Institution: Durham

Unit of Assessment: 8

a. Context

Durham Chemistry's approach to impact during the REF period has been an evolution of strategies developed over many decades of working closely with industry and other key stakeholders. Our approach is based on a belief that valuable societal impacts will result from high quality scientific research, and that parallel execution of "blue skies" projects and research with more immediate application is mutually beneficial.

Within the REF period our research activities have had impact on each of the six main areas outlined in REF guidance. Our major impacts, as exemplified by the case studies, have been **economic** (e.g. creating and hosting businesses, licensing IPR, transferring research to industry), **environmental** (e.g. energy-reducing, cleaner processes), **healthcare** (e.g. medical diagnostics) and **societal** (e.g. outreach activities). Aspects of our work have also influenced **policy** and **professional services** (e.g. changes in drug legislation). During the REF period each of our Research Groupings has contributed to the impact activities described.

b. Approach to impact

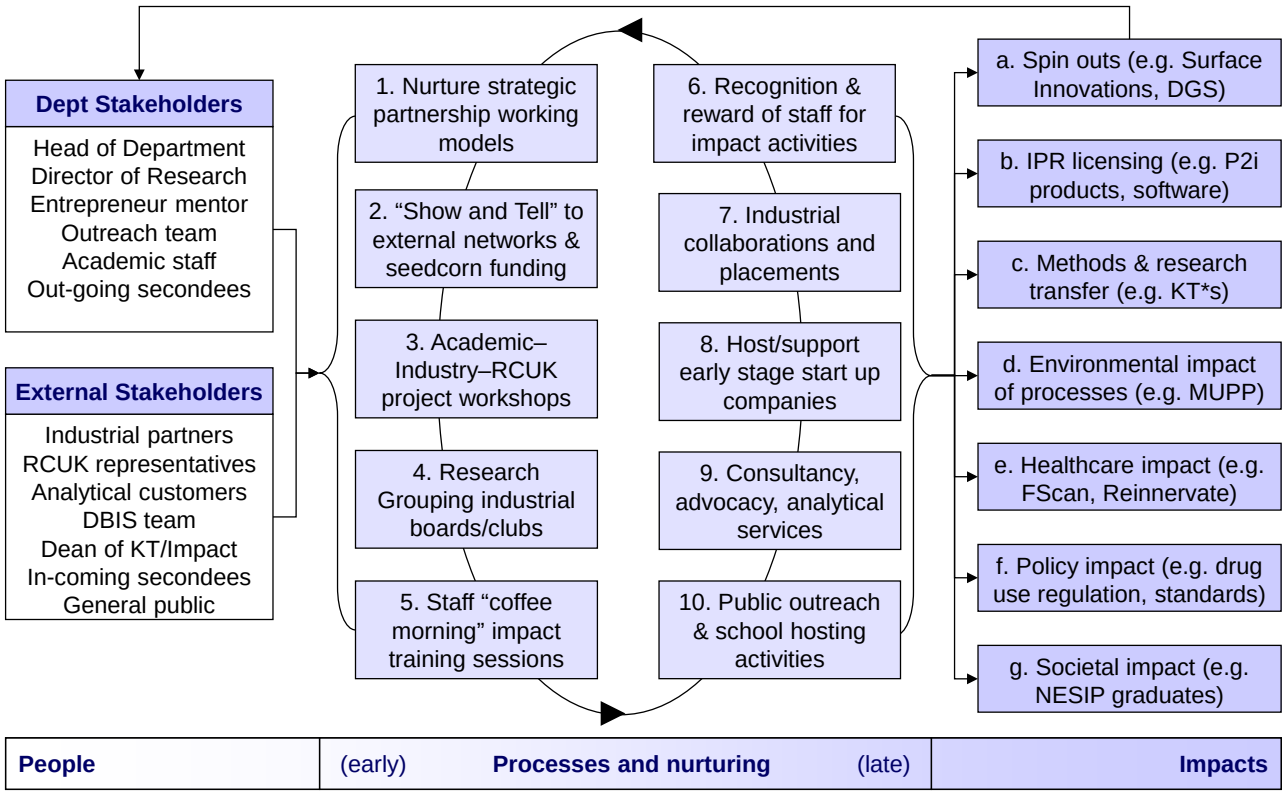

Figure 3.1: Impact structure at Durham Chemistry (MUPP = Microscale Polymer Processing, NESIP = North East Schools Industry Partnership, DGS = Durham Graphene Science; see text for details)

Processes and Nurturing: Our approach to impact is summarised in Figure 3.1. In overview, we have a variety of well-established processes within the Department (numbered 1–10 in Figure 3.1 centre) for engaging internal and external stakeholders to maximise impact and to guide our research strategy. These processes are managed by the HoD and DoR, often with the involvement of our Entrepreneurial Mentor (Prof JPS Badyal).

Our internal impact processes align with and inform the broader university strategy led by our Dean of Knowledge Exchange (Davies) and Dean of Technology Transfer (Tanner, Queen's Award for Enterprise Promotion, 2012). Chemistry has a close and successful working relationship with Durham's Business and Innovation Service (DBIS) which provides broad support across the impact arena. The Department and DBIS meet/communicate weekly and were co-recipients of the 2012 Times Higher Education Award for "Outstanding Contribution to Innovation and Technology".

Selected activities to exemplify how each of the processes numbered 1–10 in Fig 3.1 work are:

1. *Strategic partners*: We have focussed on building deep relationships with a small number of major industrial organisations. For example, we have a strong partnership with Procter and Gamble (P&G), funded initially via a £6M (£1.4M to Durham) Regional Growth Fund project on

surface modification supporting 8 PhD students and 3 PDRAs. We have developed these projects further under the SMC^3 (Surface Modification and Characterisation Collaboration Centre) project with the CPI (Centre for Process Innovation), one of the Government's Catapault Centres; we will launch a EU-funded industrial doctorate programme (€1.5M) with P&G in 2014. The overall partnership, which now involves 75 Durham academics, has won the P&G Global Partnership award, been cited in US congress, and been highlighted in the Wilson report and in letters from P&G's Global Vice President to the Prime Minister (more details in REF5). Our relationship means we can move quickly to co-support new interdisciplinary research opportunities (e.g. potentially complex negotiations over 3 inter-departmental case studentships in 2013 required a single 10 minute phone conversation to finalise). We became one of IBM's 14 UK strategic partners in 2013.

2. *Show and tell events*: We have run several events where Durham staff and industry (e.g. P&G Aquinas research network, IBM, BP) have presented short research/capability presentations. The Aquinas event led on to funded projects (7.5 PDRAs, 8 PhDs) in areas such as ligand design, antimicrobials, modelling and enzyme mechanistic studies. We can access a £250K pa University seedcorn funding to help kick start proof-of-concept research.
3. *Industry workshops*: We have organised a number of joint workshops involving non-competitive companies (e.g. BAE systems & Dyson) and Research Councils aimed at exploring pre-identified common research challenges in depth. The N8/NORSCC sustainable chemistry network and the Centre for Soft Matter also run regular industrial research workshops; the latter will launch an industrially-linked CDT in 2014.
4. *Industrial advisory boards*: Several of our research groupings have formed industrial advisory boards/clubs to advise on research directions. For example the Centre for Sustainable Chemical Processes' board has 12 industrial members and meets biannually; Phil Souter (P&G) holds an Honorary Chair in the Department and advises on our research-led undergraduate curriculum from an industrial perspective.
5. *Impact training*: We have regular Departmental briefings on areas such as entrepreneurship and outreach via our Departmental ~3 weekly coffee morning training sessions (e.g. Hammond on Industry-Academia linking schemes; Beeby/Robson on outreach activities; talk from University Dean of Impact).
6. *Recognition/Reward*: Spin-out and related activities are encouraged and enabled by the Department, recognised in our workload model and promotions procedures, and discussed during annual staff reviews. For example, Coleman has 50% teaching relief funded by Durham Graphene Science (DGS) to drive the company's growth. Staff receive a share of licensing fees and maintain equity in spin-out companies.
7. *Collaborations and Placements*: We have deliberately grown our industrial collaborative research portfolio to ~15% over the REF period with over £4M of industrial funding awards; much of this research will lead to economic impact. We also encourage staff and student secondments to/from industry to develop new ideas. For example, Dyer holds a Royal Society Industrial Research Fellowship (2011–13) to spend 50% of his time seconded to Johnson Mathey. Companies such as AWE, Cambridge Research Biochemicals, Catalytic Technologies, Lomox and Pfizer have seconded staff to Durham in the REF period. The innovative Durham Industrial Bridging Fellowships scheme (HEFCE funded) protected jobs following the 2008 recession by allowing five industrialists (£115K) to perform research at DU.
8. *Hosting start-ups*: The Department provides space and infrastructure access to spin-out companies in their early years. For example, Brock Fine Chemicals, DGS, Olexsys Software and Reinnervate have all been hosted (see case studies). Beyond this businesses can relocate to space at Netpark, the University science park; Reinnervate followed this route.
9. *Consultancy/support services*: Departmental expertise and infrastructure has provided significant impact to external organisations. Staff have individual consultancy contracts with 37 major international and national industrial organisations, including Unilever, DuPont Teijin Films, Asahi Glass, BP, Michelin, Clariant, Teva, Shell, P&G and CDT. Our analytical services provide data and interpretation to many organisations (£1.5M in REF period). For example, solution state NMR has supported 23 companies including International Paint, Johnson Mathey, Lucite, Millenium Chemicals; the solid state NMR service has supported 42 companies including BP, Huntsman, Pfizer and Shasun (£360K); our Crystallography Service has impacted pharmaceutical problems in all three stages of development, from lead

compounds to formulation; Mass Spectrometry and Separation Science have provided significant services to Nissan. Our flow expertise has helped several chemical and pharmaceutical companies such as Abbvie, Aesica pharma, Argenta, AstraZeneca, Biofocus, GSK, International Fine Fragrances, Novartis, Reaxa, Syngenta and Unilever.

10. *Outreach*: Our Outreach Committee (chair: Beeby and 5 academics) works closely with the Science Faculty outreach team to coordinate a range of events (examples below).

Impacts: Our impact can be broadly classified into the 7 areas a–g given in Figure 3.1 (right). Many of these are exemplified in the individual Case Studies submitted. Further highlights and examples of how our processes 1–10 have translated to impacts in each of areas a–g include:

a. *Spin outs*: A number of companies have been successfully spun out of the Department in the REF period: P2i, Surface Innovations, Durham Graphene Science (DGS), F-Scan, Olexsys, Reinnervate, VPC and Brock Fine Chemicals. They have won numerous awards including P2i's 2011 International Business Award for "Most Innovative Company in Europe", the RSC Rita and John Cornforth Award for Reinnervate and 3 sequential NE Universities Blueprint awards (F-Scan, DGS, Brock). Coleman received the RSC Chemistry World Entrepreneur of the Year Award 2011 for his work with DGS and our approach to this project won the 2012 Times Higher Education Award for "Outstanding Contribution to Innovation and Technology". DGS will float on the AIM stock market as "Advanced Graphene Materials" in November 2013 and anticipate a valuation of £25M.

b. *IPR licensing and ideas transfer*: Several patents filed by DU staff have been exploited commercially in period. Spray plasmachemical deposition techniques (Badyal) have been transferred to Dow Corning, 11 key patent families developed by Durham IP company Surface Innovations have been sold to P2i and P2i itself has exploited Durham-derived IP (see case study). Patents licensed to Asahi Glass Japan on continuous flow technology have created a >£125K royalty stream from 2002–present (Sandford). IPR on high throughput screening assays of kinase inhibitors has been licensed to Molecular Devices USA. Apparatus and methods developed in the Department have also been transferred to industry: X-ray cooling devices co-developed with Oxford Cryosystems (Howard, Evans) have sold around 60 units (£3.2M); methods for the determination of photo-luminescence quantum yields (Beeby) have been commercialised by Horiba Jobin-Yvon (160 units, £1.6M); automated analysis and data processing solutions for mass spectrometry has been transferred to SpectralWorks (Moseley). Durham single crystal software (Howard) is used by many X-ray manufacturers and academia (see case study).

c. *Methods/research translation*: Durham and Newcastle University were awarded a £2.6M EPSRC Knowledge Transfer Account (Oct 2009–Sept 2012), £604K was awarded to Chemistry across 16 projects that have leveraged an additional £390K in contributions from both companies and medical professionals. Under the KTP scheme joint projects have been undertaken with CPI, Du Pont Teijin, Rawwater Engineering and Pfizer (total value £600K). We have run 5 projects (£83K) under the Knowledge Transfer Secondment (KTS) scheme and a further 5 (£60K) under Pathways to Impact. The N8-funded METRC programme has provided £5–10K seedcorn funding each for 14 small-scale academia/industry projects. For example, a process development project with Aesica is now in plant-scale operation leading to on-going £50K per annum savings. The work of over 60 industrially funded PhDs/PDRAs (see REF5) has/will transfer further ideas.

d. *Environmental impact*: Our research impacts energy efficiency of chemical processes and/or the efficiency of reagents use. For example, the EPSRC "Microscale Polymer Processing" (MuPP) project (McLeish/Hutchings, £720K) developed a suite of software tools to enhance polymer design for efficient (energy, time, cost) polymer processing; tools which have been adopted by multinationals (Dow, Lucite International, Basell) and SMEs. Smart Polymer Processing (http://polymerprocess.org/) has been set up to connect more widely with the polymer processing industries to maximise the impact of MuPP.

e. *Healthcare impact*: Research showing impact in the health care arena is developed in 3 case studies: the $4.65 billion anti-fungal V-fend utilising Durham fluorination chemistry; the F-Scan diagnostic imaging agents spin out; and Reinnervate products for the growth of cultured cells.

f. *Policy/Standards*: Based on Parker's expert witness advice, the US FDA issued new guidelines to the radiology community, advising against the use of DTPA-based systems in renal patients, minimising the risk to the 40 million patients who undergo a Gd-assisted MRI

scan each year. Evans' methods for powder data analysis have been adopted for calibration of the world standards for crystallographic work by the US National Institute of Science and Technology. Staff provide expert scientific advice on a variety of legal matters including for: Apotex; Cisbio; Liber; Mayne Pharmaceutical; Novartis; Simmons and Simmons; Spangenburg; Sun Pharmaceutical; and Shibley.

g. *Societal impact*: Our "Spectroscopy in a Suitcase" outreach programme provides a low-cost, high-impact means of demonstrating spectroscopy for schools and science fairs, and was supported by the RSC "Chemistry for our Future" programme (£30K). It has reached over 5000 school children throughout the UK including at the "Celebrate Science" (2010, 2011), "Newcastle Big Bang" (2011) and Centre for Life "Light my Fire" (2012) science fairs. A demonstration suitcase has now been sent to South Africa. We have used the 2013 visit of the Lindisfarne Gospels to Durham to showcase spectroscopic research on pigments and their provenance to the public. A 3-day residential Durham Chemistry Teachers Conference for 30 teachers from across the UK was held in 2011 to transfer research ideas to the classroom. Our annual North East Schools Industry Partnership (NESIP) programme brings teachers, schoolchildren and companies to the Department to perform a week-long industrially-driven research project.

c. Strategy and plans

Our current impact strategy is well developed and has been discussed and evidenced in detail in Section B. Looking forward, our underlying principles for the REF 2020 period remain:

1. to engender a research environment in which research is undertaken that provides world-leading impact across different sectors;
2. to support the development and optimisation of partnerships with influential national and international businesses, research councils, spin-out companies, non-governmental organisations and public sector bodies with mutually beneficial research agendas;
3. to enable the identification of impact opportunities as they arise within research projects and provide support (financial and time) for their rapid and agile development.

We believe that the processes of Fig. 3.1 will allow us to achieve these aims.

We can already see that our strategies and research from 2008-2013 will lead to impact by REF2020. Examples currently in the centre "processes and nurturing" stage of Fig. 3.1 include: research associated with our P&G partnership; research within DGS; collaborative research underway with the coating and printing industries; work on fog-harvesting; work related to biofuels; and work arising from our process and flow research activities. We are in the early consultation stage (left of Fig. 3.1) with external partners in several areas around soft matter, personal products and product stability.

d. Relationship to case studies

All of our impact cases went through most of processes 1–10 of Fig. 3.1. We can highlight this using the "Elemental Fluorine for Fine Chemical Manufacture" case study as an example.

BNFL Fluorochemicals, later F2 Chemicals, seconded a research unit (3 FTE supported by 1 PDRA + 2 PhD students) to Durham Chemistry in 1993 and began a fundamental research project concerning the use of elemental fluorine gas as a reagent in organic chemistry. IPR arising from Durham was patented by the company (> 20 patent families filed) and technology marketed to the industrial and pharmaceutical sector. Transfer of trained personnel and results from Durham to F2 Chemicals enabled scale-up of fluorination technology and the synthesis of intermediates for Pfizer, using environmentally sustainable fluorination methodology. IPR on multi-channel continuous gas/liquid flow systems was developed and, after discussions with DBIS, a world-wide exclusive licence was negotiated with Asahi Glass Co. (Japan) for use in fluorination reactions. Know-how in the use of fluorine gas was used as the background for a business case for the Brock Fine Chemicals spin-out company which, after advice under our coaching for commerce scheme, secured investment from a NE venture capital fund. Development of the business was aided by expertise available within DBIS and personnel brought to Durham under the DIBF scheme. The Department is supporting the company with free laboratory and office space for the crucial proof-of-concept phase.