Institution: The University of Huddersfield

Unit of assessment: 8 Chemistry

a. Context

The Department of Chemistry has a long tradition of research with direct economic impact and close interaction with the chemical, pharmaceutical and related industries. Links with major regional companies have always been extremely strong. Our collaboration is both national and international, and the research is focussed on areas of industrial, economic and environmental significance.

There has been major investment in the Department of Chemistry over the assessment period which, following previous long-term investment, has delivered state-of-the-art research infrastructure and enabled the recruitment of new staff, at both early research career and established professorial levels. Several have strong industry-facing profiles, including **Gill** (formerly AstraZeneca) and Sweeney (Royal Society Industry Fellow 2009-2011 and 2011-2013). In another example, Heron and Gabbutt joined in 2011 from the Department of Colour Science in Leeds, bringing research with direct industrial application and funding (Essilor and QinetiQ).

The policy to direct research to the needs of industry is further illustrated by IPOS (Innovative Physical Organic Solutions), a research unit founded in 2006 in the Department of Chemistry. Major expansion of IPOS followed the award of European Regional Development funding (£3.6M) in 2008. The unit is run by Atherton (who joined from ICI/Zeneca/Avecia) and Page, together with Powles and Stirling (both formerly Syngenta). Research is conducted in process chemistry for industry alongside more fundamental research related to industry's long-term needs (£600k pa). Successful collaborative projects have been carried out with over 150 companies, over 70 of which have been SMEs, with the majority being in the Yorkshire/Humberside region. Through this work, IPOS is making a significant contribution to the growth of chemical and related industries in the region.

Research in the Department is concentrated in three Groups:
Synthetic and Physical Organic Chemistry (incorporating **IPOS):** Sweeney, Page, Atherton, Laws, Hemming, Moran, Gill, Heron, Gabbutt, Powles, Stirling;
Materials and Catalysis: Brown, Cooke, Parkes, Lamont, Panchmatia;
Supramolecular and Structural Chemistry: Rice, Elliott, Gillie, Harding, Patmore.

Work from the all three Groups is directed towards socio-economic impact. Examples include Page's research in physical organic chemistry which has attracted 5000 citations over a 30 year period and which, in part, has led to the establishment of IPOS. Brown and Parkes' work on porous and catalytic solids has involved Johnson Matthey, Dstl, QinetiQ, BAT, and MEL, mainly in efforts to improve product performance. Other work in synthetic and pharmaceutical chemistry has involved a combination of pure research and research directed towards the fine chemicals and pharmaceutical industries. In this area, Sweeney is working with the pharmaceuticals sector and UK academics on a strategy for leveraging value from academic research for biomedical targets. In line with this, he is also a member of the steering group for the EPSRC Grand Challenge, Dial-a-Molecule.

b. Approach to impact

Overview: the Department encourages and supports research activities which have relevance to industry and society. We regularly evaluate the relevance and impact of all of our research activities. This is done both on an informal basis and formally through annual staff appraisals which incorporate a section on research plans and expected outcomes, including intended impacts, with a mapping of individual plans onto Departmental strategy. The main strands of our Departmental strategy include the following actions.

1.Recruitment: staff recruitment is dependent on their potential to develop research programmes that are timely, capable of generating impact and compatible with the facilities and current programmes in Huddersfield. Since 2011 we have recruited six new members of staff, including a

Royal Society Industry Fellow (Sweeney) and a Royal Society University Research Fellow (Patmore).

2.Working with Industry and Business*:* collaboration with industry is a major theme for the Department. Some of this is through IPOS (described above), incorporating extensive collaboration with staff in the rest of the Department. A dedicated Business Development Officer facilitates links with industry, directly and via local, national and international networks. The University financial model for externally-funded projects is specifically designed to facilitate collaborative research projects and a number of university funding programmes are readily available to pump-prime speculative projects, for example the Collaborative Venture Fund. Another initiative is the 3M Buckley Innovation Centre (3MBIC http://hud.ac./n7), which opened on campus in 2012. This £13M facility is funded by ERDF, Kirklees Council and the University. It allows access to University expertise/facilities for regional companies which establish offices and labs in the Centre. In our case, we are in discussions with several companies who could benefit from our capabilities in all areas, including synthesis, analysis and materials characterisation. In the last of these, links with the School of Engineering mean the University can provide a range of techniques to companies, on macro-, micro- and nano-scales.

Current directly-funding project partners include Johnson-Matthey, Agilent, ACAL, Fuji, Syngenta, MEL Chemicals, Solvay, Dstl, Essilor, QinetiQ, AstraZeneca, GSK and others. Schemes such as the Knowledge Transfer Partnerships (KTP -TSB) are strongly favoured. KTPs have been held over the assessment period with Yorkshire Water and Burmatex. CASE projects are currently held with GSK and AstraZeneca.

3.*Impact mentoring:* all researchers are given support to ensure impact is central to their work. New staff are provided with a research mentor. All staff generate a personal Research Development Plan as part of the appraisal process in which the potential impact of planned research is considered.

4. *International Advisory Board (IAB):* in 2012 we established an International Research Advisory Board for chemistry research, made up of academic and industry partners, which meets regularly, through Skype or video conferencing. The remit of the IAB includes providing an assessment of the Department's impact strategy. Membership: Prof R Grubbs [Cal. Tech.], Prof H Kroto [Florida State], Prof W Jones [Cambridge], Dr J Casci [Johnson Matthey], Prof D MacMillan [Princeton].

5. PhD funding: the Department has a policy of matching industry funding for PhD studentships. This has led to a string of productive collaborations with external companies, with funding increasing over the census period. In addition, typically four full studentships are awarded by the Department each year and the criteria used to award these include the potential for socio-economic impact from the project.

6. Public engagement and awareness: the Department has a history of engagement with local and national communities. From STEM activities (five staff are STEM ambassadors) to direct engagement with local schools and colleges (all our staff deliver lectures in local schools), to engagement with national educational policy and activities (e.g. Sweeney**:** *Skills Needs of the Chemical Industry* [Salters' Hall 2013]), the Department is committed to outreach and public engagement. We are proud of the Department's Public Lecture series (http://hud.ac/s) in which a wide range of topical subjects are presented in an accessible manner to audiences of regularly up to 250, including students from local schools.

c. Strategy and plans

Overview. The Department's impact strategy is to continue to encourage and promote impactful research, in line with the approach described above, and to develop new research activities in fundamental science which will have a significant socio-economic impact. Exemplars of future strategy are:

1.Translational Catalysis: an initiative is under way to bring together physical chemists and

synthetic chemists from the three Research Groups to work on long-range catalytic processes for industry end-users in pharmaceutical and fine chemical synthesis. Directed by Sweeney**,** the research plans and target reactions/syntheses are being guided by a steering group (from Merck, GSK, Pfizer, Peakdale Molecular and AMRI). Its objective is to provide a mechanism for the study of reactions of potential significance to industry. Companies will submit 'problem' reactions (based on, for example, lack of substrate scope, incomplete mechanistic understanding, or cost-ineffectiveness), and we will analyse the reactions with a view to developing catalytic processes fit-for-purpose. This will generate research outputs (an example might be in the mechanism of Heck reactions of aromatic heterocycles which is still a poorly understood area) with resonance/impact in a GDP context.

2. Innovative Physical Organic Solutions: the success of the Innovative Physical Organic Solutions ('**IPOS**') unit (http://hud.ac/n8), supported initially by ERDF, will be consolidated and developed further. Based on the same modus operandi, the objective of IPOS to provide expertise to industry will remain, and industry-funded projects will continue as the core of its activity. Integration of research projects and shared PhD student supervision with the wider Department will continue, and will be used as leverage for longer term external funding. IPOS will continue to be a centre for fundamental research, particularly in physical organic chemistry and biological chemistry. Management succession, through Powles and Stirling, will ensure that these themes remain central. Key to progressing will be strengthened inroads in European projects. Strong collaborative links already exist as the basis for this movement and the platform is now in place for directing significant effort to joint projects.

3. Researcher Mobility Programme: as part of a general objective to stimulate collaborative research, the Department has implemented a policy to encourage researchers working in appropriate areas towards secondments/placements with industry partners, with the aim of establishing collaborative research programmes. The Department will support a limited number of staff to spend up to 20% of their time embedded in partner companies, to be funded through the University and other agencies (such as the Royal Society).

d. Relationship to case studies

The research underpinning *"The Impact of Physical Organic Chemistry Research at Huddersfield"* has occurred continuously throughout the period since 1993 and continues today. Collaborative research with industrial partners has been a major focus of the work throughout and has been encouraged and supported by the Department in line with the approach to impact described above. Full and 50% studentships have been awarded regularly for projects in this area on the basis of potential for impact. Regular Departmental investment in staff, equipment and facilities has provided continuity. A direct consequence of the industry engagement in this area of work, and in particular the very close ties with Syngenta and Avecia, led to the establishment of IPOS in 2006, through which a large part of the cited impact has been generated. Impact has been with a range of industry end-users, in biological and medicinal chemistry, catalysis, fuel cells and other areas where IPOS has been able to bring expertise to bear. The establishment of IPOS has greatly increased direct engagement with industry end-users and has had direct influence on operations and profitablity in industry, especially in the Yorkshire/Humberside region.

The second case study*, "New Thermal Methods for Materials Preparation and Characterisation"* is based on long-standing research in Huddersfield in this area. Since 1997 there has been a critical mass of researchers in thermal methods for both materials synthesis and materials characterisation, and it is the expertise in this niche area that has brought collaborators to us. The Department has supported the area with studentships, with strategic staff appointments and with very substantial investment in instrumentation and labs. Major companies such as Johnson Matthey, Dstl and QinetiQ have established long-standing relationships with us and have provided significant funding which, with Departmental and EPSRC support, has underpinned the major research effort in this area. In return, the research has made a substantial contribution to the work and profitability of these partners.