Institution: University of Birmingham

Unit of Assessment: UoA 8 – Chemistry

a. Context

With the strategic aim to focus on *Chemistry for Health and Sustainability* through newly created outward-facing research themes that reflect areas of national importance, the School of Chemistry (SoC) is committed to delivering on and maximising the impact of its distinguished record of academic research, which has been built up over many years. The SoC is able to deliver impact into a wide range of sectors and to a diverse public-sector (e.g. medical) and industrial community, with beneficiaries including large pharmaceutical companies (e.g. *GSK* and *AZ*) as well as companies and public bodies involved in energy use and management (e.g. *Infineum* and the nuclear industry). The wide applicability of the SoC's interests is also reflected in the spread of companies involved in Centres for Doctoral Training (CDTs), which have involved instrument and medical diagnostics companies. The types of impact generated from the SoC's work are generally those that stem from core research activity, ranging from initial stand-alone projects through to those with industrial/end-user partners and those involving CDTs, with each being facilitated towards impact generation through engagement with the SoC research themes.

b. Approach to impact

Engagement and Development Strategy: In the REF period, in order to boost, promote and facilitate research applicability and end-user/industrial engagement, the SoC has reorganised and revitalised its research structure into two interconnecting streams of activity, as outlined below:

Core structure – The SoC has four research units that evolved from its three core areas in RAE2008: (i) *Biomolecular, Supramolecular and Nanoscale Chemistry*. (ii) *Molecular Synthesis and Catalysis*, (iii) *Physical and Theoretical Chemistry* and (iv) *Solid State Chemistry*. These units reflect and build on existing SoC research strengths that underpin impact generation.

Outward-facing structure – The SoC has three outreaching research themes: (i) *Chemical Biology and Drug Discovery (ii) Imaging in Chemistry and Biomedicine and (iii) Materials Chemistry and Energy***.** These themes are geared towards knowledge application and allow the SoC to link and promote the core research it undertakes to regional, national and international research initiatives and to facilitate cross-disciplinary research, both within the UoB and academia (e.g. the medical school and CDTs) and more broadly through external networks and industrial connections.

The bold vision to change the culture towards connectivity and interdisciplinarity in specified research areas aligns with the strategic goals of the UoB, as well as with the findings of two important reports on chemistry published in the REF window: (i) the RSC-commissioned report on the *Economic Benefits of Chemistry Research to the UK* (2010), which underlines the fundamental importance of chemistry in developing growth in areas central to the UK economy such as healthcare and energy; (ii) the 2009 EPSRC-commissioned *International Review of UK Chemistry Research*, which highlights the important role of interdisciplinary research in disciplines such as materials science and chemical biology that need to be developed further if the UK is to remain competitive in emerging areas of innovation and technology. With these research structures in place, approaches by the SoC in the REF period to generate impact are summarised as follows:

- *Turning Core Research into IP* – Promoting an active policy among SoC staff of turning core research findings into impact-generating activity through records of invention (ROI) and patents.

Evidence – Records of invention represent the starting point for bottom-up impact generation; the number lodged each year by SoC staff with the UoB's technology transfer company *Alta Innovations* has risen year-on-year in the REF window, with 17 recorded since 2012 and 26 in total. Similarly, the number of new patents associated with SoC staff is at a record high, with 21 patents filed or published by staff in this unit's return in the REF window (with 14 of these since 2011). This number is more than double that recorded for the RAE2008 return (<10 patents filed or published). This activity bodes well for future impact generation, given the previous success in turning patented core research into spin-out activity, as exemplified by the IM case study.

- *Facilitating Specific Industrial Interactions* – Encouraging research collaborations between SoC staff and industrial partners through individual grants, collaborations and fellowships.

Evidence – Increased industrial funding and partnerships, for example to **Preece** for microcapsule research with *P&G* (supported by EPSRC) and greater numbers of PhD (including CASE, EngD) studentships involving industry (e.g. with *GSK*, *AZ*, *Nuclear Decommissioning Authority*). Other examples include a *Royal Society Industry Fellowship* awarded to **Fossey** to work with *Syngenta* and **Hriljac** recently obtaining PDRA funding from *Infineum* to develop biofuel analysis. Over 30 papers have been published by SoC staff jointly with industrial and non-academic partners since 2008, including outputs with *P&G*, *Johnson Matthey*, *National Nuclear Laboratory* and *GSK*.

- *Forging Research Alliances* – Promoting and coordinating departmental and institutional-level partnerships involving industry and end-users, including studentship training schemes, both within the UoB and among other institutions in the region.

Evidence – **(i)** The *Science City Research Alliance* (SCRA) involves the UoB in regional collaborative projects across scientific themes in Advanced Materials, Energy and Translational Medicine and is part of the *Birmingham Science City* initiative with the University of Warwick. The £2.2M investment in SoC equipment and infrastructure for materials characterization has facilitated core research activity, generated SoC publications and attracted day-to-day interaction with industrial users of the equipment, generating income and facilitating collaborations. **(ii)** The *CDT in Hydrogen, Fuel Cells and their Applications* involves members of the *Solid-State Chemistry* research unit in the SoC who contribute to work on fuel cells and hydrogen storage within the training centre. National interdisciplinary activities to engage stakeholders in incorporating hydrogen into the UK energy platform have included the *UK Sustainable Hydrogen Energy Consortium* (UKSHEC2), now superceded by the *H2FC Supergen* research hub, with **Anderson** and **Slater** both on the Science Board; **(iii)** The *CDT in Physical Sciences of Imaging in the Biomedical Sciences (PSIBS)* involves several cores areas of chemical research (e.g. biomedical and analytical chemistry) and is coordinated within the SoC through the *Imaging in Chemistry and Biomedicine* theme led by **Hannon**. This has led to strong links with the medical community at the UoB and 18 industrial partners (e.g *Perkin Elmer*, *GE Healthcare* and *Smith & Nephew*), resulting in cross-disciplinary papers and patents (e.g. to Pikramenou on nanoparticles) and the recent announcement (Nov 2013) of a new £7M *Physical Science for Health* CDT, again hosted by the SoC, to apply a range of physical science to address key health challenges such as ageing, trauma and cardiovascular disease. (iv) *Drug Discovery Initiatives*: The UoB has set up a partnership with *Lilly* on the *Open Innovation Drug Discovery* programme for compound screening assays which involves several SoC staff (5 at present). Also, *Institutional EPSRC Additional Sponsorship Funds* obtained by **Simpkins** have involved a PDRA in a *Knowledge Transfer Partnership* (KTP) to work with *AstraZeneca* to transfer compound library knowledge back to the UoB. The results from this study have informed the UoB strategy for various drug-discovery/Pharmacy initiatives currently being developed across the UoB campus, which are coordinated in the SoC through the *Chemical Biology and Drug Discovery* outreaching theme.

***School and University Support Mechanisms**:* All activity concerning impact generation is overseen by the SoC *Research and Knowledge Transfer Committee*, of which the SoC IP coordinator **Preece** and the School BDM (see below) are members. SoC industrial and end-user engagement is coordinated on a day-to-day basis by a *Business Development Manager* (BDM) assigned to the SoC from the Engineering and Physical Science (EPS) college, who provides a strategic overview for projects involving SoC staff and advises on government initiatives (e.g. TSB *Knowledge Transfer Networks*). SCRA projects across the UoB are coordinated by a dedicated Business Engagement Manager, and focus on the advancement of technology, know-how and R&D through connecting regional industry with SoC academics and equipment. The UoB's Research and Innovation Services (RIS) unit advises the SoC on RCUK priorities and strategies for capturing funding alongside commercial partners.

c. Strategy and plans

The impact strategy of the SoC over the coming years is to further enhance the culture within the SoC of applying its core research through ROIs, patent generation and engagement with industry and end-users, as described in Section (b). This approach is aligned with the *International Review of Chemistry*, which highlights the practice of investing in core chemistry research as a continuingly

important way for universities to generate novel and unexpected impact. However at the same time, the *Economic Benefits of Chemical Research* report acknowledges the widely known issue of lengthy timescales (quoting up to 20 years) in which such bottom-up research has historically generated impact. While the newly created research themes are designed to speed up this process, various paths to impact generation (e.g. monitoring conversion rates of ROIs into patents, contributing to UoB drug discovery initiatives, engagement with TSB programmes) will be continually monitored by the *Research and Knowledge Transfer Committee*, which will also coordinate the dissemination of good practice. The recent award of a CDT in *Physical Science for Health* will only serve to strengthen the cross-disciplinary focus of the SoC towards impact generation, as will recent awards involving industrial partners, for example the EPSRC consortium DISTINCTIVE, involving **Hriljac** and **Read**, bringing together nuclear waste management research and the EU *Initial Training Network* COOPERA-TB, involving **Cox** and GSK, working on tuberculosis drug discovery. Other plans for future development include:

Staff Training Strategy: The UoB offers a number of courses for academics and researchers related to impact generation, for example the "*Researcher to Entrepreneur*" programme, the *Medici Enterprise Training Programme* (for raising IP awareness) and the *Enterprising Birmingham Fund* for funding proof of commercial viability projects. The success of these programmes, as noted by staff feedback and activity, has resulted in the SoC planning a rolling programme (to be part of a staff development requirement) to ensure all staff are trained in impact awareness and generation through courses such as the *Medici Enterprise Training Programme*. IP training is now a compulsory part of the doctoral induction program (whether on CDTs or conventional programmes) and training workshops will be set up at regular intervals for registered students and research staff.

Public and end-user engagement: There will be an increased focus on the participation of research-active staff in engaging the public and potential end-users (e.g. the medical community) in various research awareness events, for example through open day and outreach activities. These will build on existing good examples of good practice in the SoC (e.g PSIBS CDT students regularly work with school children at *Thinktank*, Birmingham's science museum and fuel cell workshops are regularly run by the SoC). Such activities will now be rolled out and coordinated through the SoC outreaching themes and overseen by the SoC outreach coordinator **Read**. SoC funds will continue to be made available to maximise participation by staff in such activities, with examples of 2 forthcoming events in 2014 being the *Big Bang Fair* and the *British Science Festival*.

d. Relationship to case studies

Irresistible Materials Limited – This spin-out company arose as a result of a research collaboration between the School of Physics (Palmer, Robinson) and the SoC (**Preece**); this study highlights the way in which core chemistry can be applied in an interdisciplinary manner, and illustrates the pathway and timescales from the patent to spin-out stage. This work is set as an exemplar of research collaboration within the UoB, with this area of research now coordinated through the outreaching theme of *Materials Chemistry and Energy*.

Glysure – The chemistry in Glysure's glucose sensing product arose from original work undertaken in the SoC by Tony James (now University of Bath) over 10 years ago but continues to the present day through collaborative work with **Fossey**. It underlines the continuing long-term investment that the UoB has invested in core research areas allied to carbohydrate and supramolecular chemistry. The application of research in this area is now coordinated through the outreaching themes of *Chemical Biology and Drug Discovery* and *Imaging in Chemistry and Biomedicine*.

Astrochemistry – This work arose from original blue-skies work carried out by Ian Smith FRS and Ian Sims throughout the 1990s within the SoC at the UoB. The full impact of this research on various space agency programs was not realised at the time but it demonstrates the long timescales often involved for generating impact, as well as the importance of bottom-up research in generating novel and unforeseen impact.

MOLPRO – Complete system of *ab initio* programs for molecular electronic structure calculations, developed by Knowles and co-workers. Much development was done at the UoB while Knowles was in the SoC, from where it was first licensed before moving to Cardiff in 2003. The work demonstrates again the use of core research, which in this case has generated impact through the continued income from license sales and the facilitation of drug discovery and design processes.