Institution: University of Sussex

Unit of Assessment: UoA 8 Chemistry

1. Context

Chemistry at Sussex is in a period of revival, with successive phases of stabilisation, restructuring and limited but intensive growth having now been achieved. Translational activities now dominate the planning and development of research. Research conducted within the UoA is focused towards directly exploitable areas, while retaining the academic core. The UoA recognises that maximising the impact of its research is an important factor in securing the future of the subject at Sussex and the implementation and refinement of the UoA's pro-impact philosophy is embedded in the future strategy for the UoA. The main non-academic user-groups for the UoA's research are those associated with the new research axes of the UoA: 'Translational Drug Discovery' and 'Energy'. These include, but are not limited to, industrial concerns spanning start-ups (e.g. Pastel Biosciences, Sirigen Ltd) and SMEs (e.g. PpTek Ltd, reViral Ltd) to multinationals (Cummins Inc, Finning International). The former group serves the expanding UK biotechnology sector in several ways – for example through the discovery of new, rationally designed molecular entities or the development of new analytical techniques for biomedical applications. The latter group focuses on solutions to major chemical problems of global significance – the correlated problems of sustainable energy supply coupled to climate change. The new School of Life Sciences structure, where Chemistry sits, aids in this approach by lowering barriers for intersubject interactions. In both areas, fundamental scientific discoveries of processes, properties and materials aid and inform external commercial activity through direct interactions and collaboration. The main mechanism used in the period of assessment for effecting these collaborations is through joint applications to external funding bodies, which include EPSRC and the Technology Strategy Board. The case studies reflect only a small part of the UoA's research activity. In particular, the considerable impact potential of the recently established Translational Drug Discovery Group does not feature in the current submission, but will form a significant component of impact submissions in future REF processes.

2. Approach to impact

The academic and financial restructuring of the School in 2009 has accelerated the growth of impact of the UoA, which is now on a strong upward trajectory. Since restructuring, the stance of the UoA is that basic research remains the core of our endeavours, with considerable attention being paid to identifying aspects of our research that are amenable to commercial exploitation, or have relevance to the needs of commercial, governmental and not-for-profit organisations.

Industrial interactions are core activities within the UoA, directly generating impact *via* translational research. A key driver of the restructuring was to optimise opportunities for impact. Of particular importance was the revitalisation of the organic and medicinal side of the Chemistry Department at Sussex. The formation of the cross-disciplinary Drug Discovery Initiative is already opening up major opportunities for working with industry to achieve impact, and attracting substantial targeted funding for the development of new therapeutics. For example, in collaboration with a biotechnology company – reViral Ltd – the Translational Drug Discovery Group headed by Ward has been granted ~£1.4M by the Wellcome Trust Seeding Drug Discovery Initiative for 'A stream-lined lead optimisation project with the potential to deliver first in class small molecule inhibitors of Respiratory Syncitial Virus (RSV)'. Similar projects are being developed in Chemistry, with the potential for considerable future impact on the economy, by adding commercial value to UK biotechnology activity. Evidence for these include: the CRUK-funded 'New targets' grant centred around the anti-cancer protein target TDP1 inhibitors between Ward (Chemistry) and El-Khamisy (Genome Damage and Stability), and an EU fellowship between Ward (Chemistry) and Hochegger (Genome Damage and Stability Centre) centred around Greatwall kinase. A second Wellcome Trust Grant of ~£4M has also recently been awarded (Ward) for discovery and optimisation of a drug candidate to treat the cognitive impairments associated with schizophrenia. Another successful initiative has resulted in Bagley and Turner becoming key members of a consortium led by Brighton and Sussex NHS Trust Nuclear Medicine – that includes Aposense, Teva and KCL – for the development of tandem imaging and therapeutic radiopharmaceuticals.

Industrial interactions also formed part of the development of the Energy strand with evidence for success of this policy including a strong relationship between PpTek Ltd and Turner and Chen in the UoA during the period of assessment. This has grown from the initial development of new

hydrodesulphurisation technology, which has been patented by PpTek, through an EPSRC CASE award to a successful TSB application. Within this external funding structure, with a total award value of ~£750k, scientific discovery within the UoA has directly informed and affected the commercial performance of PpTek. The company estimates that this interaction has added well in excess of £3.5m of value to the company in terms of commercial contracts awarded and direct investment; moreover, the current and future IP of the company, partly developed with Turner and Chen in the UoA, has led to very significant inward investment to PpTek from two multinational corporations and other private funding bodies. Turnover at PpTek has risen from ~£900k to ~£3M and the company has tripled in size during the period of assessment, growth that would have been impossible in the absence of this interaction. Moreover, as part of the evaluation for this inward investment, the previous, current and future technology being developed between PpTek and Turner and Chen in the UoA was estimated to add value to the company well in excess of £1m. As well as the economic impact, this work is helping the UK towards targets for renewable energy/carbon/climate change. Similarly Heggie's work, which has allowed the extension of nuclear power stations, is acknowledged to contribute towards the UK's energy security of supply.

Further evidence of the development of a culture of translation is seen by the success of Osborne who, in collaboration with Pastel Bioscience, won a SEEDA Commercialise PoCKeT award (£50k) for proof-of-concept experiments towards the development of its ultra-sensitive protein detection and biomarker discovery technology. The results generated were significant in supporting Pastel's IP and, importantly, have provided a platform for demonstrating to potential investors that the technology is underpinned with credible, preliminary data. Pastel is currently in late-stage discussions to secure a major investment (>£1M), based in part on the aforementioned data, which is expected to fund continued R&D operations for the next 3–5 years. If successful, it is expected that Pastel will engage in further collaboration with Osborne to progress the technology from proof-of-concept to a next-generation biomarker discovery platform.

In a parallel strategy, staff have exploited these industrial interactions to secure sponsorship of CASE awards for PhD students (PpTek – Turner and Chen), industrially-funded PhDs (Avexa, Novartis, AstraZeneca – Spencer) and have made a successful bid for Technology Strategy Board funding in collaboration with PpTek. Another recently established interaction is the Master's level research scheme with Novartis.

Impact through consultancy: Chemistry staff are developing a growing portfolio of consultancies with a range of companies, both in the UK and abroad. For example, the UoA has a well-established tradition in molecular synthetic chemistry, especially in the area of paradigm-changing organometallic molecules; Cloke is actively engaged with multinationals (Air Products, Intel) using bespoke synthesis of such compounds for their specific needs, as precursors to thin films for next-generation electronic-device construction. Recent changes in the University terms for consultancy have encouraged faculty interactions with industry, diverting 85 per cent of the fee into individual research activities.

Engagement with wider stakeholders and therefore potential funding streams is critical to achieving impact from the work of the UoA; to facilitate this, and supported by the Director of Research and Knowledge Exchange, staff actively engage in networking events organised through the University Research and Enterprise Division and wider consortia. Engagement activity is also an important strand in the annual appraisal mechanism of the Department. As part of the UoA's coherent impact policy, Chemistry maintained membership of the London Technology Network, with a staff member (Turner) being a business fellow until the demise of LTN. These activities have significantly increased exposure of Chemistry research at Sussex to a wider user-group community. Similarly, Chemistry faculty also take every opportunity to engage with a wider audience and convey the potential impact and socio-economic benefits of their research: Turner has presented on 'chemical economics' to the UK FCO and at energy policy conferences, and has interacted with global multinationals; Cloke has recently been interviewed by the *Sunday Times* for an upcoming article on the current and likely future technological importance of the lanthanide elements (as a consequence of the high level of concern about current Chinese domination of lanthanide mining and production); and Turner and Higgins represented Chemistry at Sussex at the 2014 Labour Party Conference.

3. Strategy and plans

The future strategy of the UoA builds on the relationships developed during the period of assessment and is informed by the successes and failures to date; the UoA has learned a great deal with respect to

translational research post-restructure. Going forward, the impact strategy is focused on two areas of growth: the Drug Discovery Initiative (DDI) and Energy.

The translational nexus within the University, which includes the Medical School, other UoAs within the School and the local NHS Trust, will be the main vector to expand Translational Drug Discovery activities. The main strategic focus of the cross-disciplinary DDI is effecting this type of impact, and the connections that service this end will increase in the future. Formal arrangements, including a steering and oversight committee which includes staff in the UoA, the NHS Trust and external pharmaceutical companies, provides the administrative, practical and intellectual framework and the next steps: to raise the level of external funding, partnered by industrial stakeholders, from medical funding bodies that include the MRC, CRUK, Wellcome and BBSRC.

The DDI has two key strategic foci for the future: cancer drug targets and neuroscience, both in strong collaboration with staff from other UoAs in the School. This includes recent appointments that were specifically targeted for this purpose, given the disproportionate withdrawal of 'Big Pharma' from areas of neuroscience, where there is an existing market that is not currently served in the R&D sector. This forms the niche into which the DDI is expanding. Having validated the scientific structure and approach of the DDI via recent grant success, a key strategic goal in the future is portfolio funding from bodies such as Wellcome or the MRC, in collaboration with SME-scale pharmaceuticals and the multinationals. The early-stage inclusion of industrial partners is essential to widen the scope of capabilities and to smooth the pathway to impact; activities towards the delivery of this goal are already in place. External visibility that will aid this approach will be derived from three main sources: patents, publications and the placement of lead NMEs in clinical trials.

Expansion of the Energy strand in the future will include faculty appointments in materials chemistry that are currently open and the establishment of an electrochemistry subgroup to pursue photovoltaics and electrochemical catalysis focused towards small molecule activation; with respect to the latter, potential candidates have already been identified. An electrochemical subgroup will substantially broaden and strengthen the scope of the Energy axis and will lead to increased IP generation, which is then translatable through current industrial collaborations directly to application. Additionally, negotiations with external industrials to expand activity via a Knowledge Transfer Partnership have begun; successful completion of this scheme will serve as a template for future interactions with other actors in the energy market. Future expansion of the Energy strand will also include direct investment from private sources, which include venture capital, private equity and 'philanthrocapital' which will share IP with the University.

4. Relationship to case studies

The impact case studies by Heggie, Hill, and Turner and Chen show how academic activities within the UoA have been translated into a variety of impacts with external stakeholders via differing mechanisms, within the overall framework given above. Heggie has longstanding expertise in computational solid-state physics and directed this effort towards a fundamental understanding of defects in graphite and graphene. This has direct impact on models of graphite structural elements in nuclear reactors and particularly in the source of Wigner energy. By direct interactions with external stakeholders such as EDF and the IAEA, he has influenced the construction and modelling of nuclear reactors leading to the extension of life of nuclear power stations, demonstrating a path from curiosity-led research directly to impact with external stakeholders through application of his new theory of defects. A different mechanism of impact is shown by Hill. After her discovery of endocrine-disrupting chemicals in the environment, she has deployed the very powerful mass-spectroscopy suite at Sussex as a tool to determine the nature and scope of the biological effect of modern synthetic chemicals in the environment. Her work has been important in affecting European and UK Environment Agency policy towards monitoring and limiting the spread of harmful chemicals in the environment. The impact of her work therefore lies in contributions to the scientific framework for policy decisions. A third mechanism is shown by Turner and Chen, who have deployed analytical and synthetic chemistry to immediate commercial applications in direct collaboration with PpTek Ltd. In this case, the close collaboration has directly changed the practices of the company, with a large effect on the relative size of the company, and has led to new processes and applications, and an increased market share within the UK and internationally for PpTek.