Institution: Newcastle University

Unit of Assessment: UoA 8 Chemistry

a. Context

The incorporation of impact into the unit's research strategy has resulted in significant achievements over the last 10 years. A major change has been the engagement of research staff in impact-related exercises; this has resulted in greater impact and has helped facilitate the securing of extra funding, thereby maximising the opportunities to generate further impact. The research activities of the unit at Newcastle University (NU) embrace both fundamental and applied aspects of chemistry, with overall impact being assessed through; benefit to the scientific community, translation to biomedical applications and commercial success. Impacts emanating from the unit's activities are predominately manifested as industrial collaborations. The main vehicles are; licence agreements and spin-out companies, the provision of advice to industry, education and training and medical advances. For instance, we hold license agreements which centre on catalysis-based and anticancer drug discovery groups, while interdisciplinary educational and spin-out activities are found throughout the unit. Impact is exemplified within the area of anticancer drug discovery and imaging, with patient benefit being the ultimate goal, and the potential industrial impact of small-molecule *X*-ray crystallography (as detailed in the case studies). The unit has collaborated with the Northern Institute for Cancer Research (NICR) for over 23 years. This multidisciplinary collaboration provides a clear pathway for the unit's outputs into the clinical area. The anticancer medicinal chemistry group (Cano, Hardcastle, Golding and Griffin) liaise extensively with colleagues within the NICR, with the objective of developing novel cancer therapeutics. X-ray crystallography research (Clegg) has led to the establishment of beamlines dedicated to small-molecule diffraction at the Daresbury and Diamond facilities, and both have been widely utilised by commercial users, leading to impact in diverse areas of chemistry.

b. Approach to impact

Supporting Infrastructure: Our Research Committee and Head of Unit (Green) support staff to prioritise key areas of research leading to impact. The Head of Unit has more than three decades of industrial experience, he represents the University within the North East of England Process Industry Cluster (NEPIC) which addresses various aspects of industrial chemistry, and is a committee member of the Industrial Division of the Royal Society of Chemistry (RSC) where he provides advice to staff on commercial aspects of their research. At 6-monthly Performance Development Reviews (PDRs), the Head reviews impact activities with staff and assists in setting impact-related objectives.

Industrial Contacts: In 2006, the unit in collaboration with UoA12 (Aeronautical, Mechanical, Chemical and Manufacturing Engineering) established an Industrial Advisory Board (IAB). This comprises senior members (typically VP level) of multinational companies which include Avecia, SABIC, BP, AstraZeneca, Croda, INEOS, JM, GSK, Davy Process and Pfizer as well as the CEO of NEPIC and the CEO of the Centre for Process Innovation (CPI). The purpose of the group is to ensure that chemical research at NU is brought to the attention of appropriate companies and that NU's research aligns to their needs. Interactions with the IAB have resulted in a collaborative agreement between the NICR Medicinal Chemistry Group (Griffin) and Pfizer, which involves Pfizer graduate chemists conducting research placements in Newcastle as part of their work-based PhD. The CPI collaborated with NU chemists in the establishment of a spin-out company (Dymeryx).

Collaboration with Engineers: A successful 'conductive nanomaterials' collaboration between the unit (Houlton/Horrocks/Fulton/Pike/Tuite), Electrical Engineering and UoA12 in 2008 resulted in a Regional Development Agency grant of £1.7M for an interdisciplinary research centre. The resulting Chemical Nanoscience Laboratory (CNL) is a translational research centre that assists in the development and exploitation of new nanoscale materials, and undertakes fundamental and translational research in chemical aspects of nanotechnology. The CNL facilitates the development of academic-industrial partnerships and drives basic research through to exploitation. The activities of the CNL have included: (i) interdisciplinary research, partnering with industry to develop new technologies, (ii) training of scientists and engineers for the next generation, and (iii) providing external companies with access to state-of-the-art facilities.

CNL has worked with 14 companies to date, including Intel, Pfizer, Akzo Nobel, Croda, INEOS and Johnson Matthey and has secured a Knowledge transfer partnership with Alphasense. The CNL is a partner in two EU consortia; LAMAND (which includes Intel) and NanoEmbrace (ITN network on materials). The CNL has established a long-term relationship with QuantuMDx, a medical device SME, who rent space and pay for access to instrumentation, and with whom the CNL has initiated joint research projects worth £1.3M.

Expert Support Team within the University: Research and Enterprise Services (RES) at NU provides advice on aspects of impact and commercialisation. This includes assistance and financial support for IP protection and licencing, and third-party negotiations. Within the period eight patent families have been filed based on the unit's research and the resulting IP licensed. For example, the unit has signed a licencing agreement to commercialise its work on the use of microbial DNases (Hall) for the disruption of mixed species biofilms.

Direct Support for Staff: The unit maximises the impact arising from its research. For example, the development of spin-out companies is facilitated through the provision of laboratory space, technical support and analytical facilities. Academic staff engaged in spin-out activities are also assigned reduced teaching and administrative loads. To date, five spin-out companies are operating as a result of chemistry research conducted at NU, in the areas of custom synthesis (*NewChem*, Golding), medical imaging (*Nimasol*, Carroll), CO_2 chemistry (*Dymeryx*, North), DNA synthesis (*NUNA Bio*, Tuite and Pike) and nanomaterials (*Newcastle Nanomaterials*, Pike, Houlton and Horrocks). In addition to the employment of chemists and management staff, these companies have had a direct impact on the success of their clients and customers.

Research Collaboration with Industry: The unit maps its impact to the needs of its customers. Some examples are:

- Catalysts developed by Doherty and Knight have been licensed to Strem for general sale in their chemistry catalogue.
- Higham was awarded an EPSRC Knowledge Transfer Account (KTA) to commercialise his research with High Force Research, in the area of new phosphines.
- Horrocks was awarded a KTA with South Tees NHS to develop silicon quantum dots as cancer diagnostic agents.
- The NICR Medicinal Chemistry Group are members of a multidisciplinary team that has recently entered into a five-year multimillion pound alliance with Astex Pharmaceuticals, for the clinical development of anticancer agents.
- Christensen works with Nissan and Smith Electric Vehicles on the safety of lithium battery technology.

Impact in the Public Sphere & Press: The unit publicises its research to the wider community (beyond the normal academic channels) *via* the School website and the University press office website. For example, Hall's work on the use of NucB from seaweed in toothpaste attracted global press coverage in July 2012, including the BBC World Service and World TV News, the Radio 4 Today program, and several major national and overseas newspapers. The research on the clinical development of PARP inhibitors as anticancer drugs (Griffin and Golding) featured in the Daily Mail (June 2011) and Chemistry World (August 2011). In July 2012, Harriman and Benniston's work appeared as a research highlight in Chemistry World. The installation of a Sir Bobby Robson Foundation funded cyclotron within the unit featured on the BBC News in August 2012.

Engagement with Secondary Schools: The unit sees the promotion of scientific activities within local schools as a long-term investment in the future of chemistry research. In 2009 it appointed a full-time outreach officer (Hoare) and raised £200k for a dedicated chemistry outreach laboratory, which offers school pupils the opportunity to gain experience of contemporary chemical research being carried out at NU. This is part of the unit's dissemination of cutting edge science to the local school sector in a format that is accessible and interesting to both pupils and parents alike. Outreach activities in the period have enabled the unit to interact with over 20,000 school pupils.

International Advisory: Members of the unit serve on national and international committees to ensure that their expertise makes an impact on the wider chemical community. Through their positions, staff from the unit have driven changes to the policies and governance affecting the discipline. Examples include:

- Green served on RSC council (2007-11).This resulted in a change in policy in relation to RSC members and the governance of the society
- Errington sits on Dalton council and Griffin is a former committee member of the RSC

Chemistry Biology Interface Division (CBID).
- Harriman leads the RSC roadmap initiative on photochemistry.
- Clegg is chairman of the Diamond User Committee since 2011. This has led to increased use of the cyclotron facility by international industry as well as its duplication in the USA.
- Griffin is a former member of the Cancer Research UK Science Funding Committee and the Chemicals, Pharmaceuticals and Standards Expert Advisory Group of the Medicines and Healthcare Products Regulatory Group (MHRA) ensuring research funding is effectively generated and targeted.
- Fulton and Hall have participated in the Royal Society's scientist/MP/civil servant pairing scheme to facilitate the transfer of knowledge between the unit and the UK government.

c. Strategy and plans

The future strategy of the unit involves the following:
1. The development of strategic research themes. This will be done in collaboration with our existing and potential external partners. We will utilise our substantive academia-industry forums such as NEPIC to ensure this.
2. Once identified the unit will undertake strategic investment in these areas, through the appointment of new staff and investment in capital stock and equipment. In particular, the unit will invest in staff able to enhance our academic capabilities in areas where need has been identified and put staff in place who will manage impact specifically.
3. The unit will use its existing highly connected staff as the base on which to build more robust academic-industrial networks. These networks will be both a vehicle for impact and a seed-bed for new industry-led collaborations and impacts. To date, negotiations have already resulted in several research collaborations.
4. Recognising the international nature of its discipline, the unit will target collaborators in fast growing economies such as Brazil, India and South Africa to facilitate international impact.
5. The unit will adapt its workload model to encourage impact activities, this will: (i) enable those staff who have successful commercialised discoveries to act as mentors for less experienced colleagues, (ii) foster better industrial interactions by giving staff reduced workloads to prepare Knowledge Transfer Partnerships and Technology Strategy Board projects, (iii) increase the number of appointments of key industrialists and high-level visiting Professors to the unit.
6. The unit will build new (predominately European) cross disciplinary research groups to create new pathways to impact and facilitate the uptake of its research.
7. The unit will use its key facilities as the base of new collaborations, for example the cyclotron and the shared NHS facilities available through the Institute of Cancer Research. Collaborations will be used to drive impact on novel therapeutic areas in the treatment of cancer.

d. Relationship to case studies

ICS 1 The provision of novel compounds for the healthcare industry via the Newcastle University based company NewChem: Research in this case study resulted in the development of novel compounds of medical significance to the pharmaceutical industry. The success of the relationship between the unit and NewChem, a Newcastle based SME, has demonstrated that the spin-out pathway (which has now been adopted) for commercialisation of our other biomedical research is effective.

ICS 2 Development of the first-in-class poly(ADP-ribose) polymerase-1 (PARP-1) inhibitor Rucaparib for the treatment of cancer: This study exemplifies the success of close collaborations with the Medical School and the pharmaceutical industry which has led to an expansion in our work in the medical-chemistry field. It illustrates the importance of collaborative, multidisciplinary, multinational and multiagency research to find novel solutions for the treatment of several cancers.

ICS 3 International synchrotron facilities for crystal structure determination: The development of international facilities has led to increased activity in the field of crystallography. This case illustrates one way in which our work is impacting on industrial and medical developments.