Institution: Heriot-Watt University

Unit of Assessment: 8 (Chemistry)

a. Context

Chemistry at Heriot-Watt University (HWU) extends from a core of mainstream chemistry into the boundaries with cognate subject areas, particularly the life sciences, materials science, chemical engineering and physics. Consequently, the main non-academic users and beneficiaries of our research are in the private and public sectors across this spectrum. We have partnered with over 70 companies over the REF period in a variety of modes that we develop in (b) below, gaining substantial leverage from a range of public funding bodies including the Research and Funding Councils, Charities, EU, NHS, and the economic development agency, Scottish Enterprise.

Economic impacts are clustered primarily in the pharmaceutical sector (through the development of new drugs and improved production processes); in medical imaging; in energy (including carbon-capture and utilisation, and materials for energy applications); and in advanced instrument manufacture (in the vacuum-technology sector). **Impacts on health** will be realised through engagement with healthcare companies to deliver next-generation diagnoses and treatments. **Environmental impact** is achieved through development of more efficient catalysts, by process intensification, and through improved long-term understanding of atmospheric processes. **Impact on society**, through improved awareness and understanding of science, is delivered both at school level and to the public more generally.

b. Approach to impact

Our strategy to achieve impact is through partnership with other researchers, within and beyond HWU, and engagement with end-users. The flexible range of mechanisms we adopt includes direct funding from, and exchange of personnel with, established companies, through to creating new companies. Wherever possible, we seek to amplify the impact deliverable with our own and the partner's resources by leveraging additional external funds. Early-stage involvement of end-users focuses the research phase of publicly funded programmes on aspects likely to lead to impact and accelerates its ultimate delivery.

A prime example of direct funding of research by end users is the application of ***Molecular Chemistry*** expertise to drug-discovery programmes funded by Kyorin Pharmaceutical Ltd (as part of a £14.9M programme - see also REF3b). This provided the key foundation to a major respiratory-disease programme continued by Kyorin. It also led to the transition of Scottish Biomedical (originally a technology management company founded by Scottish universities) into a fully independent drug discovery services company.

Our most pervasive engagement mechanism is to partner with private companies in collaborations that are supported by **Research Councils, Funding Council, EU, Charities** or other public bodies. Principal examples in ***Materials Chemistry*** include work on thermoelectric materials with both SMEs (European Thermodynamics Ltd) and major corporations (Tata Steel UK) as project partners through Energy Technology Partnership and European Commission funding (£850k in total to HWU). Interactions with a range of companies have been supported by **EPSRC** funding, including Ingenza Ltd on biocatalysis; Aquapharm (see below and REF3b) on marine biotechnology; with 9 adsorbent-manufacturing or energy/engineering companies, jointly with St. Andrews and Edinburgh via a Science and Innovation Award on CO_2 capture from gas-fired plants; with EURATOM/UKAEA and 3 industrial partners on materials for fusion reactors; with industrial partners AstraZeneca, Pfizer, GSK, and others including HWU spin-out NiTech Solutions Ltd (see below and REF3b) through a Centre for Innovative Manufacturing, (£6.0M from EPSRC as part of £60M total investment) joint with Strathclyde, Glasgow and Edinburgh on continuous manufacturing and crystallisation.

Via distinct mechanisms, ***Structure & Dynamics*** impacts on 6 vacuum, laser and other high-technology instrument manufacturers through industrial placements (up to 80 person months across all partners) in the **EU FP7 ITN** LASSIE network (£5.5M in total); and with 6 advanced photonics manufacturers as partners in an **RCUK Science Bridges** award (SU2P, £1.6M in total), joint with Strathclyde, Glasgow, St Andrews, and (in the US) Stanford and Caltech.

Molecular Chemistry led the chemistry work packages for a major stem-cell technology

programme (£9.5M in total) with Cellartis, who established a new UK facility in conjunction with the programme, funded by **ITI Life Sciences** (with Glasgow and Dundee). This was the foundation for a new initiative in industrial-scale red-blood-cell production partnered by the Scottish National Blood Transfusion Service and Roslin Cells Ltd through **SFC Horizon Funding**, joint with Glasgow, Edinburgh and Dundee. The SME Aquapharm (see below and REF3b) was the partner for a distinct programme into new anti-infectives for the control of antibiotic-resistant human pathogens funded by NHS (Scotland) Chief Scientist Office.

The potential to deliver impact in ***Biological Chemistry*** has led to partnerships with Edinburgh Biosciences Ltd, Sagentia, and other companies supported by major **EPSRC** funding (£9.3M in total) of an Interdisciplinary Research Centre (IRC), joint with Edinburgh, in optical molecular sensing and imaging; and with Leica Microsystems, Olympus, Nikon, and Hamamatsu via an **MRC/BBSRC/EPSRC** project grant (£1.95M) to establish the Edinburgh Super-Resolution Imaging Consortium (ESRIC).

We have participated actively in the **SFC/academic/industrially co-funded SPIRIT** award scheme, developed under the ScotCHEM pooling initiative. The PGR students supported split their time between industry placements and academic research laboratories. It has helped to foster closer ties between the chemistry research community and the successful Scottish chemical industry. The HWU projects were with Fuel Cell Scotland in fuel cells; with Solid Form Solutions and, separately, NiTech Solutions Ltd in crystallisation of pharmaceuticals; with Ingenza Ltd in sustainable low-energy/low-waste catalysis; and with Helia Photonics in polymers for optical-based security. The last of these was extended through a **Knowledge Transfer Partnership (KTP),** a route also pursued very successfully through a multiple award-winning (KTP Scotland and UK National Awards, UK Best Partnership, UK Engineering Excellence Award) partnership with Caledonian Alloys.

As part of the strategy to create new markets through spin-out companies, the impact of NiTech Solutions Ltd (enabled by two **SMART awards**) and Aquapharm is described in the respective REF3b documents. In addition, activities in ***Biological Chemistry*** have led to the recent formation of Edinburgh Biosciences Ltd to exploit biophotonics technology developed in HWU. This venture is also supported by a **SMART award**, and **MRC 'Confidence in Concept' award**, by Techcomp HK (an Asian technology company) and private investors. **Scottish Enterprise Proof of Concept** funding for biomedicinal work in ***Molecular Chemistry***, jointly with Strathclyde, is paving the way to a new drug-discovery spinout company.

Impacts on local businesses (e.g. Charles River Laboratories and the thriving start-up, Solid Form Solutions) are achieved through commercial use of our specialist analytical facilities. Single-crystal (>80 structures solved in REF period) and powder X-ray diffraction, and NMR spectroscopy (>900 spectra) are heavily accessed. A notable example of impact is nomination of Organon/Schering Plough/MSD for a Scottish Enterprise Life Sciences Award (2010), and award of an earlier RSC Malcolm Campbell Memorial Prize, for the pharmaceutical 'sugammadex', whose challenging structure was first determined by XRD at HWU.

We deliver substantial societal impact by raising awareness and understanding of science through multi-stranded outreach activities. We have a well-established Schools Outreach Programme, delivering lectures on >160 occasions in >140 secondary schools directly to >7,500 pupils and >310 teachers across Scotland and northern England in the REF period. A primary aim is long-term engagement with teachers to support the motivation of pupils to study STEM subjects at University, which we further achieve through an annual residential Teachers Study Week, refreshing the enthusiasm of the participants (>80). Separately, we target major public scientific exhibitions, including the Edinburgh Science Festival, particularly through the Stars 'r' Us exhibit (see REF3b). Other examples include repeated *Get SET* events; *Biological Chemistry* activity highlighted at an ESRC Genomics Policy and Research Forum (2012); two bi-annual Royal Society of Edinburgh Masterclasses on 'Chemical Cluedo' and extracting DNA using kitchen chemistry; and a high-profile TED Global event, with hands-on experiences and other mechanisms to expose the research to the public.

c. Strategy and plans

Link to staffing and research strategy

Since RAE2008, our staffing and major-investment strategy has been strongly focussed in specific priority areas, recognising the potential for KT growth. We are addressing challenging

interdisciplinary questions related to national and international priorities of economic growth, security of supply of energy, health and quality of life and environmental integrity, in particular by establishing ***Biological Chemistry*** and the participation of ***Materials Chemistry*** in the CAESAR Materials for Energy initiative. These and other areas with strong potential to deliver impact will participate in the planned further expansion of staff (as described in REF 5).

Staff development and Institutional Support for Impact

HWU has a long tradition of working with industry. In 2009 it revolutionised its model for knowledge exchange, expanding on the traditional existing research-funding and technology-transfer unit, Research and Enterprise Services (RES). The overall HWU package, reinforced with additional support and resources from research-pooling initiatives, including ScotCHEM, provided £6.2M of investment over 4 years. Expert support in the delivery of impact is now provided by the two dedicated business-engagement staff who are embedded in this UoA. They work alongside industry professionals who provide expert licensing and new-company support. This has created a simple and desirable single pipeline to enable the flow of knowledge and expertise between researchers and users. An innovative aspect has been HWU leadership of a pan-Scotland 'Converge Challenge' programme to create market-facing entrepreneurs. This has provided residential training to 90 staff annually from all the Scottish universities, with webinars attended by >1,400 researchers. The 'Scottish Crucible' programme has been further developed at HWU under Converge. Crucible is a highly successful, professional and personal-leadership and networking development programme initiated by NESTA and in Scotland led by the PVC (R&KT) and other staff from HWU. It won The Times Higher Education "Outstanding Support for Early Career Researchers Award" in 2010. The target group is recently appointed ECRs (6 in this UoA have already participated, with 2 winning follow-up funding) and Research Fellows (also with a high rate of uptake from this UoA). New appointees will be encouraged strongly to engage. Developments at HWU allow researchers to form networks with industrial strategic partners. A successful example is a 6-month industrial placement of a member of staff (Westacott) at Ineos, Grangemouth.

Leverage of external funds and future funding strategy

Hastening the delivery of impact requires external funding, in which we now have a successful track record. Looking to the future, to help ensure continued success, dedicated support staff (Dr Alex Peden for ICS and Dr Grant Sellar for IB3) have been tasked to source commercial collaborators and income for development work. Interdisciplinarity built on a robust central core of chemistry has underpinned recent successful funding initiatives with a strong emphasis on impact, including e.g. an EPSRC IRC formed with Edinburgh and MRC 'Confidence in Concept' scheme for accelerating commercialisation. Further related developments are planned, with partnership and engagement of different audiences, sectors and disciplines continuing to be our focus. As examples, Olympus, Leica and Hamamatsu are funding and co-organising summer schools with us (from 2014) to provide training for European student delegates in biological-labelling chemistry and imaging. EPSRC Impact Acceleration funding (£14k) has been used to enhance the public engagement impact of the Star 'r' Us activity through participation in the Cheltenham Science Festival. Further funds (£50k) have been committed to develop economic and future health impacts of a novel stem cell survival compound, with collaborators at Glasgow.

d. Relationship to case studies

The four case studies selected reflect a range of range of impacts (three economic and one public understanding) from amongst those outlined in (b). In all cases, they sit in a wider context with multiple cross-links between modes by which impact is delivered. This illustrates our agile approach to maximising impact by linking funding from alternative sources. For example, the creation of the spin-out company, NiTech Solutions Ltd, is re-coupled to public funding through an EPSRC Centre for Innovative Manufacturing and to the SFC Spirit Awards scheme. Aquapharm has also re-engaged with HWU through partnering in EPSRC-funded work and an NHS CSO project. There are many strands to drug-discovery developing out of the programme originally funded by Kyorin, including extensive public funding and a (planned) spin-out company. This experience, in particular, has guided our future strategy to be less dependent on the business plans of a single external organisation.