Institution: University of Sheffield

Unit of Assessment: 3C - Allied Health Professions: Biomedical science

a. Context

Main non-academic users groups/beneficiaries and types of impact

The broad spectrum of our biomedical research ranges from molecular approaches to understanding basic cell and developmental biology, through translational studies utilizing animal models of human disease, to clinical studies in patients. Therefore, our impacts as exemplified below are similarly diverse. These range from collaborations with the pharmaceutical industry, through the development of university spin-out companies, to influencing policymakers, clinical guidelines, patient care, charities and outreach activities. Some of these interactions developed out of long-term collaborations while others are the result of novel Knowledge Exchange activities.

Patients:

Improved patient care: Highlights include the discovery of a novel therapy for breast cancer. This was the first example of the ***selective*** killing of a tumour through the use of an inhibitor of DNA repair to induce synthetic lethality and heralds a new era of personalised cancer therapy (Case Study *Development of a New Breast Cancer Treatment*). Improvements in patient experience have been enhanced by the development of ZedScan, a device for the detection of cervical cancer that allows doctors to 'see-and-treat' patients in a single visit. ZedScan has been shortlisted in the prestigious Institute of Engineering and Technology Innovation awards 2013.

Biomarkers and genetic testing: Polymorphisms in genes encoding the interleukin-1 cytokine system identified by researchers in this UoA are the basis of genetic tests, which inform treatments of periodontitis (Case Study *Personalised Dental Healthcare*), and which are currently being applied to cardiovascular disease (*Francis*). *Sisley* has identified genetic factors that determine the prognosis of UV melanoma, which are used widely as biomarkers in the NHS.

Commercial companies:

University spin-outs providing commercial reagents, services and products: Our spin-out Axordia (founding director *Moore*) was acquired by Intercytex Group plc in 2008 in a trade sale which valued Axordia at £1.68M (Case Study *Stem Cells*). Under contract from Pfizer, the Centre for Stem Cell Biology expertise in Good Manufacture Practice (GMP) was used to manufacture a clinical grade stem cell bank (GMP SHEF-1), which was approved by the Medicines and Healthcare Products Regulatory Authorities as starting material for stem cell transplants. Asterion (Case Study *Asterion Spin-out*) is a company that is developing technologies that reduce the frequency with which drugs need to be injected, thus minimising risk of infection. Intellectual property has been developed around an antibody with therapeutic potential for a range of inflammatory conditions (PCT/GB2013/051373). The antibody was originally developed under an MRC-T GAP funded project (£140k), with a pre-clinical data package being funded by a MRC-DPFS grant jointly to MRC-T and the University (K00770X) (£490k).

National and International Policymakers:

Use of animals in research: Hosting a major animal facility using non-mammalian model systems within the MRC Centre for Developmental and Biomedical Genetics (CDBG), this UoA influences public policies and legislation. The success of the CDBG has established it as a leading UK centre for non-mammalian models of human disease, thereby addressing the NC3R mission to reduce experimentation on mammals. CDBG plays a major role in promoting the use of, and facilitating, animal models for medical research and members of CDBG were commissioned by the MRC/Bioscience coalition to host politicians and policy makers (2012), prior to the transposition of a new European Union Directive on the protection of animals used for scientific purposes (2010/63/EU) into UK law (Nov, 2012), which amends the Animals (Scientific Procedures) Act 1986. *Tozer* is an author on the highly cited (180) 'Guidelines for the Welfare and Use of Animals in Cancer Research', while *Mead* co-authored 'Guidelines for Preclinical Animal Research in ALS/MND' (>50 citations) – documents influencing both users and the public perception of animal use in research. *Furley* is a partner in FP7-HEALTH-2013-INNOVATION-1 Supporting Action, ANIMPACT: an initiative that investigates decision making in animal research (2013-).

Clinical guidelines: Our work on atopic eczema has led to changes in the advice given through the NICE Quality Standards and Guidelines on the use of Aqueous cream (Case Study *Eczema*

Treatment Guidelines). We have invested in a contract research facility that has been used by UK industry for dermatological testing on human skin biopsies and is contributing to the development of next-generation emollients to repair defective skin barrier function. Researchers from our Centre for Stem Cell Biology have influenced national policy making in the field via the MRC Stem Cell Users Liaison Committee (2005- to date), providing input into the drafting and finalisation of the UK Code of Practice for Stem Cell Research. *Moore* was also on the MRC working group on commercialisation of stem cells (2008-2010). Work on structured education programmes for diabetics influenced NHS guidelines for patients (Case Study *Diabetes Management*).

Biomedical Charities

In 2011 *Holley* was appointed to the specialist Action for Hearing Loss panel for the new Translational Initiative in Hearing (TRIH). This panel brings together representatives from the charity, academia, the MRC and several major pharmaceutical companies (including Sanofi, AstraZeneca, GSK) to encourage translational research, to raise funds and to allocate awards internationally. The scheme is recognised across the Association of Medical Research Charities for its innovation in nurturing translational research opportunities between scientists, policy makers and commercial interests.

Societal Impact

Researchers in this UoA have had extensive interactions (>100 presentations) with schools in South Yorkshire, many of which are located in challenging inner city environments. In addition to the Case Study *The Great Sperm Race*, we have also contributed to local, national and international events aimed at disseminating scientific knowledge and engagement to the general public, including Researchers' Night where the University hosts a variety of public engagement activities as part of an international event involving 800 institutions in over 32 countries.

In 2006 *Holley* devised a public demonstration lecture, now a roadshow, entitled The Bionic Ear in collaboration with Deafness Research UK and with grants from the Wellcome Trust and the Scottish Executive. The roadshow still tours the UK, funded by the National Lottery, with a variety of scientists as presenters. It was a finalist in National Lottery Award for Best Health Project 2012 and reached a milestone of being seen by 100,000 adults and children in April 2013.

Holley leads the University of Sheffield component of a Wellcome Trust Society Award entitled Authentic Biology. The project involves over 100 local A-level students in a school-based research project to discover genes linked to cardiovascular disease in patient groups and to study these genes in animal models.

Postgraduate students from this UoA have an opportunity as part of their outreach training to visit local schools to talk to pupils about their research and instil an enthusiasm for scientific investigation. We have received extensive written feedback from teachers and pupils that demonstrate that the schools involved find this work valuable in influencing career choices.

Through wide-ranging activities, CDBG staff have impacted on public awareness of the use of animals in health-related disease. Impacts are directed towards a wide public audience, emphasising the link between research and continued development in medical understanding and healthcare. Key examples include the Royal Society Summer Science Exhibition 2009, a prestigious event attracting over 1500 visitors/day, including politicians and policy makers, and its associated website FishforScience (http://www.fishforscience.com/) – a site that 'serves as an inspiration to any research laboratory considering how to develop its programme of outreach activities and improve the public understanding of science' (from Understanding Animal Research).

b. Approach to impact

Developing and Sustaining Relationships with User Groups

The University receives the maximum HEIF (Higher Education Innovation Fund) allocation of £2.85M per year. This allocation recognises the high level of existing interactions between Sheffield and industry. A primary level of engagement has involved the hiring of impact-related staff. We recently established the Science Gateway (http://ssg.sheffield.ac.uk/) and Healthcare Gateway (http://shg.sheffield.ac.uk/), which are key components of our overall present and future impact strategy. Since 2008, the Faculties of Science and Medicine have had specific investment of £2.3M to fund schemes such as proof-of-concept, R&D voucher schemes to stimulate interaction with SMEs and larger industrial partners, rapid response projects, as well as funding business research fellows (BRFs) within the Science and Healthcare Gateways who provide a

single point of contact for businesses with scientists and clinicians. The roles of the BRFs are to: mine for opportunities (both licensing and potential spin-out material) and assist staff and students with disclosures to the University; maintain a high profile through seminars to undergraduates, postgraduates and post-docs on commercialisation and intellectual property; invite speakers from industry to give seminars about commercialising research; and to provide opportunities to showcase our research. The Science and Healthcare Gateways provide regular targeted updates of funding opportunities and arrange for user groups (e.g. GSK, Novartis, Pfizer, CRUK, MRCT, CRT) to attend showcase days at which selected researchers present their translational projects. CASE studentships allow us to link our research and PhD training program directly to applications with industrial partners (e.g. with Astra Zeneca, GSK, Pfizer and UCB during the current REF period). This is a route that we intend to exploit further in the future and will be complemented by a Collaborative Studentship scheme, with 50% funding from the University and 50% from industry.

Early career researcher (ECR) training via the Think Ahead Program (developed within Medicine) includes modules on Innovation, Enterprise & Industry, networking and non-academic career paths. ECRs also benefit from the Industrial Knowledge Forge, which develops links with industry and instils development of industrial knowledge, through networking and partnering for research projects. It ran 22 events in 2012, including networking events with industry and commerce.

Finally, the University has formed an Innovation, Impact and Knowledge Exchange Strategy Board composed of the Pro-Vice Chancellor for Research and Innovation, members of the Faculty Research and Innovation Services (RIS), Human Resources, the departmental research directors and external advisors from industry. This board provides a higher-level steer to co-ordinate impact activities across the university and to ensure that best practice is shared, so enabling the impact activities of this UoA to gain from the experience across the whole organization.

Identification of potential impact: A Commercial Assessment System (CAS) is embedded into the grant application process at the University. Academics consider whether their research could generate exploitable IP, services or software at the time of project costing. New knowledge with potential IP and/or commercial value arising can also be notified at any point using our online reporting system (Commercial Opportunity Disclosure), which is then followed up by staff from RIS who provide access to IP professionals and consultants. Patenting has always been strongly encouraged. Within the UoA there have been over 300 patent applications filed since 2000 and 8 **granted** patents in the US since 2008. During the REF period, 17 PIs within the UoA have engaged in research collaborations with industrial partners. We have exploited funding opportunities to maximize impact, e.g. *Cunliffe* obtained a BBSRC Small Business Research Initiative Project Grant (£225k to develop surface chemical gradients as a research tool with Plasso Technologies). We have also hired strategically to ensure our research both maintains its academic excellence and has maximum potential for impact in the future. For example, recruitment of *Zeidler* established the Sheffield RNAi Screening Facility, which has potential to identify novel therapeutic targets

Funding the pathway to impact: The University uses a proportion of its HEIF allocation to fund proof-of-concept and R&D projects, which in turn has leveraged further funding, facilitating start-up companies (*Sayers: Case Study Asterion spin-out*) and generating IP (*Bellantuono*). In addition, the University has been awarded £400k from the first-round MRC Confidence in Concept Scheme and has submitted a second-round application (2013). Typical awards are between £10-50,000 and have been successful in leveraging further development funding, e.g. £180k benefit-in-kind from BioLine and £35k from Yorkshire Forward (*Smythe*). Investment of £90k from the University of Sheffield in the Skin Barrier Labs (*Cork*) resulted in industrial funding in excess of £800k. In 2013 the University won a BBSRC Sparking Impact Award (£100k) to support partnerships between academics and industry (*Goldman*). The University has, for some time, encouraged PIs to start up spin-out companies where appropriate, e.g. Axordia (2001), Asterion (2001), BioServ (2009) and Zilico (2009). **FusionIP** Ltd partners with the University to exploit its R&D, facilitating access to the White Rose Technology Seedcorn Fund, Local Development Association (LDA) grants, MRC, DPFS and BBSRC Follow-on Funding schemes, and the private sector to support these early-stage spin-outs. FusionIP successfully raised a further £20M fund in 2013 for investment into university spin-outs. The difficult financial climate for raising venture capital that prevailed in recent years has led us to adopt a more varied and flexible approach over the current assessment period, which has been very successful and will be a foundation for the future.

Incentives to undertake Impact activities. Achievement of impact is a major factor in promotions at all academic levels. As well as direct reward, impact activities can lead to altered workload, providing staff more time to build and exploit impact activities, including undertaking secondments, by relieving them of other commitments. Individual departments can also use strategic resource (technical assistance, PhD studentships) to support particular impact activities led by staff. Individuals are permitted to undertake up to 35 days consultancy work per annum and are awarded bonuses for exceptional or sustained impact activities. Spin-out founders are offered equity stakes of 40% in their companies, while retaining at least 60% net income share from sales of patents to FusionIP and 30-50% of all net income generated from licensing revenues.

c. Strategy and plans

Our overall strategy is to embed impact activities further into the day-to-day activities of staff in this UoA and to increase the number and value of our engagements with end-users. To achieve these aims, we will build on the solid foundations described in the previous sections. The BRFs hired as part of the Science and Healthcare Gateways will be embedded in the host departments, since we believe that impact can only be maximised by a close working relationship between research-focused and impact-focused staff. These personnel will maintain and build our impact pipeline, helping to identify novel pathways to impact, and the resource and external expertise required to achieve that impact. They will provide advice on the documentation of impact for RCUK grant proposals and other funding sources, and will also provide the key link to faculty/university resource (financial and advisory), which the university is committed to providing.

Because of the perceived benefits and culture change achieved by the participation of the Department of Biomedical Science in the original BBSRC Excellence with Impact competition, an Institutional submission has been made to the current competition (Lead: *Goldman*), to which members of this UoA will be making a significant contribution.

Looking to the future, our impact activities will be focused on three main areas. These will be (**a**) **biomedical science**, in the context of genetic screening and personalized medicine, with key partners in the pharmaceutical industry; (**b**) **policy focused**, in particular around stem cells and their potential for use in regenerative medicine; (**c**) **biotechnology**, particularly in the exploitation of IP and the expansion in university spin-outs. We will also continue to invest in **outreach** work primarily focused on young people, informing them about our work and enthusing them with an appreciation of science and its benefits to society.

d. Relationship to case studies

The case studies reflect the diversity of research within this UoA generated by staff who are leading authorities in their field interacting with a broad range of stakeholders. The Case Study *Development of a new Breast Cancer Treatment* reflects the ability of the UoA to protect University IP, which was bought and developed by the biotechnology sector and ultimately acquired by big pharma, with worldwide investment in drug discovery. The pre-eminent role of the Centre for Stem Cell Biology on the international stage and early recognition of commercial possibilities underpinned our Case Study *Stem Cells*. University and regional development agency pump-priming for a spin-out company facilitated this impact, as did activities of the University IP company. Another spin-out company (Case Study *Asterion spin-out*) also arose out of excellent academic research, whose translation was supported by university mechanisms to raise funding and promote the company. A number of our case studies impact on patient care. The Case Study *Personalised Dental Healthcare* illustrates how interleukin-1 gene biomarkers have revolutionized dental healthcare, and since periodontitis is linked to cardiovascular disease, could also have a major impact on the treatment of heart failure. Impact on health outcomes is also illustrated by the Case Study *Eczema Treatment Guidelines*, with research from this UoA leading to the development of novel methods to repair defective skin barriers in atopic eczema. This work has influenced NICE guidelines and educational campaigns by the National Eczema Society. The Case Study *Diabetes management* has stimulated a similar programme for adults and children with Type 2 diabetes. The case study relating to public understanding of science (Case Study *The Great Sperm Race*) arose from research into the basic biological processes of human sperm transport through the male and female reproductive tracts, leading to an approach by a UK TV company and ultimately the broadcasting of a documentary that had an estimated audience of around 10 million worldwide. Our strategy going forward is to support both mature lines of work, and our developing case studies, to ensure that impact with excellence is embedded within the research of this UoA.