Institution: The University of Manchester

Unit of Assessment: UoA08 Chemistry

a. Context

Main non-academic user groups and beneficiaries

UoA 8 has the potential to Impact widely on society in health, energy, transport, environment, food, communication and consumer products. The UoA, with a very diverse range of research activities, has Impact right across this spectrum. Most directly, the UoA works with the chemical industries, both nationally and internationally, to discover and develop new products, to understand how products work, and to provide the academic foundation to exploit full potential. The UoA also works closely with government agencies that set the legislative framework for the development of new capability and mitigate risks associated with both new and existing technology. The UoA has an extensive outreach programme, both to work with children and adult audiences in order to educate the wider population and also to attract the best and brightest young scientists into the profession. The beneficiaries include patients requiring new drugs; consumers requiring a cheap, safe and sustainable energy and food supply in a healthy environment; young members of society that will be drawn into employment in an industry of vital significance to the future UK economy.

UoA research in relation to Impact

There are a number of specialisms within the UoA where major Impact has been and continues to produced. The activities in nuclear research are of strategic importance and are the most extensive within any UK university. These are having particular Impact on legislation, risk mitigation and safety within the nuclear industry and on public perception. There are also significant programmes in chemical biology, biotechnology and biocatalysis that are feeding into new methodologies in drug design. Similarly, the School is very strong in aspects of materials chemistry that have particular Impact in the fields of optoelectronics, molecular magnetism and solar energy. This will be boosted in the forthcoming REF period by major developments in graphene chemistry research in the UoA and the opening of the National Graphene Institute in Manchester. Research in analytical and physical methods including NMR, EPR and mass spectrometry has produced Impact in the areas of instrument development and analytical methodologies.

b. Approach to impact

Our approach to Impact is on four fronts, each of which presents different opportunities:

- a collective approach to commercial exploitation with industry;
- industry-specific Impact;
- an individual, ad hoc approach to generating Impact;
- Impact through outreach and public engagement.

These are discussed through the following examples.

A collective approach to Impact

The Centre of Excellence for Biocatalysis, Biotransformations and Biocatalytic Manufacture (CoEBio3) is a model for the collective fostering of industrial interactions in order to generate Impact. CoEBio3 is an outward-facing centre of excellence set up in 2004 and provides an extremely effective mechanism for establishing new industrial contacts. For example, CoEBio3 operates a research club whereby companies subscribe for a three-year membership that funds PhD studentships and gives them access not only to the knowledge generated, but also to the biocatalysts developed within the Centre (subject to material transfer agreements). The membership fee depends upon the size of company: £40k per annum for large; £20k for medium; £5k for SMEs. The membership fees are used principally to fund PhD students; by the end of the current phase a total of 35 students will have been trained via this direct mechanism within the research groups of 10 academic staff. Follow-through is ensured as companies pick up specific parts of the research and enter into confidential collaborations. One example here would be BASF, with whom a number of patents have now been filed, and another GSK, who have contributed to a recently funded £5M BBSRC sLoLa (Strategic Longer and Larger) award. Agility of approach has been inherent in the whole CoEBio3 philosophy from the outset, with critical mass, infrastructure and an unconstrained working environment permitting quick turnaround. This model was particularly apparent in its largest industrial contract (£3.5m) with Shell. This took one year to

put in place, requiring tough negotiations that, without the infrastructure of CoEBio3, would have been impossible to secure. A similar approach has been adopted with the plethora of large EU projects that require a real team approach to problem solving. One Impact Case on the development of a generic drug, that has not been returned at this REF round due to its stage of commercialisation, was developed not through the Club route but through company contacts developed as a result of the reputation of CoEBio3, again indicating the importance of size and visibility. UoM has been key in providing support for CoEBio3, from the funding for the Manchester Institute of Biotechnology (MIB) building that houses the Centre and many world-class facilities, to the provision of multiple academic appointments that give critical mass. UoM Intellectual Property (UMIP) management and commercialisation company has been fundamental to securing and exploiting patents. Staff are able to concentrate on Impact-related activities by a reduction in their teaching commitments to allow time for the preparation and management of projects. The highly creative environment of CoEBio3 has resulted in the development of key staff able to take on more senior positions in similar ventures within the university.

In a similar vein, the Knowledge Centre for Materials Chemistry (KCMC), established in 2008, is a virtual centre of expertise that brings together mutual interests in materials chemistry from the Universities of Manchester, Liverpool and Bolton and the Daresbury Laboratory of the Science and Technology Facilities Council. A Business Manager is employed by KCMC within the School to identify industry needs and match them with the expertise of the staff within the Centre, and also a Knowledge Exchange Fellow markets knowledge generated within the Centre to industry. This synergistic technology push and industry pull maximises the potential Impact of the Centre. KCMC has a steering group with representation from 10 companies helping to develop a clear understanding of industry needs and facilitating close links with the KCMC academics. The KCMC is supported by the University through UMIP helping to protect IP but also providing funding for driving exploitation through a Proof of Principle (PoP) scheme. For example, UMIP has helped to broker license deals for discoveries of polymers of intrinsic microporosity and contributed PoP funding for the development of new methods for making organic semiconductors, novel biocidal polymers and conjugated polymer nanoparticles leading to their licensing. Further support for KCMC is provided by the University through a £90k per annum contribution to the Chemical Innovation Knowledge Transfer Network. This supports the activities of the knowledge transfer team and underpins the Centre's infrastructure in terms of equipment and staff. The critical mass and infrastructure provided by this approach permits an agile response to opportunities and has led to over 100 industrial projects in the Centre since 2005, numerous (>10) EPSRC and TSB grants and several Framework 7 programmes. A fast response to opportunities is also provided by the ability to provide laboratory space for start-up companies and the employment of post-doctoral scientists to work specifically on industrial contracts. Goods and services at a level below £25k can be signed off without escalation enabling quick project decisions. Staff within the KCMC that are extensively engaged in Impact activities are given reduced teaching and administration duties in order to encourage and facilitate the work.

Industry-specific Impact

In response to the lack of trained radiochemists within the UK who could respond to the present and future demands of the nuclear industry, the University of Manchester won a competitive bid from BNFL in 1999 to establish a Centre for Radiochemistry Research. With a further substantial injection of funds from the University of Manchester and Government, the infrastructure, equipment and four academic appointments were set up. The unique capabilities of the Centre have led to Impact in chemical research, risk mitigation and on Government policy, in particular, in nuclear decommissioning. The School has further strengthened the Centre such that there are now 8 full-time academic staff. Recently, the Dalton Cumbrian Facility, which provides gamma ray and accelerator sources to simulate nuclear irradiation, has been established, with the appointment of a further 3 staff. Staff within the Centre sit on a variety of high-level advisory panels (UK Government: Committee on Radioactive Waste Management; Cabinet Office Scientific Advisory Committee; Nuclear R&D Advisory Board; and ONDRAF (Belgian Nuclear waste disposal organisation Expert Advisory Group) and their expertise, acquired through basic research, is being translated into national nuclear programmes and Government policy both in this country and overseas (plutonium management; UK nuclear R&D roadmap). Further basic research, both practical and theoretical, within the Centre is being adopted to transform methodology within the

nuclear industry (for example in the clean-up of nuclear fuel storage ponds and contaminated land, and in geological disposal in the UK and overseas). Such Impact is very specific, but also has important consequences for one of the largest industrial sectors in the UK. Our nuclear research is flexible, allowing rapid response to emerging needs and opportunities. For example the bid for the recently funded £1.2M Sellafield Decontamination and Effluent Treatment Centre was put together with a two-month turnaround.

The UoA has made two recent appointments which have been co-funded with leading instrument manufacturers. Waters have supported a Chair in Mass Spectrometry (2013) and Bruker a Senior Lectureship and Applications Scientist in EPR (2012). In addition to the funding, the staff also have access to the research and development laboratories of the companies enabling then to participate and contribute to cutting-edge activity in commercial instrument development.

Individuals developing Impact

Most academics within the UoA do not work directly within one of the larger entities described above, and therefore Impact generation is often on a much more ad hoc basis. 15% of our publications during the REF period have involved industrial co-authors which is one indicator of the extent of industrial engagement. UMIP is very active in helping to deliver such new Impact through Proof of Principle (PoP) awards, and this has led individual academics to develop and licence new materials technology such as the production of graphene and new porous polymers for gas separation. In all these applications, patent authors are rewarded through a very generous percentage >85% of net income from commercialisation going to investigator to act as incentive. In the case of the development of porous polymers, the researcher (Budd) was given a one-year sabbatical in order to drive through the Impact and this activity was instrumental in his recent promotion to a Chair. Such ad hoc development of Impact is an important route, and the School works closely with UMIP, through an embedded staff member, to ensure that staff are both alerted to such opportunities, and supported in their exploitation. Impact and IP training is also included in the New Academics Programme of the University.

An example from one of our submitted Impact Case Studies discusses the development of nuclear magnetic resonance (NMR) techniques and computer software for diffusion-ordered spectroscopy (DOSY). These are now incorporated within commercial NMR products, and directly influence the development of products from drugs to flavourings. The impetus to develop this family of techniques came from an unrelated collaboration between the academic, Gareth Morris, and Pfizer Global Research. Pfizer described the problems they were encountering in the NMR analysis of tissue extracts from gerbil brains. Professor Morris immediately realised that a type of technique he had previously considered working on, but rejected, could solve their problem, and he was encouraged (and funded) by Pfizer to work on its implementation and testing. The subsequent development of DOSY software for the proprietary operating system of a major NMR manufacturer gave both the opportunity to exploit the intellectual property generated, and an effective vehicle for disseminating the results to a wide range of users including many industrial research organisations. Key to this Impact were the School policy of maintaining shared high-resolution NMR facilities, and the assistance of UMIP in negotiating software licensing.

Outreach and public engagement

Our outreach work is directed at generating Impact in the 'society, culture and creativity' category. Evidence of scope, reach and intensity comes from our log of events (ca. 400 events over the 5-year REF Impact period, reaching over 66,000 people directly through live lectures and hands-on science events, leaving aside media Impact). For example Louise Natrajan's hand-on lectures on luminescent lanthanides at festival events such as the Manchester Science festival and the Jodrell Bank Summer Science Festival have reached over 7,500 members of the public. Nick Turner's accounts of Designer Enzymes, that successfully convey the concept of chemically modified enzymes to children and their families, have reached over 5,400 participants. Sabine Flitsch and her group took part in the 2013 Royal Society Summer Exhibition showing their latest research about sugars and glycomics (Sweet Success) which could provide answers to a range of problems, ranging from disease to clean energy. This has led to the development of an on-line game called "Cell Invaders". Our popular 'Flash-Bang' shows, which include discussions on hydrogen as a fuel and work on porous polymers, have reached over 40,000 people. O'Brien, whose outreach work in both the UK and Africa has been recognized by the 'Colin Humphreys' award of the Institute of Materials, Minerals and Mining, has reached over 3,000 people through hands-on nanoscience

and media events discussing his work on nanoparticles (part of our Nanoco Impact Case). The main reason this robust effort did not result in a specific Outreach Impact Case Study was the challenge of credibly linking such work to individual outputs, rather than general research areas. Over the upcoming REF period we intend to increase yet further the proportion of our Outreach activities that are directly relevant to our own research activities, so that a case that better reflects the importance we place on this area can be made.

c. Strategy and plans

The UoA has developed a very strong mechanism for delivering Impact that has been exemplified in part (b) and much of our future strategy will rely on building upon and fostering this strong foundation. This will be focussed around educating staff in the process of generating Impact and much of this is already available through the current University mechanisms including weekly drop-in sessions in the School and a range of specific courses on IP and commercialisation organised by UMIP. Personal Impact programmes for researchers will be reviewed as part of the annual staff Personal and Development Review process in order to identify Impact and ensure that the necessary support mechanisms are in place to maximise Impact potential. We will grow our income from knowledge transfer and translational research over the next 5 years and this will be facilitated by forming strategic industry partnerships and leveraging our links through, for example, the BP-ICAM and the National Graphene Institute. We will develop closer links between the Faculties of Life Sciences and Medical and Human Sciences in order to further our Impact in the area of Chemical Biology and Medicinal Chemistry. Our future Impact strategy is based upon the following seven principal drivers to Impact:

- recognise the importance of Impact and Public Engagement in staff management and progression;
- use appropriate training to improve awareness of how to achieve Impact;
- improve participation in training in IP and Copyright;
- understand competitor analysis - how do others succeed and why?;
- make sure all are aware of sources for funding – UMIP, PoP, and beyond;
- celebrate and study success;
- understand how the markets for IP and ideas actually function.

These are the principles that have been engendered within our highly successful spin-out company Nanoco that develops next-generation quantum-dot technology and has led to a current market valuation in excess of £350m.

d. Relationship to case studies

Case 1 Selectfluor preceded our current support mechanisms.

Case 2 Nanoco benefitted from the expertise at UMIP for licencing.

Case 3 C_{60}-SIMS benefitted from the expertise at UMIP for patent development.

Case 4 Nuclear benefitted from infrastructure and appointments made by the University.

Case 5 DOSY benefitted from the expertise at UMIP for licensing, and access to shared high-resolution NMR facilities.

Case 6 OMIC benefitted from the expertise at UMIP for patent development, PoP funding and licencing. The University support provided to infrastructure and cash injection to the Chemical Innovation Knowledge Transfer Network.