Institution: University of Oxford

Unit of Assessment: 8. Chemistry

a. Context

Oxford Chemistry takes a highly proactive stance towards commercialisation opportunities, collaborations with industry and the public sector, and engagement with the general public and schools. Our impact ultimately arises from our high-quality fundamental research, coupled with a strong desire to educate, and to translate our skills, beyond academia. We aim to contribute to addressing global challenges in e.g. healthcare, energy, environment, security, food supply and the economy. Through public engagement work we publicise and bring greater understanding of the important contributions that chemistry makes to society to the wider non-scientific population.

Commercialisation: Through our successful spin-outs, products, patents, and licences, we contribute to the health of the local and national economies, and pioneer new technologies and products for industry and healthcare. **Industrial and Public Sector Collaboration**: Our industrial partners are diverse including major companies in the chemical, pharmaceutical, specialist materials and thin films, energy, petrochemicals and fuel additives, agrochemical, fragrance, healthcare technologies, analytical, electronic, cosmetic, food, automobile, and instrumentation manufacturing sectors. We also have strong collaborations with the NHS and other public sector organisations. These collaborations, together with the expert consultancy and advice we provide, and bespoke synthesis of reagents/technical services we supply, lead to enhanced business viability of companies and organisations, the development and adoption of new technologies, and the sale of new products. **Engagement with General Public and Schools**: A strongly interactive programme based on our research is exemplified by activities such as audio trails in the University's internationally-renowned Botanic Garden, lectures for the public and schools, and the podcast series "Chemistry for the Future". **Shaping Strategy**: Our PIs make significant contributions in public policy forums including ethical/legal areas, e.g. biotechnology, genetic engineering for agriculture, and energy futures.

b. Approach to impact

Oxford Chemistry encourages a culture in which making a genuine impact on society is considered important. We support researchers at all levels to maximise the impact of their research and the knowledge arising from it. The Chemistry Management Board (CMB) takes directed action to facilitate impact (allocating specific funding where appropriate) including by:

- Creating new posts to give tailored support for impact; these include 2 full-time Research Facilitators (Chemistry and Chemical Biology), the Publicity & Communications Officer, and a Schools Liaison Officer; 3 of these are new positions since 2008.
- Providing staff with the training/advice necessary to optimise impact from their research (e.g. media training days, IP workshops, courses delivered by industrialists).
- Establishing policy on publicising impact: both internally (e.g. a weekly newsletter) and externally (e.g. Chemistry website news (updated daily) and the annual 'Periodic' magazine).
- Encouraging staff to participate on external boards to enable impact: e.g. industry boards, RCUK, RS and RSC divisional committees, government, Wellcome, and CRUK at research/policy level.
- Public recognition of historical success: 2 RSC Chemical Landmark Plaques were mounted since 2010 celebrating the discovery of the lithium battery cathode material (Goodenough) and the blood glucose sensor (Hill). The ceremonies were used to promote our entrepreneurial culture.
- Leading by example; Davies (Chairman of Chemistry 2006-11) pioneered chemistry spin-outs, including the recently founded MuOx (2012), and is non-exec. director of 8 companies; Softley (Chairman 2011-) has led initiatives such as the science engagement website, Oxford Sparks.
- Setting policy on recruitment, tenure review, and promotion, in relation to impact.

The Commercialisation of Research is supported by both Departmental initiatives and University central services:

- Isis Innovation (the University's technology transfer company) has 3 full account managers assigned to Chemistry; an Isis team member spends (at least) 1 afternoon per week in the Department for PI drop-in sessions. Termly meetings of the OU Innovation Society, run by Isis, give PIs a chance to forge relationships with venture capitalists, industrialists and entrepreneurs.

- Oxford University policy allows PIs to spend up to 30 days p.a. on external activities (consulting, company board membership etc); it also allows a generous portion of IP income due to licensing to come to the inventor, and a generous fraction of equity in a spin-out (typically 40%) enabling and incentivising individuals to obtain financial reward for exploiting research outcomes.
- Provision of courses and workshops both within Chemistry and in the wider university (e.g. Said Business School) to shape researchers' understanding of commercialisation activity.

A distinctive aspect of Oxford Chemistry's strategy is our close relationship with IP Group PLC, started by a ground-breaking contract in 2000. This contract provides for a 50% share of the University's returns from licence deals and spin-out shares from Chemistry to be received by IP Group over a 15 year period (2000-15) in return for their up-front investment of £ 20M in Oxford Chemistry. This external recognition of our commercialisation potential has developed into an active symbiotic relationship with IP Group. Particularly in the early stages of company formation, IP Group helps PIs and their spin-out company managers by providing advice to execute fund raising through their extensive network of investors. £ 14.5M investment (in addition to the original £ 20M) has been secured since 2008 from IP Group for Oxford Chemistry spin-outs. The Chairman of Chemistry meets IP Group board members regularly to identify new opportunities and to sustain the momentum in recognising intellectual property.

During the REF period, the support above has enabled Oxford Chemistry to achieve:

- 253 patent applications filed, with 201 granted to date; 30 technology licences executed leading to commercialisation; 15 examples of sales of advanced materials and novel reagents.
- Active interest of researchers at all levels: 35 of our 84 REF-entered PIs were directly involved with commercialisation activities (disclosures, patents, licences, material sales), including many new members of staff (10 of the 35 appointed in the REF period). In 2013, 45 Chemistry staff or graduate students attended the University's "Building a Business" course.
- Enhanced performance by spin-outs (13 since 2000) through new research in the Department (e.g. > £ 2M re-invested by Oxford Nanopore Technologies in Bayley's research to advance DNA sequencing technology).

Industrial collaborations are of tremendous importance to us, both from basic science and translational aspects. Strategies to encourage impact in this area have included:

- Support to PIs from the two Chemistry Research Facilitators (e.g. organisation of industrial liaison meetings, support for preparation of large grant proposals with links to industry, support for networks such as Oxford Synthesis Connections).
- Support from the Mathematical, Physical & Life Sciences (MPLS) Division Business Development Team (e.g. Healthcare Technologies and Energy Officers) for interdisciplinary industry links.
- Oxford Chemistry Annual Industry Symposium to encourage two-way engagement between PIs and industrial researchers; the 2012 symposium was attended by 8 local major pharmaceutical and agrochemical companies and 30 members of academic staff. We have also held 2 international petrochemical forums with KACST and regular workshops with specific industrial partners (recently Infineum, BP, UCB, Shell, Dow, Samsung, LG, BioFocus). Visits are organised by our 2 Research Facilitators, and supported by Isis. Many new research contracts have arisen from these (e.g. B. Davis, Gouverneur, and Schofield with UCB).
- Membership on the Chemistry Development Board of industrialists from companies such as Syngenta and Ineos and membership of our PIs on boards of 17 companies.
- Provision of analytical services to industrial partners (e.g. Infineum, BP, Nanopore Tech.); the University recently prioritised HEIF funding to establish and fully fund a full-time post to encourage more external industrial usage of Chemistry facilities. This leads to the development of a close relationship with local industrial R&D centres and new collaborative opportunities.
- Consultancy by PIs, supported by Oxford University Consulting, has led to subsequent research agreements (e.g. Perkin with a Formula 1 racing manufacturer and Schofield with Nuevolution). OUC hold annual workshops in Chemistry to raise awareness of opportunities and services.
- We are a major partner in the EPSRC DTCs in Systems Biology and the Life-Sciences Interface, and the Industrial DTC on Systems Approaches to Biomedical Sciences and the BBSRC Doctoral Training Programme; overall, 12 PIs are involved in training, and were also involved in their

formation and management. These all have strong engagement with industry (e.g. Microsoft, GSK, Pfizer, UCB as industrial partners). In developing a new training programme in Synthesis for Medicine and Biology, we have secured substantial financial support (>£ 5M) from industry to enable an IP-free, pre-competitive research collaboration to be established with multiple partners.

- Targeting of EPSRC DTA studentships; priority allocation is given to projects for which partial support for the studentship can be found from industry or government laboratories. Around 25% of the research council studentships have had partial industrial support in the last 3 years.
- Websites in the areas of synthesis, drug discovery, energy and catalysis to promote interaction with industrial and other external partners (e.g. http://oxsync.chem.ox.ac.uk/).

As a result of these strategies, Oxford Chemistry has held >150 industrially funded grants with >40 different companies since 2008, both within and outside the UK, totalling £ 11M. 51 PIs have held a research agreement with industry since 2008, a *ca.* 30% increase over the period (39 in 2002-07). There have been >60 consultancy arrangements organised for Chemistry PIs with external partners through OU Consulting since 2008. The strong record of engagement with industry is reflected in recent EU research funding successes [RADIOMI (Innovative Radiochemistry to Advance Molecular Imaging) and OxIOSCR (Innovative Synthesis in Cancer)]; these required us to show both an academic and an industrial environment to young researchers in training.

Examples of how engagement with Oxford Chemistry has impacted on industry include:

- Establishment of a 'Centre of Excellence' in Oxford in applications of double-layer hydroxide compounds with SCG (Thailand) (>£ 2M invested by SCG to 2017); industrial-scale pilot plants are being established in Thailand for improved catalytic pathways for polymerisation.
- Compton's collaboration with Asylum Research led to design of a new electrochemical cell for an AFM instrument, with 13 instruments sold including to a leading mobile-phone company.
- Through the provision of a compound synthesised by Robertson, TdeltaS Ltd has developed a new 'nutraceutical' that shows promise in improving physical and cognitive performance.
- A collaboration with Oxford University Medical Sciences departments on the development of probes for epigenetics has attracted support from 10 pharmaceutical companies (e.g. GSK, Pfizer, Eli Lilly, Novartis), establishing an IP-free environment where probes at a pre-competitive level are available to industrial partners.
- A long-term collaboration between Thomas and Unilever has led to substantial improvements and economies in processes for major detergent production.

Public and Schools Engagement: We actively encourage and support staff in public engagement. We aim to generate interest, understanding and response, and to build relationships that bring in external perspective to help maximise impact of our research across a very wide range of sectors. Strategies developed since 2008 include:

- Appointment of a Chemistry Publicity & Communications Officer (2012) and a Schools Liaison Officer (2013) to promote the Department's research to a wide range of external audiences (industry, government, general public, alumni, schools, etc) and to provide the agility and support for academics to take advantage of engagement opportunities.
- Development of an active social media presence; our Twitter feed has >2,600 followers, the most of any UK chemistry department, and frequent interactions with science journalists, researchers and the general public ensure our messages are spread widely.
- Production of a magazine 'Periodic' in 2013 (8000 hard copies circulated to public), providing an opportunity for budding science journalists in the Department to contribute.
- Holding media training days and podcasting workshops for research staff to develop science communication skills and enable participation in the "Chemistry for the Future" podcast project.
- Targeted allocation of EPSRC Pathways to Impact funds to support such engagement activities.

Examples of public engagement and schools activities supported by these means include:

- Audio trails in the Oxford Botanic Gardens ('Chemistry at the Garden') http://www.botanic-garden.ox.ac.uk/chemistry-garden-discovery-trail-1 (see Case Study 8).
- An animation 'Towards Absolute Zero' and associated schools pack on the Oxford Sparks website (>4000 downloads via YouTube site) http://www.youtube.com/watch?v=g97MzBArEkM

- Participation in e.g. Oxfordshire Science Festival, 'Pint of Science' (BSA), Oxford Christmas Lectures for schools http://podcasts.ox.ac.uk/series/christmas-science-lectures and multiple other activities including radio interviews by PIs (e.g. B. Davis).
- Departmental tours for the general public ("Oxford Open Doors").
- Chemistry blogs on the University Science Blog website (e.g. on the Glucose Sensor).
- A new series of audio and video podcasts (35 podcasts from 29 researchers), "Chemistry for the Future," launched in 2013, showcases the breadth of our research and its implications for global challenges. It covers themes such as 'Transforming Energy 'and 'Human Health' (EPSRC Pathways to Impact funding) http://podcasts.ox.ac.uk/units/department-chemistry.
- An exhibit "Solving the energy crisis: from ancient to future solar fuels" by Oxford Chemists at the 2013 RS Summer Science Exhibition (Case Study 8) and teaching resources sent to over 80 schools; promotion of research in other public events, such as a poster competition in the House of Commons (PhD student Chris Spicer won 1st prize, 2012), and the opening of a CRUK store.
- Donation of 'Chilli meters' (Case Study 4) to a group of 7 state schools near Huddersfield for school pupils to carry out projects.

In addition, **Participation in public policy forums** has helped us to shape strategy, e.g. Edwards acted as co-organiser of a Royal Society discussion on "Can solar power deliver?" for around 200 technologists and scientists, and Bayley/Oxford Nanopore made an important contribution to the House of Lords inquiry (2009) on genomic medicine.

Internal recognition and reward of impact achievements of individuals:

Oxford Chemistry demonstrates the value it places on impact achievements in several ways:

- The potential impact of research is a factor in PI promotions and tenure-reappointments. Flexible interpretation of the 'research achievement' criterion is applied; details of patents, commercial activities, consultancies or public engagement activities are considered as part of the applicant's research portfolio – high profile appointments of active entrepreneurial scientists (e.g. Davies, Bayley, and Compton) to statutory chairs/readerships illustrate the importance of this factor.
- Achievements of individuals are celebrated through e.g. Oxford Impacts leaflets (see http://www.ox.ac.uk/research/research_impact/oxford_impacts/health/index.html) and our Oxford Chemistry Impact folders (a flexible A5 folder format that can be tailored for specific audiences); publicity about commercialisation of chemistry on the departmental website and in the Oxford Chemistry Annual Report (special feature on commercialisation in 2010).
- Individuals are nominated for appropriate prizes (e.g. Bayley was the RSC World Entrepreneur of the Year 2010, B. Davis and Schofield were finalists in BBSRC Innovator of the Year awards; Vincent won the RSC Overall Emerging Technologies Prize 2013, J Davis won an RS Brian Mercer Feasibility award 2012, Moloney a THES Serendipity award 2009). The Oxford MPLS Division introduced Impact Awards in 2012 to recognise impact (Compton, award winner 2013).

c. Strategy and plans

Commercialisation: We aim for new spin-out generation at an average level of 1-2 companies p.a., and to continue the current rate of IP disclosures and patents. The period since 31 July 2013 has already seen formation of a new spin-out, Oxford Biotrans, and the set up of a second research centre for ATDBio (spin-out of new professorial appointment Brown). The objective to encourage new spin-outs will be supported by a new IP agreement to be negotiated beyond the end of the current IP Group deal (from 2015), using our strong IP record as a basis for negotiation. We will encourage all PIs to attend regular informal meetings where they discuss potential for commercial development of their work with each other and Isis representatives. An Impact Director for Chemistry, linked to Isis, will be appointed to develop a programme of regular activity designed to stimulate commercial developments. We will continue to offer specific skills and training sessions for young researchers to encourage a culture of impact via commercialisation.

Industrial and Public Sector Collaboration: We will develop coordinated, larger agreements in the UK and overseas, and will increase industry-related funding coming to Chemistry by 10% a year to 2020. The department will target, engage and cultivate relationships with multinational and SME companies particularly in the energy and petrochemicals industries. A new Chemical Industries Business Officer will be appointed in 2014 to support this increase, liaising with the

University's business development team. Our priority research themes (see Environment Statement), including Synthesis, Catalysis, Energy, Advanced Materials, and Innovative Measurement, will be used to focus discussions with appropriate industrial partners. At the interface with biology and medicine, we will continue to strengthen our links with NHS clinicians (e.g. ^{18}F labeling synthesis for PET imaging with the CRU/EPSRC Cancer Research Imaging Centre on the Oxford University Hospitals Trust site). In some fields, we will seek pooled funding from multiple industrial partners to generate open-access IP at a pre-competitive stage. A Chemical & Pharmaceutical Industries Advisory Forum will be established with regular meetings with key partners to encourage alignment of our research interests with those of partner industries. We will continue to encourage industrial collaborators to give dedicated training, such as the series of lectures on Medicinal Chemistry to be delivered by Dr Patel (GSK) in Autumn 2013 to >100 staff and students. The attendees' improved understanding of the industrial perspective will facilitate new research initiatives targeted at industrial challenges. We will explore the possibilities (already discussed with UCB) to embed small industry research groups within Chemistry space.

Public Engagement: The Publicity and Communications Officer will work to enable our PIs to engage and influence people in all walks of life on the importance of chemistry to society through a range of projects such as public engagement talks and exhibits (e.g. stall at Big Bang Fair 2014, with 60000 visitors), further collaborations with local institutions such as the Botanic Garden and local museums (already planned for the International Year of Crystallography 2014), websites, podcasts, and research training. Success of activities will be measured through feedback via social media and other interactive means. Further media training days will be organised in 2014 and mechanisms have been established to ensure any researcher can easily develop podcast material. The Chemistry Schools Liaison Officer will support activities including training chemistry PhD-student and post-doc ambassadors ('The Alchemists'), and holding schoolteacher update days. We will broaden the range of practical activities that schools can undertake in their own labs, linked to Oxford research (as in the example of the Chilli Meters). We aim to see >100 schools with such activities in place by the end of the next REF period. We will purchase and equip a 'lab-in-a-van' to visit schools and enhance engagement with school children, their parents and teachers.

We will continue to develop the Chemistry Alumni Programme, started in 2013, to strengthen external relationships with diverse sectors and hence increase the impact of our research. Many of our 9000 alumni have roles in e.g. policy making, journalism, industry, venture capital, and patent law, giving us direct access to science communicators and facilitating impact in industry.

d. Relationship to case studies

The case studies have been selected to illustrate the breadth of Oxford Chemistry impact via commercialisation, industrial collaboration and public engagement.

Three of the case studies (1. Oxford Catalysts, 5. Oxford Nanopore Technologies, 9. Computational Chemistry (Inhibox)) relate to **Commercialisation** involving spin-out companies directly evolving from research in Oxford Chemistry. In each case, the spin-out was formed before 2008, but the scope of the companies and their commercial viability has been significantly enhanced as a result of ongoing research activities in the Department and product development in the company; the impact of the commercial operations of those companies has significantly increased in the REF period. For ONT and Oxford Catalysts, there has been substantial inward investment and benefits for UK employment. Isis Innovation has worked closely to support and facilitate the commercial impact in all these cases. There has also been close engagement with, and support from, IP Group (see above). The Departmental culture, reinforced by the publicity surrounding these cases, has encouraged researchers to look for opportunities to commercialise their work. Our push to further develop the interface with Biology/Medicine has also been a significant contributor to the healthcare impact cases (ONT, Oxygenases). Our **Industrial Collaborations** are exemplified in Cases 2-4,6,7 (Modified Mass Spectrometer; Oxygenases; Measuring Chilli Heat; Calibration-free pH Measurement; Understanding Solid-Liquid Reactions), which stem, at least in part, from collaboration with companies in diverse sectors leading to development of advanced measurement techniques or improved scientific understanding of processes with resultant commercial developments, patents, and sales of new or improved products, and improved business viability. Our policies on, and support for, **Public Engagement** are exemplified by the development of the Chemistry at the Garden activities (Case 8) and the use of the Chilli Heat meters (Case 4) for electrochemical projects in schools.