategy

a. Introductory synopsis

As a joint School of Chemistry and Chemical Engineering (CCE), the School bridges the gap which often exists between Chemistry as a fundamental science and Chemical Engineering, which can provide the means by which chemistry can be deployed into technological solutions. Having both Chemists and Chemical Engineers working in close partnership provides a unique environment for research and teaching. In particular it means that the School has the capacity both to work on making fundamental discoveries and translation of these into solutions to real world problems. Past successes include processes for mercury capture in natural gas and for improved alkylation of gasoline which are Impact Case Studies, while current joint C and CE projects include research on porous liquids, solid phase synthesis, optical sensors and CO₂ valorisation.

The Chemistry (and indeed also the Chemical Engineering) research in the School is focused on two broad themes: **Healthcare** and **Sustainability**, which we promote *via* our strapline: "CCE - Building a Healthy and Sustainable Future". Research in both these themes is linked to University virtual research centres: CCE leads the Sustainable Energy Research Centre and is major partner in the Materials for Healthcare Technologies (MATCH) centre. The Healthcare and Sustainability themes align directly with many of the United Nations Sustainable Development Goals, particularly "Good Health and Well-Being", "Clean Water and Sanitation" and "Affordable and Clean Energy". Research funding within the School ranges from fundamental research through to application-oriented work to directly industrially driven contract research. The School leads the EU-funded Bryden Centre for renewable energy research (€9.4M, 26 QUB academics, 64 overall) the industry-led Centre for Advanced Sustainable Energy (CASE, £10M, 11 projects funded in CCE) as well as our world-leading QUILL (Queen's University Ionic Liquid Laboratories) Research Centre (18 QUB academics, >£20M since foundation in 1998). As well as facilitating world class research, this approach informs our teaching so that students trained in our School are equipped with the skills that allow them to engage with real world challenges of societal importance, for example in the Grand Challenges around Clean Growth, Future Mobility and an Ageing Society which are recognised in the UK Government's Industrial Strategy. Our objective for the next 5 years is to combine our existing research strengths in the School and, by working with our academic and industrial partners, address major challenges in healthcare and sustainability.

b. Organisational structure, size and context

The School of Chemistry and Chemical Engineering was formed when the two existing Schools merged in 2006. At this point it is now fully integrated, occupying a single building with shared facilities and a harmonized research portfolio with Interdisciplinary Research at the heart of the School's organisation.

The School teaches 3 main degree pathways in Chemistry, Medicinal Chemistry and Chemical Engineering, where the educational requirements between the former and the latter mean that, apart from common modules in first year, the two cohorts are separated and are taught by different members of staff. In contrast, a significant proportion of the research in the School crosses traditional disciplinary boundaries with the result that in the current REF exercise 32 staff are returned under UoA 8 (including 10 who also contribute to the Chemical Engineering teaching pathway) and 10 under UoA 12. Over the REF period,

the research structure of the school has been reorganised from 4 interdisciplinary groups (the Centre for Catalysis (CentaCat), Innovative Molecular Materials (IMM), Synthesis and Biological Chemistry (Synbioc) and Atomistic Simulation) to the current two main research themes of “**Healthcare**” and “**Sustainability**”. These themes feed directly into 2 of the University’s 5 Pioneer Research Programmes (PRPs), which are interdisciplinary virtual research centres with >30 academic members drawn from several Schools and have significant University support (including equipment budgets, postdoctoral staff and studentships). The Sustainable Energy PRP (29 academics) is led from CCE (Rooney) with staff from 4 other Schools including Mechanical and Aeronautical Engineering (MAE) and Natural and Built Environment (NBE), while Materials for Advanced Healthcare (MATCH) is led from the School of Pharmacy with significant involvement from CCE and MAE.

The change in the research structure in the School since REF2014 is a direct result of the **objectives that were set out in the 2014 Environment statement** where the School’s strategic aim was “*to expand our world class capability in multidisciplinary research at the interfaces between Chemistry, Physics, the Life Sciences and Engineering to address societal needs in healthcare, energy, and the sustainable environment.*” This has led to our current strengths in Healthcare and Sustainability (which now includes energy and a sustainable environment in a single combined theme). Over the current period we have followed the pathways anticipated in our REF2014 submission. Specifically, we have continued the work established under **CentaCat** in developing the energy efficient conversion of dilute waste feedstreams into high value chemicals and investigating ground-breaking theoretical and *in-situ* spectroscopic and diffraction methods to probe catalysis at the gas-liquid-solid interface. Within QUILL, new ionic liquid-catalytic technology for the activation/conversion of CO₂ to fuels and chemicals and next generation ionic liquids for the promotion of enhanced oil recovery and replacement lubricants under extreme temperatures and pressures have been developed. The **IMM** theme developed new multifunctional, multiscale materials in the way predicted in 2014, with significant advances in molecular logic switches, molecularly imprinted polymers, plasmonic metal surfaces and nanostructured photocatalysts in water-splitting solar cells. The anticipated Photocatalyst Standards Testing Centre was established in 2018 by Mills. **Synbioc’s** objective of carrying out the total synthesis of complex pharmacologically-active natural products and their analogues has been met, as evidenced by a number of high-quality publications in the field. Significant new organic reaction development has taken place and research into flow- and new-reactor chemistry has been undertaken. Over the REF period the work of the **Atomic Simulation Centre** has moved increasingly towards computational physics, hence the Centre will be returned under UoA 9 in REF2021.

Within our current structure, in the **Healthcare** theme much of the work focusses on fundamental science and is funded through UKRI but we do have close contacts with local pharmaceutical companies, particularly Almac Ltd. Within the Healthcare theme we have built a critical mass of researchers and our research, which lies in the following main areas, is underpinned by well-recognised leadership, expertise and funding, e.g. **De Silva** (diagnostic devices), **Mills** (colourimetric sensors), **Bell** (drug detection)

- **Developing future drugs** - drug design and synthesis, computational modelling
- **Advanced pharmaceutical manufacturing** – advanced drug delivery technologies, manufacturing processes for high-quality medicines tailored to demand; reducing the footprint and cost of making drugs
- **Healthcare technologies and analytics** – sensors, biomarker technologies for drug discovery and analysis; low-cost diagnostic devices

These topics provide the basis for both advancing healthcare through conventional means and for taking more innovative approaches to improving health. Traditionally, we have the

advantage of close ties with the School of Pharmacy, recognised through formation of the MATCH PRP, which itself built on an existing solid foundation of interdisciplinary collaboration. One good example is antimicrobial resistance which is recognised as a global scale threat but one where we have already made significant progress, including (see Major impact achievements in (a) Healthcare) development of a significant new antibiotic. Work on synthesis of further novel drugs is ongoing but this work is complemented by collaborations with the School of Pharmacy which are aimed at identifying infection, to help with stewardship of existing antibiotics and in developing photocatalytic materials which can be used to help prevent infection. Our ability to work with the faculty of Medicine, Dentistry and Life Sciences to devise innovative healthcare solutions provides a sound basis for leading the search for new ways to solve long-standing problems. Three new appointments (ECAs **Knipe**, **Cochrane** and **Dingwall**) with research directions in antibiotic development and reaction kinetics strengthen our ambitions in the Healthcare theme.

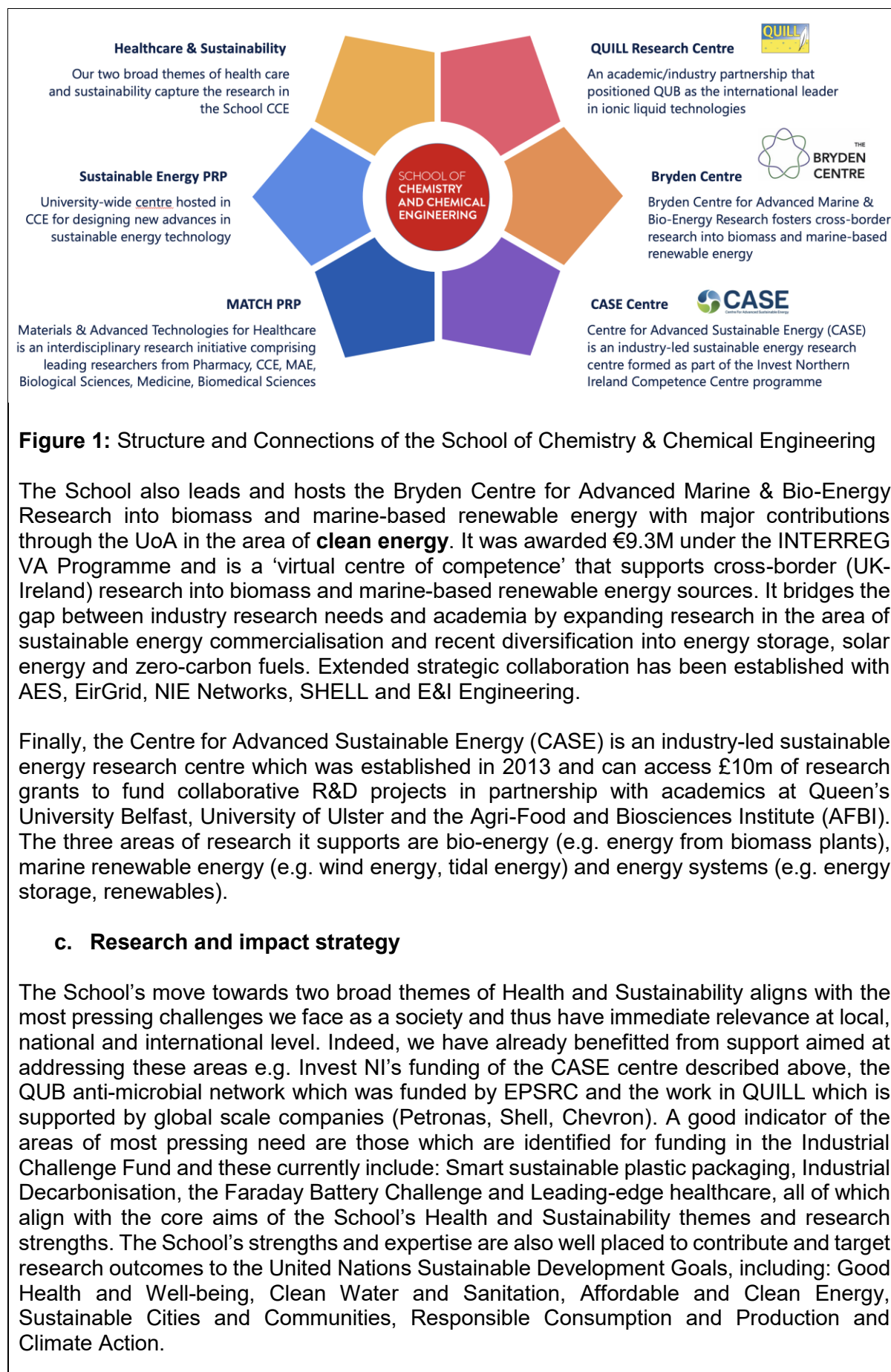
For the **Sustainability** theme research is dedicated to both understanding and addressing how the principles of green chemistry can support and enhance life, the environment, business, and the economy by addressing the following areas

- **Circular economy in manufacturing** - Remediation, recycle, renewal, sustainable transformations in chemistry and engineering, process intensification
- **Green and renewable energy** – Zero-carbon power generation, renewable resource utilisation and materials to enable energy generation, storage and delivery
- **Zero-emission manufacturing** - Bottom-up new materials, novel engineering, circular economy resources and production

The strengths within the Sustainability theme that will underpin this work are the use and development of ionic liquids (QUILL), porous liquids, mechanochemistry, catalysis, energy storage and plastic recycling.

A specific feature of the School is the high degree of industrial involvement in our research. This arises, at least in part, from being a combined School which gives us the ability to develop ideas from fundamental concepts and bench scale demonstrations to full plant scale in a single unit. We have well established Centres (e.g. Bryden, CASE, QUILL) within the School that bring in industrial support and provide solid links to industry (e.g. Chevron, Petronas, Shell, Johnson Matthey).

The first of these centres is QUILL (Queen's University Ionic Liquids Laboratory) which is an academic/industry partnership established to exploit QUB's lead in ionic liquid technology led by **Swadzba-Kwasny** with currently 18 academic members who are predominantly staff from CCE. Ionic liquids or deep eutectic solvents have structures which can be designed to deliver specific sets of properties. Applications include battery electrolytes and hydrogen storage media, through superhydrophobic coatings and high-performance lubricants, to solvents for polymers, media for metals separations, and components of emission control systems. The team have a strategic, collaborative research partnership with Petronas which in March 2020, was strengthened by seven new first phase, research projects with a total value of £2.4M. There are plans for further funding in the second phase (years 4-5) with the aim of reaching higher technology readiness levels. All the new projects are broadly related to the area of sustainable chemistry and chemical engineering, enabling Petronas to develop transformative low-carbon technologies in several areas of their business portfolio.



We expect the demand for innovative solutions in the area of **Sustainability** to increase over the next years as governments attempt to find methods to mitigate climate change. Within the UK, the recently announced 2050 Zero Emission target is a clear indication where we can expect the government's priorities to be directed in the next decade and beyond. Of course, along with the need to minimize climate change there is also an economic incentive, stated very clearly in the documentation for the Clean Growth Grand Challenge in the Industrial Strategy: "The move to cleaner economic growth – through low carbon technologies and the efficient use of resources – is one of the greatest industrial opportunities of our time". Our approach in this area is to build on the work initiated under the Sustainable Energy PRP but to continue to broaden its reach to bring together complimentary strands in resource management, carbon capture, catalysis etc. to allow a more sophisticated multifaceted approach to be developed. This will increasingly draw in researchers from other Schools in QUB as well as other universities, local government and businesses. We have already started on this pathway through our close involvement with the PRPs which provide a mechanism for collaboration between Schools (including those from different faculties) within the University.

Within the **Healthcare** theme we again have built a critical mass of researchers in the School. We have expertise in synthetic organic chemistry, advanced pharmaceutical manufacturing and analysis, as well as in design and preparation of multifunctional materials and sensors. This core disciplinary excellence underpins our collaborations with other partners and provides opportunities for us to work together to take more innovative approaches to improving health. In this, our close ties with the School of Pharmacy will be important but we also will develop further links through HIRANI (Health Innovation Research Alliance Northern Ireland) a collaboration of NI universities, health organisations and industry, recently awarded £1M to promote the Life & Health Sciences sector in N.I. The example of antimicrobial resistance was discussed above but more broadly, the ageing population means that resources for healthcare will be increasingly stretched, so our ability to work with the faculty of Medicine, Dentistry and Life Sciences to devise innovative healthcare solutions across a range of application areas will be important.

The impact strategy

Our Impact strategy is to promote fundamental work which is in areas where there is an obvious need for new solutions to significant problems and to provide an environment which encourages researchers to translate their fundamental work into real world applications. Evidence for the success of this approach is shown by the impact case studies (one in healthcare, two in sustainability) which we have submitted, our spin-out activity as well as a range of major grants from RCUK and other sources.

Major impact achievements in (a) Healthcare

The School has a long standing and continuing tradition in synthesis of drug compounds. One of our impact case studies centres on development of a major new antibiotic to treat *Clostridium difficile* (*C. diff.*) infection which is estimated to cause over 30,000 deaths annually in the USA with associated annual acute care costs at \$4.8 billion. A series of compounds synthesised by the **Mann** group in QUB which were originally developed as anti-cancer drugs but were also found to exhibit antibacterial activity. These compounds were taken up by Summit Therapeutics Ltd, leading to development of Ridinilazole, which had outstanding success in its Phase 2 clinical trials and whose Phase 3 trials (in progress) are being supported by a \$62 million US Government grant. **De Silva** developed the fluorescent PET sensing/switching principle which was adopted by Roche Diagnostics for their OPTI blood electrolyte analyser (now marketed by Optimedical Inc. and Idexx Laboratories). Sales of the associated disposable fluorescence sensor modules have now exceeded \$550 million. This analyser continues to be used around the world in critical care wards, ambulances and frontline clinics. This work was chosen as an example of successful

application of fundamental science by the Royal Society of Chemistry for a presentation to policymakers in the Houses of Parliament (2015). **Mills** work on smart plastics has led to the creation of £7M company, Insignia Technologies, which develops smart indicators for the food industry and which works with companies such as: Sainsbury's, Walmart and MacDonald's. **Muldoon** leads on an EU-funded ITN which looks at continuous flow processes for the pharmaceutical industry and this involves the Arran Chemical Company and the Almac Group. This funding was obtained under H2020: "Active Pharmaceutical Production in Flow" £644k.

Major impact achievements in (b) Sustainability

The QUILL Research Centre (QUB) provided long term support for Chevron's development of **ISOALKY™ Technology**, the first new successful alternative to the conventional catalyst-based technologies for producing alkylate gasoline in 75 years. Following a very promising pilot trial and demo plant trial (10 barrels per day, operated 2010-2015), Chevron decided to commercialize the technology. The first full-scale plant in which the conventional catalyst (HF, toxic and poisonous liquid with high vapor pressure) has been replaced with a non-volatile Lewis acidic ionic liquid catalyst began construction in 2017 and started operation in Jan 2021. In September 2016, Honeywell UOP and Chevron formed ISOALKY Alliance to license the ISOALKY™ Technology to the industry, and it has already been licensed to Sinochem Hongrun Petrochemicals (2019) for their plants in China.

QUILL has also developed the **Hycapure Hg™ technology** for removing mercury, a toxic, corrosive contaminant naturally present in hydrocarbon reserves, with the Malaysian national oil and gas company PETRONAS. The process captures all mercury species present in natural gas and has up to 3 times higher capacity than competing state-of-the-art commercial alternatives. This technology represents a significant improvement towards ensuring the health and safety of workers, process plant and the environment. The technology has now been successfully installed at an industrial scale in 13 PETRONAS gas processing plants across Malaysia where it is used to process millions of tons of gas per annum. In 2014 it was licensed to the global giant specialty chemical company, Clariant.

The sustainability theme has considerable activity that will achieve impact outside the case studies described above. **Nockemann** is co-founder of spin-out company *Green Lizard Technology* (2015) which specialises in the development of green chemistry technologies. The QUB spin-out company is providing green, sustainable and secure technological solutions and attracted overall so far > £14m in funding for developing processes for glycerol upgrading and plastics recycling and was recently awarded a £2.6M grant from UKRI to build a 10k tonne per annum waste PET recycling facility in Teesside. **Nockemann** is co-founder and director of start-up company Seren Technologies Ltd. (founded 2016), focusing on developing technology for the separation of rare earth metals. The technology is based on a breakthrough extractant developed as part of a Marie Skłodowska Curie Horizon 2020 grant (REMSIL), resulting in a granted QUB patent (WO/2018/109483). After successfully running two pilot plants at QUB, Seren Technologies opened its rare earth magnet recycling demonstration plant in Teesside (2018) with investments of > £2M. **James** is the co-founder of two spin-out companies; MOF technologies who develop metal-organic frameworks and Porous Liquid Technologies (2018), which is based on porous liquids that can dissolve remarkably large amounts of gases. **Goguet** developed several vehicle exhaust after-treatment projects in partnership with Johnson Matthey, Toyota, Ford and Ferrari.

2. People

a. Staffing profile and recruitment

The School's staffing strategy is to appoint high-quality staff whose expertise matches the

School's strategic priorities (i.e. the general areas of health and sustainability) and are able to work across disciplines while also maintaining a balance between Chemistry and Chemical Engineering in order to support teaching. All proposed appointments are discussed by the senior management team, and this includes establishing strategic fit, balance within the School, current funding council priorities, and any School needs for succession planning or leadership. This level of rigor applies whether the post is new or replacement i.e. when someone resigns, we carefully consider whether to replace with a similar post or support a different area. We have also made strategic choices in some cases to replace senior posts with early career staff, with a view to the long-term sustainability of the School. Since the last REF, we have appointed five Research staff at Lecturer level, one Senior Lecturer, and made three Professorial appointments. We have also taken a strategic decision to appoint three new Lecturers (Education), on the basis that they can take on significantly larger teaching and administration loads, thereby both improving the student experience and freeing up research time for other staff.

Within the current REF period the School has remained diverse in terms of its international make up, with 25 UK, 10 EU, and 9 other International staff, the gender balance is 32 male 12 female. At the REF 2021 staffing census point since REF2014, 11 new academic staff (including one World Class Professor, **Ansllyn**) had joined the School, 3 academic staff had retired and 1 was deceased, 4 had voluntary severance and 7 had left the School. These 11 appointments add to our increase in highly research active academics, help succession planning and reduce overall age profile, 31 staff are below the age of 55 with 13 being 55+. Since 2014, the School has invested in 7 as early career academic appointments.

We fully engage with the University procedures for staff support and development, including academic probation, mentoring, annual appraisal and promotion. At the staff census date ten School staff had been promoted since the last REF: three to Professor (**Stevenson, Holbrey, Nockemann**) and seven to Senior Lecturer (**Muldoon, Thompson, Manesiotis, Poulidi, A. Marr, Manyar, Swadzba-Kwasny**). We use a Workload Allocation Model (WAM) to ensure a fair administrative and teaching load which allows all research active staff to have broadly the same amount of time for research. There is also scope within the WAM to provide administrative relief for holders of large grants.

Dr Leila **Moura** was appointed as a Royal Academy of Engineering Fellow in 2019, and Dr **Swadzba-Kwasny** as a QUB institutional fellow in 2015. Additionally, there are two new ECR Fellowship holders to start shortly after the census date, whose applications were supported by the School (one Vice Chancellor's "Illuminate" Fellowship and one Leverhulme Early Career Researcher). As well as accessing support from within the School, Fellows are also made members of the Queen's Fellowship Academy and through this can access additional support for leadership development, research, funding, networking and impact strategies.

b. Staff development and career progression

We encourage all staff to avail of training opportunities provided by the University, and many of our academic and postdoctoral staff have attended the wide range of QUB courses available on topics such as supervising research students, report writing, grant/fellowship applications, leadership training, entrepreneurship, IP and career development (CV preparation, academic interview advice, etc.). New academic staff are required to complete specific courses as part of their probation, notably the Postgraduate Certificate in Higher Education Teaching (PGCHET). All new staff are assigned an independent mentor within the School. Our world leading professor (**Ansllyn**) runs advice clinics for ECRs on obtaining grant funding and publishing in high-impact journals. All female staff are offered and encouraged to also access the Queen's Gender Initiative mentoring from outside of the School, as part of our Athena SWAN activities. Staff are supported to attend management

and leadership development training to increase their effectiveness or as part of succession planning. In addition, participating in the School's internal committees supports ECRs in developing skills and experience to prepare them for succession to leadership roles with the School.

As stated above, we have deliberately chosen to appoint early career staff in recent years, and we provide them with considerable support. Probationers have reduced teaching loads starting at 33% and reaching 100% after 3 years and no substantive administrative duties. They receive support with grant applications, which are read by at least two colleagues and go through several iterations before being submitted. They are provided with at least one PhD studentship, and start-up funding.

Most analytical services in the School are provided without direct charge and are supported through university funding, supplemented by income from providing a commercial service to external users. The School is supported with studentships from the studentship budget provided to QUB by the Department for Economy (DfE). A proportion of DfE studentships are allocated to the research themes, and theme members can bid for studentships via a research proposal mechanism, and these are then prioritized by the Research Committee based on scientific merit. Partial funding of studentships within the School (50%) is available to encourage interaction with industry. Other DfE studentships are available for all staff via a QUB-wide competitive process, including some ring-fenced for interdisciplinary research. All studentships are provided with consumables funding. A university central conference fund encourages networking.

c. PGR students

All studentships are advertised widely and are appointed via a competitive process in which the students are interviewed by the supervisors and references are obtained. Websites such as "FindaPhD" are used regularly to attract high quality candidates. Research students receive support on many levels, and all have two supervisors with specific training in PhD supervision. The Director of Postgraduates, who is an academic member of the School's management team, oversees PhD administration, ensures compliance with regulations and acts as a point of contact for students. Student progress is reviewed on an ongoing basis, starting with a review after the first three months to confirm the feasibility of the project and the availability of the necessary resources. Differentiation, a significant exercise involving a 30+ page written report and an interview, normally takes place at the end of first year. There is a requirement to have 10 formal supervisory meetings per annum (in addition to the normal day-to-day contact between students and supervisors). At the end of the year, second- and third-year research students give a presentation to the research group and the School, respectively.

In addition to School and project-specific training, the University-wide training programme, based in the Graduate School (launched 2015), provides access to a wide range of training courses and skills development opportunities coordinated by the QUB Postgraduate Training Team. As part of the induction interactive events, and throughout the year, we also run careers sessions which are open to both PGR students and PDRAs. Guest speakers from both Academia and Industry (Solvay, Genentech, Eli Lilly, Thermo Fisher Scientific, Almac) are invited to provide candid advice, share their experiences in pursuing their chosen career paths and to highlight different careers and opportunities within their fields. These sessions are run as an open dialogue with question time for the panel of speakers and are well attended with positive feedback on the sessions conveyed to the Director of Postgraduates. During the COVID-19 disrupted year we have been proactive in maintaining events such as careers information sessions, Research Presentation days and PGR forum opportunities in an online format to continue to engage and support our PGR students. We have regularly highlighted to students QUB central resources such as wellbeing services,

stipend extension opportunities and hardship funds to further support them over this disrupted period.

During the REF census period 112 students have graduated under the supervision of members of UoA8. Approximately 47% of our PGR students graduated during REF were from outside the UK or EU, 42% from UK and 11% from EU. Specialist support for international students is available in the International and Postgraduate Centre as well as from the international academic staff. Currently enrollment is 123 PhD and 5 MPhil students (approximately 45% UK, 48% Overseas, 7% EU).

d. Equality and Diversity

The School of Chemistry and Chemical Engineering and QUB both have a current Athena SWAN Silver Award. In the School there has been a steady increase of female academics, from 7 in 2013, to 12 in 2020, with the current number representing 37.5% of academic staff. In the same period, the percentage of women PDRAs has been 40-55% (47.6% at the census). We are therefore closing the gap at the PDRA-academic transition point. We support a PDRA teaching fellowship scheme which gives an opportunity for contract research staff planning to pursue an academic career to gain experience in teaching by extending their contract by 1 month. The “Diversity landscape of the chemical sciences report” published by the Royal Society of Chemistry in 2018 reported that 23% of academic staff were female (2104/15), the increase of female staff in the UoA8 is reflective of this trend and shows the School to be in line with other UK universities in improving gender representation. The School has a culturally diverse, international community, with a high proportion of international academics (44%, including ~20% non-European), PDRAs (55%) and PhDs (55%), and an active exchange program with China (over the REF period we have received up to 40 Chinese undergraduates per year, approximately 10% of the UG cohort, of which 30%-60% are female).

Retention of all staff is important, and the retention and promotion of female academics and researchers is critical. We promote flexible working patterns, and currently two of our female academics work part-time. Our workload allocation model ensures that their research is not swamped by an uneven balance with respect to administration/teaching. Our Returner's Policy remains in place, whereby academics taking maternity or adoption leave are free from administration and teaching for six months on their return. The flexible working policies have led to an increased number of male academics and staff taking paternity and other leave, which has enhanced morale and the working climate for all in the school. We make significant efforts to accommodate all working patterns when arranging meetings etc. Equality and diversity activities are now classed within the workload allocation model to recognise the importance and influence that these have on all aspects of school life. All staff are required to take the online training “DiversityNow” which raises staff awareness on equality and diversity issues. Women at all levels are visible in all promotional material. Career development information is widely distributed to staff, and promotion panels have representation from across the Schools as well as the University to ensure fairness.

Since 2015, the School has participated in the EPSRC-funded SENSE Network partnership on ‘Inclusion Matters’ led from the Faculty along with the universities of Warwick and Glasgow. The mission is to build collegiality, equality and inclusion by connecting people. It seeks to understand the attitudes of academics towards gender equality initiatives and develop training tools aimed at improving their awareness of gender issues in engineering and physical sciences. Through this programme, staff and postgraduate students from the School have been able to attend a wide range of activities including: Unconscious Bias, Parental Leave and ‘Understanding Imposter syndrome’ workshops, family-friendly events such as Family Fun Days, and International Women’s Day Charity Events with invited speakers (e.g. WaterAid).

The SENSE working group is currently establishing: a “Promotion Ready” process providing applicants with feedback and mentors to help strengthen their applications, gender Bias Language sessions exploring language in STEM further education and an Advanced HE Aurora leadership development programme supporting mid-career women with the potential to progress into more senior roles. Two academics from the School have successfully completed this programme.

During this COVID-19 affected year the School has continued to support flexible working arrangements for staff and has highlighted opportunities at QUB, Faculty and School level to access online social events and mental health and wellbeing initiatives to maintain a sense of community and support. Academics received full guidance and support to transition their teaching to online-only from the School’s Digital Lecturer who provided training videos, live sessions and on call support for all academics.

3. Income, infrastructure and facilities

a. Overview of research grants/income and strategies for funding

The grant income of the CCE School in the REF2021 period has remained strong (~£24M, with ~£16.8M directly attributable within the UOA 8 return). This is split approximately 60% from government/charitable sources and 40% from industry, showing strong support for both fundamental and applied research. Significant grant income comes to the large Centres in the School. Notably the Bryden Centre (€9.4M), QUILL (most recent grant 2020 £2.4M) and CASE (Phase 2 funding £3.6M, 2020).

Other significant grants to individual PIs include: **Mills** 3D Printed Colourimetric Indicator Strip (3DCIS) for Non-Invasive, On-demand Chronic Wound Monitoring, EPSRC, £688k; Sustainable Oxidation Catalysts for the Production of Solar Hydrogen and Chlorine from Brine, EPSRC, £311k; **Bell** Nanoengineered microneedle arrays for enhanced plasmonic photothermal therapy of basal cell carcinoma, EPSRC, £820k; **James** Porous Liquids (PLS): Understanding, Scope and Applications, EPSRC £456k; **Swadzba-Kwasny** Ionic Liquids for Lubricant Project, Petronas, £325k; **Nockemann** Impress - Improvement of Redox Flow Energy Storage with Renewable Energy to Secure Sustainable Electricity Systems, Enterprise Ireland, £867k; **Muldoon** Active Pharmaceutical Production in Flow, H2020, £644k; **Cochrane** Synthesis of novel brevicidine and laterocidine analogues active against multi-drug-resistant Gram-negative bacteria, £391k. **Manesiotis** Application of Ionic Liquid-Liquid Chromatography (ILLC) to Extractions of Metals, EPSRC, £464k.

Other UKRI grants >£200k include projects on: Colour Change Indicators, Materials for Energy Storage and Total and Semi-Synthesis.

Other grants, including a significant EPSRC award on plastics recycling (£1M), are led in the School by PIs who are being returned under UoA 12. In addition, over the current REF period, our Academics (**Goguet, Holbrey, James, Moura, Nockemann, Swadzba-Kwasny**) have collectively been awarded over £4.2M of income in-kind for research time at leading UK facilities, the Diamond Light Source synchrotron and the ISIS Neutron and Muon Source.

b. Organisational infrastructure and support for research & impact

The School works closely with the Institutional level Research & Enterprise Department (R&E) in identifying funding opportunities and support in submission of grants. This extends to grant writing support training and access to advice and example successful grants from Research and Enterprise. This assistance is open to all staff but is particularly focused at

the ECR level researchers and PDRAs. The School has run an internal grant writing and funding workshop (2020), in partnership with R&E. The workshop also contained input from senior School academics and staff with recent successful funding track records, to pass on advice and experience in targeting grant opportunities and tips for securing funding. The School had a newly created professional support administration role, filled in 2019. The Research Administrator provides strategic support to the Director of Research and more broadly to Academic staff. New academic staff are provided with start-up funds and have PhD studentships ring-fenced as part of their package when starting. Additionally, PhD studentships allocation decisions are weighted toward ECRs where possible.

c. Operational infrastructure, facilities and specialist equipment

Since 2014 there has been substantial strategic investment in building new state-of-the-art research laboratories for synthetic chemistry and catalysis research with accommodation for >50 researchers. A brand new, purpose-built analytical laboratory (18 instruments, £500k) was commissioned as part of a strategic partnership with Agilent, and which is used primarily for the training of students on the highly successful MSc in Pharmaceutical Analysis. Further investments in research and teaching laboratory space are currently ongoing, 2 of our 4 large undergraduate teaching labs were refurbished in 2019 as part of a £4M major programme of work on refurbishment of teaching and research laboratories which will be completed by 2023. The equipment pool in the School has been significantly and continuously modernised and extended, for example with a new environmental SEM facility (£400k), PXRD (£200k), Single Crystal XRD (£350k), high-end hybrid AFM/Raman microscope (£250k), NMR, 400 & 600 MHz (£500k). Access to most facilities is shared across the University. The School has an integrated professional analytical service (ASEP), providing fast service with a vast suite of analytical instruments (GCs, HPLC, MS, spectroscopies, XRD, ICP, TXRF) within the School and as a service for external industrial customers. Furthermore, in total ~£1M of strategic small equipment investment was obtained via EPSRC. These supplement the existing equipment base (4 NMR spectrometers, 3 mass spectrometers, monochromated powder XRD, ICP-AES, BET and Hg porosimetry, 2 Raman microscopes, CD spectrometer, nanosecond pulsed laser systems as well as standard spectrometers, reactors, chromatography and computational facilities). 15 permanent, university-funded technicians provide support for NMR, high-resolution mass spectrometry, microanalysis, glass-blowing, mechanical engineering, electronics, computer management and laboratory safety. Central facilities across university include TEM (TALOS F200X G2) scanning/ transmission electron microscope (S/TEM) combining high-resolution S/TEM and TEM imaging with energy dispersive x-ray spectroscopy (EDX) for chemical characterisation with composition mapping, two TESCAN LYRA3 dual beam focused ion beam scanning electron microscopes and a central imaging unit for optical microscopy (including TRIF and FLIM). The University's library constructed in 2009 provides on- and off-site access to electronic journals for all researchers.

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

a. Collaborations, networks and partnerships

Much of our research is interdisciplinary, particularly at the interfaces between chemistry, engineering, physics, biology, medicine and pharmacy. The most obvious examples of this are the three large centre (QUILL, Bryden, CASE) which were discussed above. In these centres the industry-academic links are driven through discussion with their industrial advisory boards supporting both fundamental and applied projects. However, we have a broader culture of collaboration within the School that lies outside these large Centres.

The school is part of two major EPSRC UK Catalysis Hubs (2018) dealing with Sustainability; **Muldoon**, Hub 'Science' 3: Catalysis for the Circular Economy and Sustainable Manufacturing (£3.9M) and **Marr**, The UK Catalysis Hub - 'Science': 2 Catalysis

at the Water-Energy Nexus (£4M).

Other examples include: **Anslyn** is a 20% appointment under the QUB World Leading Professor scheme who collaborates with several staff members, notably with **De Silva** in work on molecular sensors. **Bell** has been collaborating extensively with Forensic Science Northern Ireland (FSNI), most recently on a project funded by the Dept. of Justice (N.I.) which showed the use of infrared and Raman screening of seized novel psychoactive substances. His collaboration with Prof Ryan Donnelly, School of Pharmacy QUB resulted in joint publications and an EPSRC funded programme on microneedle arrays. (£821k). He was also involved in building the Queen's University of Belfast Antimicrobial Resistance Network (QUBAN), cross-faculty programme (EPSRC funded £295k). **De Silva's** Collaboration with Prof. S. Uchiyama, School of Pharmaceutical Sciences, University of Tokyo, Japan on Molecular Logic Gates, resulted in high-profile publications and an RSC monograph which has been translated into both Japanese and Chinese. **Goguet** is working with collaborators at Oak Ridge National Laboratory, USA (2 joint publications), Leibniz Institute for Catalysis, Germany (2 joint publications) and has an on-going collaboration with Ferrari, Italy. **Hale** collaborates with Professor Peter Nghiem Texas A & M University, on a new drug treatment for Duchenne Muscular Dystrophy. Furthermore, he works with Professors John Wood and Daniel Romo, Baylor University, Texas, antitumor peptide targeting antitumor drugs. **Holbrey** collaborates extensively with industrial partners through his participation in QUILL, notably on Ionic Liquid Technology for Mercury Removal in collaboration with PETRONAS in Malaysia. **Huang** has international collaborations with Max Planck Institute, University of Malaya, Zhejiang Univ, ZJUNIT, Shanghai Jiaotong Univ, Shanghai Institute of Organic Chemistry, Beijing University of Chemical Technology, all resulting in joint publications. Furthermore, she has in close collaboration with Almac Ltd which has ongoing significant (ca. £1M grant) support. **James** is collaborating with Dr Mario Del Popolo (Mendoza, Argentina), funded by EPSRC, as well as Margarida Costa Gomes (Tour) and Tomislav Friscic (McGill). **Knipe** is working with Andrew Lewis (Department of Physiology, Anatomy and Genetics, Oxford) **Lagunas'** collaborates with Givaudan (Switzerland) on metal-catalysed olefin metathesis. **Muldoon** collaborates with the Eastman Chemical Company (Kingsport Tennessee, USA) who support PhD students. He also leads an EU funded ITN on continuous flow processes for the pharmaceutical industry which involves the Arran Chemical Company and the Almac Group. **Nockemann** collaborates with the Shell Technology Centre, Amsterdam on energy storage devices and has ongoing collaborations with Van Deun and Van Hecke at UGhent. Furthermore, he collaborates with Ruck at TU Dresden, Germany. **Stevenson** works on Liquid Crystals with Kumar (Kent State). **Swadzba-Kwasny** has ongoing collaboration with Prof. A. Chrobok at Silesian University of Technology, Poland, with funding which allows for visits by up to 5 of Polish researchers per year. **Themistou** is collaborating with Madsen in DTU, Technical University of Denmark, on pH responsive deblock copolymers.

b. Wider activities and contributions to the research base

The School has extensive links and major grants involving >35 industrial partners including Johnson Matthey, Merck, Eastman Chemicals, Toyota, Ford, Ferrari, Rolls Royce, SHELL, Invista, Eli-Lilly, GSK, Unilever, Solvay, BP, ExxonMobil, Proctor & Gamble, Astra Zeneca. These collaborations have been crucial in identifying challenging scientific problems that also have the potential to lead to commercial outputs, which supports our impact strategy. Staff also hold major collaborative grants with other universities and industry, including an Innovate UK project (U. Manchester, Johnson Matthey, G-volution, Hieta, MAN), an EPSRC project on destruction of Blue-Green Algae and their toxins (Robert Gordon U., U. St Andrews, Federal U. of Rio de Janeiro and Federal U. of Ceara), the Bryden centre (Agri-Food and Biosciences Institute, Letterkenny Institute of Technology, U. of the Highlands and Islands). **Mills** work on smart plastics has led to the creation of £7M company, Insignia Technologies, which develops smart indicators for the food industry and works with

companies such as Sainsbury's, Walmart and McDonald's. Over the REF period much of Mills' work on smart indicators has been funded by industry, most notably Sensor Indicator Products (Seattle, USA), but recently he gained significant (EP/T007575/1; £690k) funding from the EPSRC to work on 3D printed indicators for chronic wound monitoring. **Manesiotis** is a founding director of the Irish Nutrient Sustainability Platform which raises awareness, promotes R&D and informs policy in the area of sustainable agriculture across the island of Ireland. **Nockemann** is founder of the spin-out company Green Lizard Technologies (2015) which specialises in the development of green chemistry technologies as described above. He is also co-founder and director of start-up company Seren Technologies Ltd. (founded 2016), focusing on developing technology for the separation of rare earth metals. The company opened its rare earth magnet recycling demonstration plant in December 2018 at the Wilton Centre (Teesside) with investments of >£2M. **James** is the co-founder of spin-out companies MOF technologies and Porous Liquid Technologies (2018), based on the invention of porous liquids, which can dissolve remarkably large amounts of gas. **Goguet** has undertaken several exhaust after-treatment projects with Johnson Matthey, Toyota, Ford and Ferrari.

Prizes and fellowships: **Bell, Hu, Mills** and **De Silva** are elected Members of the Royal Irish Academy. **Bell, Doherty, Hale, James, Mills, Nockemann, De Silva** and **Stevenson** are Fellows of the RSC. **De Silva** Boyle-Higgins Gold Medal and Lectureship, The Institute of Chemistry of Ireland, 2020. Genentech Lectureship in Organic Chemistry, College of Chemistry, University of California at Berkeley, USA (2018); **Knipe** Dave Kelly Cup Winner (Gregynog Synthesis Meeting, 2017); **Mills** Green Gown Award (2014), RSC Materials for Industry - Derek Birchall award (2019); **Holbrey** and **Nockemann** Don Nicklin medal and RSC Teamwork in Innovation award with the QUILL Research Centre; **Nockemann** Mercator Fellowship (DFG, 2015), IChemE Award in the category Food & Drink (2016) and IChemE Award in the category "Start-Up Business of the Year" with Green Lizard Technologies Ltd. (2018); **Swadzba-Kwasny** Kenneth R. Seddon Memorial Lectureship (2018). **Manesiotis** Included in the Analytical Scientist Power List 2019, Top 40-under-40. **Moura** was awarded a Royal Academy of Engineering Fellowship in 2019 and the European Federation of Chemical Engineering Excellence Award in Fluid Separations 2018.

Research Council Staff act as assessors for research centres and grants: **Bell** EPSRC Panel Member and Panel Chair (2017), Royal Society, EU, Member of College Panel for UKRI Future Leaders Fellowship scheme 2019-; International Expert Review Panel - Competence Centres, Enterprise Ireland (2017); **Hale** Outstanding Science and Technology Achievement Prize of the Chinese Academy of Sciences (2019), Member of the Irish Research Council, Postdoctoral Fellowships Evaluation Committee (2014); Newton Postdoctoral Fellowships Evaluation Committee (2013-2015); External Assessor for Churchill College, Fitzwilliam College, Robinson College and Trinity Hall Early Career Research Fellowships Scheme (2017); **Holbrey** EU H2020 Marie Skłodowska-Curie Action Individual Fellowships (2019); Member and Chair of the Science and Technology Facilities Council ISIS Facilities Allocation Panel FAP-2 (member 2013-2018, and chair 2014-2019); Member of the Royal Society of Chemistry Subject Expert Grant Assessment Panel (2015-2020); **Nockemann** SPP DFG, Germany (2015); Science Foundation Ireland (2018); Swedish Research Council (2019); INEA H2020 Energy Call (2019); **Marr** Member of the Irish Research Council (IRC) international assessment board; **Manesiotis** EPSRC, COST, British Council, Newton Fund; **Muldoon** EPSRC and the Irish Research Council; **Huang** BBSRC Grant review panel; **Themistou** EPSRC prioritisation panel member (2014, 2017, 2018); **Swadzba-Kwasny** Member of the ISIS Facility Access Panel (FAP-2) for 2018 – 2021; Leverhulme Trust grant reviewer (2016-); Research Foundation Flanders FWO, Belgium (2019-) **Bell, Doherty, Hale, James, Manesiotis** and **De Silva** are EPSRC college members.

Editorial Advisory Boards: **Bell** Analysis and Sensing (2020-) **Hale** Org. Lett. (2002-2018), Future Medicinal Chemistry (2008-), J. Chemical Engineering & Process Technology (2010-); **Mills** J. Photochemistry & Photobiology Chemistry A (2010 -), J. Fluorescence (2010-); Food Packaging and Shelf Life (2013-); **De Silva** J. Fluorescence (2002-); **Marr** PLoS one (2011-); **Swadzba-Kwasny**, ACS Sustainable Chemistry and Engineering (2016)
Journal Editorships: **Hale** Associate Editor Org. Lett. (2003-2018); **De Silva** Associate Editor-in-Chief, Chinese Chemistry Letters (2017-2019); **Manesiotis** Guest editor for Journal of Chromatography B Special Issue on Affinity-based separations in bioanalysis (2016); **James** Guest editor for Chemical Society Reviews, Special Issue on Mechanochemistry; Guest editor for Chemical Communications, web-themed issue on Mechanochemistry; **Swadzba-Kwasny** ACS Sus. Chem. Eng. special issue on Advanced Reaction Media (2019).

Plenary, keynote and invited lectures: Staff in the UoA have given >250 invited talks at universities and industry over the REF period. Over 100 invited, plenaries and keynote lectures have also been given including: **De Silva** International Congress on Chromogenic and Emissive Materials, Lisbon, Portugal (2014. plenary), 4th International conference on Molecular Sensors and Molecular Logic Gates (2014, plenary); Gordon Conference on Artificial Molecular Switches and Motors, Massachusetts, USA (2015); Royal Society of Chemistry-Tokyo International Conference, Japan (2015, plenary); 5th International conference on Molecular Sensors and Molecular Logic Gates (MSMLG2016), Bath, UK (2016, presented the Nature Chemistry Lecture); 6th International conference on Molecular Sensors and Molecular Logic Gates, Dalian, China (2018, plenary); "Chemistry Meets Industry and Society", Salerno, Italy (2019, plenary). **Hale** American Chemical Society Nichols Medal Symposium, Whiteplains, NY, USA (2014, plenary); 17th Tetrahedron Symposium on Organic Chemistry, Berlin, Germany (2015, plenary); IASCOC (Ischia Advanced School in Organic Chemistry) Symposium, Ischia, Italy (2016, plenary). GDCh German Chemical Society Special Invited Lecture Tour, Hamburg, Berlin, Leipzig, Potsdam, Marburg, Giessen, Mainz (2015); Argentinian Organic Chemistry Society Invited National Lecture Tour (2017). **Holbrey** UK Neutron and Muon Users Meeting, Warwick UK (2014, plenary); Ionic Liquid Materials (ILMAT2015), Max Planck Society, Berlin Germany (2015, keynote); Gordon Research Conference on Ionic Liquids, Sunday River USA (2016); Faraday Discussion on Ionic Liquids, Cambridge UK (2017, speaker). **Hu** 12th International Conference on Computational Nanoscience and New Energy Materials, Qingdao, China (2019, plenary); 19th National Conference of Catalysis, Chongqing, China (2019, plenary). **James** EUROMOF, Paris, France (2019, plenary); Solid-State Science & Research (SCIRES), Zagreb (2019, plenary). **Marr** 14th Pannonian International Symposium on Catalysis, Starý Smokovec, Slovakia (2018, keynote). **Mills** 11th Int. Symposium on Transparent Oxide and Related Materials for Electronics and Optics, Nara, Japan (2019, keynote); 22nd International conference on photochemical conversion and storage of solar energy, IPS-22, Hefei, China (2018, keynote); 5th European conference on environmental applications of advanced oxidation processes, EAAOP 5, Prague, Czech (2017, keynote); 1st International Symposium on Recent Progress of Energy and Environmental Photocatalysis, Tokyo University of Science, Japan (2015, plenary); **Moura** Distillation and Absorption, Florence, Italy (2018) on occasion of the award of the European Federation of Chemical Engineering Excellence Award in Fluid Separations 2018. **Nockemann** International Conference of Ionic Liquids, Rostock, Germany (2015, keynote); 16th Conference on Molten Salts and Ionic Liquids, Vienna (2016, invited keynote); Energy systems conference, Manchester (2018, plenary); ILMAT 2019, Paris (2019, keynote). **Swadzba-Kwasny** COIL-8 - the 8th International Congress on Ionic Liquids, Beijing, China (2018, plenary); SCI Formulation Forum: Disruptive Technologies, London, UK (2018, keynote); ASIL 8, 8th Australasian Symposium on Ionic Liquids, Melbourne, Australia (2018, Ken Seddon Memorial Lectureship, plenary); COIL-6 - the 6th International Congress on Ionic Liquids, Jeju, South Korea (2015, plenary).

c. Other Indicators

Seminar programmes

There is a vibrant and extensive seminar programme, with approximately 25 talks per annum. This programme has continued successfully throughout the disruption of COVID-19 closures with a move to online seminars. This change has further diversified the range of speakers who we can invite since there are no issues associated with international travel or disruption of caring responsibilities. An annual Thomas Andrews research lecture, inaugurated in 2010, aims to appeal to all levels. Biannually there is also the QUILL lecture series (est. 1999). Visiting international speakers have included: Sophie Fourmentin (Littoral-Côte d'Opal) 2020, Luca Lietti (Politecnico di Milano) 2020, Shaun McKinnie (UC Santa Cruz) 2020, Michael Harold (Houston) 2020, Jason Hallett (ICL) 2019, Marc Reid (Strathclyde) 2019, Theoni Georgiou (ICL) 2019, Anna Barnard (ICL) 2019, Deirdre Murphy (Pfizer) 2019, Richard Compton (Oxford), John Hartwig (UCal Berkeley), Joanna McGouran (TCD), Igor Alabugin (Florida State), Karen Faulds (Strathclyde) 2019, Manfred Bochman (UEA) 2018, Ian Manners (Bristol) 2017, Ning Yan (National University of Singapore) 2017, Dermot O'Hare (Oxford) 2017, Yoshi Kishi (Harvard) 2017, Paul Anastas (Yale) 2017, Rebecca Melen (Cardiff) 2016, Karen Wilson (Aston) 2016, Amos Smith (Pennsylvania) 2016, Scott Dalgarno (Heriot-Watt) 2016, Philipp Kukura, (Oxford) 2016, Robert Paton, (Oxford) 2016, Tobin Marks (Northwestern) 2015, Euan Brechin (Edinburgh) 2015, Duncan Bruce (York) 2015, Ian Paterson (Cambridge) 2015, Guy Lloyd-Jones (Edinburgh) 2015.

Society/Public Engagement

Work carried out in the School has led to interest from the media, with a number of staff engaging with the press to communicate their research to the general public. **Bell** has received national media coverage for his work on novel psychoactive substances (2016). This includes interviews on BBC TV news, UTV news, Euronews (International Multilanguage TV News channel), BBC Radio 4 Today show, BBC Radio 5 Live Breakfast show. For his 2015 work on perfumed ionic liquids (Chemical Communications) **Gunaratne** has given interviews that have appeared in national and international publications (BBC, Chemistry World, Daily Mail, New York Times) and given live radio interviews promoting the work. **James'** work on permanently porous liquids has featured in news articles in the media (Chemistry World, Chemistry and Industry, Daily Mail) and he has been interviewed live on Radio 4 World at One (2015). **Manesiotis** work on nutrient recycling has featured in news articles in the media, and he has been interviewed on the BBC (2018).

The School is passionate about engaging with and encouraging the next generation of scientists. Staff in the School play an active role in interacting with the wider community to promote Chemistry and more broadly Scientific Research. 'Ele – Mental' was a hands-on event run by the CCE School for 7 weeks in Ulster Museum (August – September 2019). The project aimed to address the gap in awareness of chemistry and chemical sciences in primary school education and was targeted to children aged between 10 to 12. The event was very successful and over 1,450 visitors participated in experiments.

For the promotion of women in Science and Chemistry **Laguas-Castedo** (2019, 2017), **Swadzba-Kwasny** (2019) and **Moura** (2017) have all participated in Soapbox Science event as public speakers. Promotion of this event was featured in an article in Chemistry World magazine (**Moura** interviewed). **Laguas-Castedo** also participated on the Guinness World Record event helping school pupils to achieve the 'largest practical science lesson' in 2015): **Swadzba-Kwasny** has been interviewed for the NTV Behind the Science programme, 23 July 2018. Moura gave a public talk and demonstration at the Horizon 2020 European researchers' Night, Science Uncovered event at the Ulster Museum, Sept 2017.

The School recognises the importance of promoting Chemistry to not only students but also targeting School teachers, who play a key role in advising students on subject selection that will ultimately lead them towards specific university options. Teachers are at the forefront when it comes to inspiring students to study Chemistry and promoting how a career in Chemistry can make an impact in today's changing world. The School has participated within the STEM Learning Grand Challenges Insight Programme, facilitated by the Northern Ireland STEM Learning Hub. This programme seeks to enhance awareness of the study of STEM subjects in higher education, in addition to the current landscape of career opportunities within these areas, via the provision of experiential learning to teachers of called subjects within post-primary schools. To date, the School has hosted three teachers, across December 2019 and January 2020, each of whom participated in three-day "placements", involving discussions with academic staff across chemistry and chemical engineering areas, and the related shadowing of experimental and educational activities. Further to administrative support provided by the STEM Learning Hub to facilitate this programme, financial support was also provided to teachers' home schools to allow for the arrangement of substitute teacher cover for those teachers undertaking placements. Feedback has been exceptionally positive to date, with participants reporting an increased awareness of the subject areas, and their related career opportunities, allowing them to more confidently and regularly promote these career paths to their students. Following the initial success of the School's involvement in this programme, a further seven placements were advertised to post-primary teachers in early 2020, and these will take place when Covid restrictions allow.

School Staff also participate in the annual [Chemistry at Work](#) event, hosted by QUB, which showcases the application of chemistry in the workplace to secondary and grammar school pupils. The event takes place over two days and normally has a throughput of 1,000 – 1,100 pupils annually. Each year 12 industrial partners participate in the event. Long term partners include Almac, GlaxoSmithKline, Randox, Bombardier, Coca-Cola, BOC Gases, Forensic Science Northern Ireland and Norbrook Pharmaceuticals. The primary aim of the event is to deliver the message that chemistry is omnipresent in our daily lives and, moreover, that chemical knowledge is vital for solving 21st century global challenges like carbon reduction, plastic recycling, clean energy production and food and water security, which align with the key themes of the School.

In line with our Green and Sustainability vision for the future our School has been involved with Green Impact since its inception in 2011. Green Impact is an environmental accreditation and awards scheme, bringing staff and students together with their wider communities to enable and showcase positive changes in environmental practice. It aims to work towards achieving a reduction in waste, an increase in energy efficiency, an increase in sustainable procurement and an increase in sustainable transport. During that period, the School has consistently won Gold and Platinum awards for our labs and it holds over 75% of the University's Green Challenge and Green Fund awards. In addition, the School We also set up the first ever White Coat Walk which raised funds for Cancer Research UK and included walks not only here at QUB but also in England, France and USA. This was so successful that Cancer Research UK now run this as a national annual event.