**Institution:** University of Greenwich

**Unit of Assessment:** (UoA8) - Chemistry

## a. Context

The University of Greenwich's School of Science is the locus for research in Chemistry. Researchers are engaged in wide-ranging, solutions-driven technology transfer of the chemistry-centric research for the benefit of the chemical and pharmaceutical industries, healthcare and environmental technology sectors, and public health and well-being.

Chemistry research has had impact in a number of arenas:

- The School has developed novel techniques to optimise drug formulations and their analysis, primarily in the areas of process technology and interfacial chemistry (**Griffiths, Mitchell, Snowden**), through collaborations with some of the leading players in the pharmaceutical industry, eg Pfizer, GlaxoSmithKline, AstraZeneca, Johnson & Johnson, Merck Sharpe and Dohme, Vanguard Medica, Roche and Phase Separations. These activities have led to improved product performance, shorter lead times to market and a reduced failure rate, in particular with Pfizer.
- Engaging in activities to tackle the challenges of the aging population, where our extended lifespans are exceeding the service life of organs and tissues (teeth, bone, cartilage and cardiovascular), the School is working to develop next generation materials/medicines. These include novel formulations to tackle the issue of brittle glass-ionomer based cements currently used in over two million dental restorations, costing the NHS £25M/year (PCT/GB2012/050147) (Booth, **Coleman**); elaboration of a family of cyclic triazine and diazo analogues as sodium channel blockers to treat neurodegenerative disorders such as multiple sclerosis, Alzheimer's and Parkinson's disease (WO/2008/007149; WO/2009/090431; Israel App. No. 196469, 30/09/2013)(**Leach**); and a radically different new generation of drug delivery technology capable of locating biologics (high molecular weight genes and proteins) to the specific targets within a human cell (GB1311057.2; filed June 2013) (Richardson).
- The School is working with the Environment Agency, exploring fundamental polymer chemistry routes to improve the environment associated with former gas work and timber treatment sites through the removal of potent carcinogenic polyaromatic hydrocarbons (PAHs) present in soil environments with the use of facile flushing/removal treatments with aqueous solutions of block copolymers (ISBN 1844320669) (**Leharne)**;
- increasing the awareness of the need for improved diets in the early years (http://tinyurl.com/9msm8p3) (**Zand**), and
- developing Accelerated Carbonation Technology (ACT) that uses waste $CO_2$ gas to generate solid carbonates to solidify and stabilise waste, and finds use as an aggregate for construction (**Hills**).

The ultimate beneficiaries of this very applied research are therefore the general public through the improved quality of life they derive from such developments, with the underlying economic benefit associated with a healthier population and therefore, workforce.

## b. Approach to impact

Cognate activity (of relevance to this UoA) is organised within clusters; (i) Chemometrics & Analysis, (ii) Biological Chemistry and (iii) Materials Chemistry, and there is considerable exchange of scientific knowledge and practise between these groups. These research clusters are strongly supported by central funds, with internal peer-review of bids driving a deterministic agenda that builds critical mass within, and credibility of, the specific cluster. Internal contracts are let against targets in terms of publishable outputs, follow-on grant applications to maintain momentum, and potential to achieve impact, using assessment criteria that mirror RCUK's Pathways to Impact guidance. Over the assessment period, internal funding from, for example Higher Education Innovation Funding (HEIF) and Research Capital Investment Fund (RCIF) to these clusters has

amounted to some £1.2M, reinforcing the science underpinning the patents listed above, plus those of colleagues, eg Douromis, being returned to cognate UoAs.

Research outcomes are assessed against publish *vs.* patent criteria, as detailed in the university's IP Policy and Guidelines (http://www.gre.ac.uk/governance/policy/ip/policy) in the context of any agreements pertaining to ownership as a consequence of the funding arrangements. Decisions taken at this stage may secure additional funding from research councils, eg **Leharne** EPSRC *EP/F01015X,* or commercial bodies. For research that contains potential IP that is not already protected, on submission of a suitable business case, the University of Greenwich provides proof-of-concept funding from HEIF monies to enable the elaboration of commercialisation opportunities and bring the technology closer to market; eg Booth, Douroumis, Richardson have each been in receipt of PoC funding during the assessment period, which has led to the first filing and/or national phase filing of new patent applications. The majority of the proof-of-concept research carried out in this unit will have been undertaken by students or postdoctoral researchers funded in part, or entirely, by the University of Greenwich, with contributions from industrial partners in several cases, which builds commercial awareness amongst the next generation of researchers.

Discovery and exploitation of new IP is facilitated by Greenwich Research and Enterprise (GRE), the University-wide office which commercialises academic endeavours. Offering services in consultancy, business and technology development, its team of dedicated business development managers (BDMs) are embedded in each School, providing an effective stage-gate process to ensure that any IP is suitably protected at an early stage. In many cases, these BDMs will alert academics to calls for funding and assist in the costing of such projects, allowing the academic to focus on the research. Many of the senior academics work closely with industrial partners and are able to market the School's and colleagues' expertise to broaden engagement.

Dissemination of publishable research output, with a view to securing subsequent projects, follows the usual academic route – scientific publications (for which there is an internal peer review process prior to formal submission), engagement with learned and professional bodies, networking at conferences, public engagement *via* the university's Public Lecture Series, the Faculty Research Day, the School's Seminar programme, working with the university's Public Relations team to target popular news outlets (eg http://tinyurl.com/bv29eg2; http://tinyurl.com/9spnz77) to ensure maximum impact. Further, several members of staff act as consultants for large commercial organisations, eg **Snowden**, BP. To promote dissemination, the School also provides competitive, peer-reviewed resources (funding, teaching cover) to enable all staff to attend one major conference per year to present their latest work and to network, or to take advantage of sabbatical opportunities. This funding is not project specific, so all staff are encouraged to attend meetings that broaden their research interests. These activities feed into each member's KPIs to ensure that the support and enablement of impact is optimal.

The UoA follows the University Balanced Academic Workload (BAW) model that specifically assigns staff time for activities aimed at achieving impact and improving reach of the university within the external community. For example, Everett was able to delegate the Headship of the School for four months (Feb - June 2012) to enable the submission of an Innovative Medicines Initiative (IMI) £40M application. Key performance indicators (KPIs) for each staff member are also allied to their particular strengths, thus driving the research agenda. Colleagues within the School enjoy a barrier-free access to all equipment, enabling any given area of science with potential impact to be elaborated quickly and fully.

**c. Strategy and plans**

Impact is derived from quality research of direct benefit to end-users. Research performance is actively managed, the most formal being the annual appraisal across a unit-wide perspective analogous to the REF process, coordinated by GRE. These exercises provide a holistic, inclusive picture of all research underway within a particular School. This information then shapes the dispersal of central, strategic funds *via* a cascade of university and School-level Research and Enterprise Committees, designed to promote research by building critical mass where needed and allowing staff to bid for funds to support a broadening of their individual activities, and allied to this,

the School research base. Within the School, individuals' research and enterprise profiles are reviewed monthly within the Senior Management Team (SMT), and personalised performance goals set with the appropriate support enabled, to generate an annual research plan.

Developmental strategies for achieving future impact arising from our research are well-established within the GRE office. On a School level, the re-prioritisation of workloads to allow selected staff to dedicate more time to research, the close link between academic staff and BDMs, financial support from GRE and the mentoring/appraisal processes ensure that all opportunities for existing staff to build impact are taken. A more aggressive marketing and dissemination platform is being adopted to ensure the results of our research reach further into the stakeholder community.

Step changes in the character of the staff profile, to consolidate and broaden expertise to ensure the School continues to expand its research activity, will be effected by strategic interventions/appointments at senior levels, for example the appointments of **Dobbs** and **Griffiths** to strengthen the areas of synthesis and formulation/physical chemistry respectively. Specific goals include a 50% increase in external and enterprise income, a doubling of peer-reviewed publications (of greater than 2* quality) and a similar increase in post-graduate student registrations, to be enabled through closer and more proactive performance management.

Finally, a Science Advisory Board works closely with SMT to ensure that end-user engagement assists in the definition of School objectives and directs strategic interventions.

**d. Relationship to case studies**

Two different case studies are presented, (i) "*Treating waste with carbon dioxide*" which describes the creation of the successful spin-out companies Carbon8 Systems and Carbon8 Aggregates and (ii) "*Managing risk associated with crystal polymorphism in pharmaceutical development*, which built on an innovative post-doctoral scheme with Pfizer. Each case exemplifies how knowledge and expertise based within the School was the focal point around which a research group or centre was created; this interventionist approach to direct and build research capacity is a consequence of a managed process in which critical mass may be rapidly acquired and consolidated through strategic appointments. Effective research is usually collaborative and multidisciplinary in nature, and these case studies embody that approach. The diversity of skillset required to address global challenges warrants a team-based approach, either between universities or between a university and a cognate industry. Underpinning these collaborative ventures, initiated between individuals, is university funding that was used to elaborate the fundamental science on which the impact is based, with any subsequent IP being protected by the university or licensed to the respective partners.

The impact arises from identifying academic solutions to practical problems, with the involvement of end users. In case study (i) **Hills** realised the potential to sequester large quantities of $CO_2$ emitted from waste-producing thermal processes by converting it into solid carbonates, and to use these materials to solidify and stabilise waste, or when combined with calcium-silicate bearing Air Pollution Control Residue (APCr), to form an aggregate for use in construction. Follow-on industrial funding consolidated this invention, with University of Greenwich activity focusing on the properties of the carbonated APCrs, their physical and chemical stability, leaching characteristics and suitability for disposal at non-hazardous landfill sites or for reuse. A second company *Carbon8 Aggregates* was formed in 2010, to scale-up the aggregate manufacture process

In case study (ii) over 20 highly trained post-doctoral researchers were generated (through the **Snowden, Mitchell,** Wicks collaboration**)**, equipped with new insights and knowledge to enable Pfizer to address major problems that limit product development. This critical technology and human resource transfer has led to many innovations on which the company now bases considerable importance, eg best practices for powder flow evaluation, and nanoindentation; the introduction of computational chemistry to process development; product development, eg the physical chemistry of thin polyol films in order to facilitate the rational development of processes and formulations for novel and improved dosage forms as well as methodological developments eg *HyperSense DNP* Enhanced Heteronuclear NMR Spectroscopy, and the universal Evaporative Light Scattering Detector (ELS).