Institution: Durham University

Unit of Assessment: UoA5 – Biological Sciences

a. Context: Durham biology's approach to impact has been to promote the exploitation of excellent basic research programmes by the introduction of mechanisms that enhance the frequency of contacts between academics and end users. The impact agenda has been developed over a number of years through the establishment of links with industry, biomedical and other charities, the NHS, policymakers and engagement with the public. In many cases these interactions are multidisciplinary in nature, and are facilitated by our active collaborative programmes with other departments at Durham (in physical sciences, mathematics, engineering and social sciences). This multidisciplinary approach to research and business engagement has led to Durham receiving Procter & Gamble's 2012 Global Business Development University Partner of the Year. Durham University supports the development of spinout companies, providing expertise in business management, legal services and intellectual property through its *Business and Innovation Service* (DBIS). *NetPark*, an industrial park at Durham underpinned by both University and Regional funding, supports spinout companies through the provision of space and facilities that allow company development. Training of high quality postgraduate students and postdoctoral scientists in a strong research environment also provides skilled personnel for industry, research institutes, government departments and others, whether in the life sciences or in other areas such as finance and business who appreciate employees with strong quantitative and analytical skills.

b. Approach to impact: Our overall approach to developing impact from our research is summarised in **Fig. 1**. The aim is to provide staff with the best possible opportunities to carry out

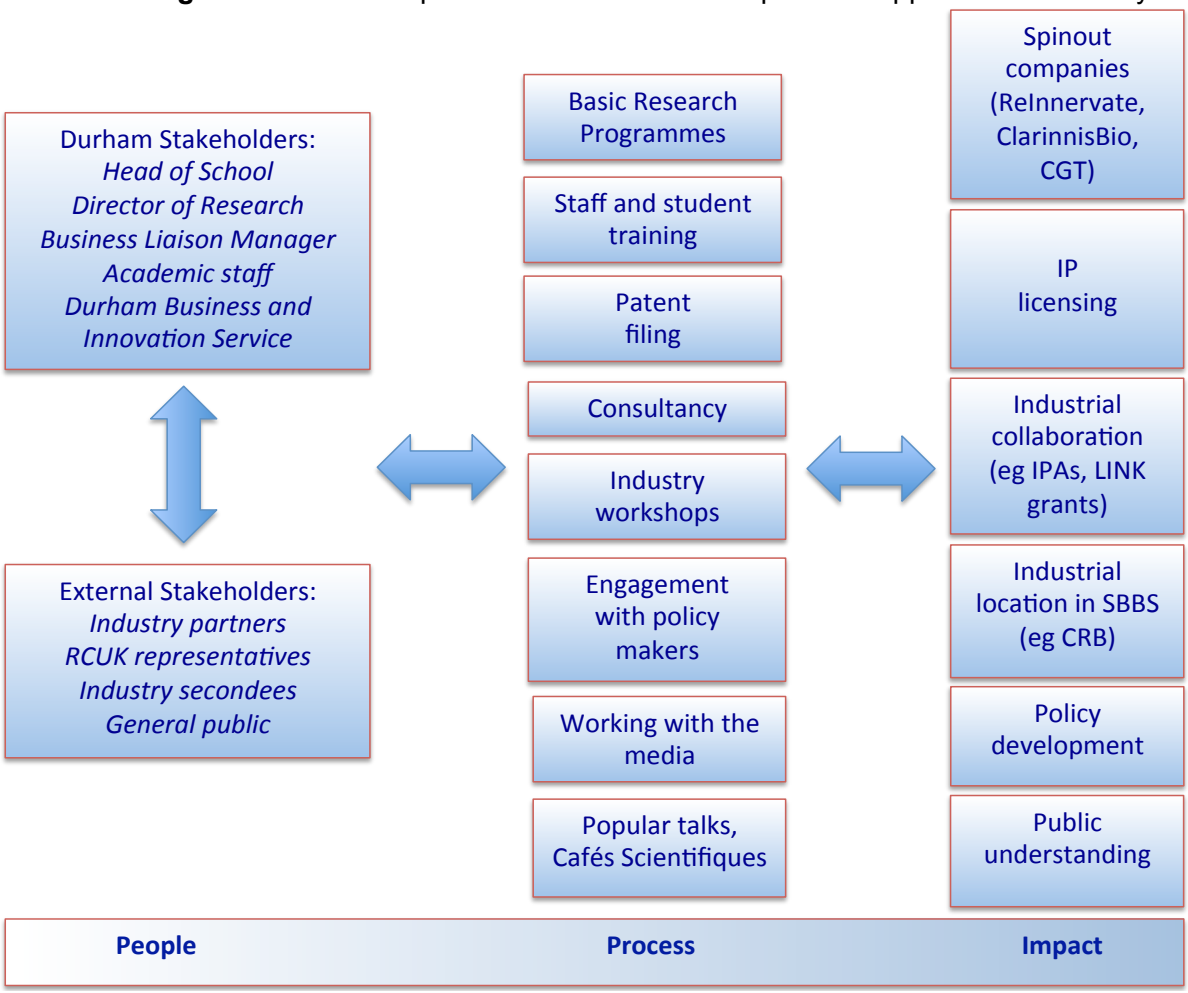

Fig. 1: Impact structure in Durham Biological Sciences

strong science programmes, and to facilitate impact-related activities. Impact activities carried out by staff are given credit through inclusion in the Workload Model, and constitute one of the criteria for staff promotion and reward (e.g. Przyborski's Chair linked to the development of *ReInnervate Ltd*).

Partnerships and People (**Fig. 1 'People'**): The *Durham Business Innovation Service* (**DBIS**)

facilitates introductions to industrial partners, provides financial assistance and advice on patent protection and filing, and helps establish consultancy agreements. SBBS has put resource specifically into its impact agenda, through the appointment of a 0.5 FTE Business Liaison Manager, whose role is to capture impact activities, and use this knowledge to work with DBIS and act as a primary point of contact to facilitate new industrial interactions between academics and industry. SBBS has received a **BBSRC Sparking Impact Award** of £100k (2013) to develop further its commercial impact agenda, notably through outward secondments (with Syngenta, Hypha and Novartis). Industrial links have been promoted in part through joint workshops with potential industrial and other partners **(Fig. 1 'Processes')**. We have invited companies to visit (most commonly they have approached us directly, or meetings have been arranged through personal contacts or DBIS), and presented our research interests/capabilities, showcased our infrastructure, and discussed potential projects of common interest. Companies with whom we have developed such collaborative links include Bayer, Procter & Gamble, AstraZeneca, Syngenta, Monsanto, Cambridge Research Biochemicals, Hypha, Novartis, FujiFilm, Sirius Minerals, Tozer Seeds, FERA, NIAB and NIAB Innovation Farm. For each of these, the workshops have led directly to joint grant applications to RCUK or direct investment in collaborative projects, including **BBSRC IPAs, LINK grants** (ca. £4M during the REF period) and other successful joint grant applications (Procter & Gamble, Syngenta, NIAB, Harvest Energy), CASE students (Procter & Gamble, Syngenta, Tozer Seeds), or direct project funding (Procter & Gamble, AstraZeneca, Cambridge Research Biochemicals, FujiFilm, FERA). Some companies (Cambridge Research Biochemicals, ClarinnisBio, Creative Gene Technology) second staff in dedicated SBBS labs.

Building blocks to Impact (Fig. 1 'Processes'): **Training.** The provision of highly trained postgraduate, postdoctoral and technical staff is a key feature of our impact agenda. Individual PG students have taken up internships during their PhDs, with for example Defra, providing them with experience with stakeholders; all BBSRC students undertake Professional Internships (PIPs). Many such individuals go on to employment in a wide range of industries, with companies and institutions in the life sciences, including GlaxoSmithKline, Syngenta, Procter & Gamble, Unilever, BBSRC, the NHS as well as our spinout companies *ReInnervate Ltd.*, *ClarinnisBio Ltd.* and *Creative Gene Technology Ltd.*; and in other industries such as business and finance (e.g. PriceWaterhouseCooper, Barclays Bank, Hillsview Investments). Our postgraduate students are encouraged to engage in impact training activities, such as through participation in the *BBSRC YES* competition, and were runners up in 2010. Two postgraduates have won poster prizes in the *SET for Britain* competition during the REF period, hosted at the House of Commons and supported by Durham's local MP. Students are mentored through these competitions by staff with industry experience both from SBBS and from the Faculty Graduate School.

Building blocks to Impact (Fig. 1 'Processes'): **Consultancy and business support.** The SBBS website provides a page dedicated to advertising Durham facilities that are expected to be of interest to industry (https://www.dur.ac.uk/biosciences/services/), and SBBS provides space for use by companies (the 'Translational Facility'; see below, '**Realization of Impact**'). SBBS also runs successful short courses for industry (typically 10-15 delegates), in Molecular Biology, Microbiological Safety Training, Protein Biochemistry, Bioimaging, Biomolecular Analysis; and bespoke courses are also developed in discussion with individual companies (e.g. *Voicentric*, *CRB*). Our DNA sequencing and Cell Technology suites run on a commercial basis, and provide support not only to academic research groups within and outside Durham, but also to a number of companies (annual turnover ca. £70 k). These facilities, overseen by our Business Liaison and Facilities Manager, provide specialized research tools and expertise unavailable to many companies.

Realization of Impact (**Fig. 1 'Impact'**): **Spinout activities.** SBBS supports its more entrepreneurial staff wishing to establish spinout companies, by providing laboratory space and access to facilities that are free at the point of entry (though these companies typically contribute an overhead when their finances allow); this support facilitates their establishment. Three spinout companies have been active and developing during the REF period - *ReInnervate Ltd.*, *ClarinnisBio Ltd*. and *Creative Gene Technology Ltd*. All three have emerged through excellence in basic science programmes over the last several years, and have been hosted in SBBS during their early years. *ReInnervate* (***Przyborski***) focuses on the development of technologies for the culture and controlled differentiation of mammalian stem cells. *ClarinnisBio* (***Jahoda***) is developing an artificial human skin model, with the aim of clinical replacement of lost skin for example after burns

and testing the effects of chemicals on skin in the laboratory, avoiding using animals. *Creative Gene Technology* (*CGT*, ***Slabas, Lindsey***) is developing technology for crop improvement, through the identification of genes underpinning oil yield and plant protection. The three Durham biology spinouts collectively have 10 patents filed or extant in the REF period, with IP and legal advice from DBIS (***Przyborski*** - cell culture systems, chemical inducers of cell differentiation; ***Slabas*** and ***Lindsey*** - genes controlling plant defence, starch and oil yield in plants; ***Jahoda*** - skin model culture system), underpinning their commercial innovation and attraction of investment (£8M for *ReInnervate*, £1M for *ClarinnisBio*, £1.5M for CGT). Beyond spinout company development, IP has also been filed by ***Ambler*** in the area of stem cell biology, ***Chazot*** (behavioural tests for rodents), ***Denny*** (screening assay for antagonists of kinetoplastid and plant inositol phosphorylceramide synthases), ***Gatehouse*** (insecticidal proteins), ***Quinlan*** (combretastatins as drugs), ***Walmsley*** (bioethanol production) and ***Weinkove*** (folic acid and ageing). This IP represents a basis for future licensing opportunities with industrial partners.

Key staff have been allowed to buy out a proportion of their time to encourage company development, including for ***Przyborski*** (and previously ***Edwards***) through successful application for external Fellowships (BBSRC-Royal Society Enterprise Fellowship to ***Przyborski***, BBSRC Industrial Fellowship to ***Edwards***).

Realization of Impact (Fig. 1 'Impact'): Company partnerships. As part of our strategy to promote company links and knowledge transfer, *Cambridge Research Biochemicals* (CRB) have located members of staff within dedicated Translational Laboratory space in SBBS, and use the animal house for antibody production, in a mutually beneficial arrangement - CRB staff discuss science with academic staff, and the company provides opportunities for work placements for postgraduates. The company also benefits from our expertise and facilities in proteomics, protein-protein interactions, FACS and bioimaging, which are core to their business development.

Realization of Impact (**Fig. 1 'Impact'**)**: Policy development.** A strategic aim is that some research directly influences science policy, particularly in the area of biodiversity and conservation. One example is detailed as an Impact Case Study (*Protection of an Endangered Distinct Population Segment)*, in which a successful petition was filed in 2005 by the National Marine Fisheries Service (NMFS) in Seattle, USA to protect the killer whale population residing in the inland waters of Washington State, following population studies carried out in SBBS and contribution to policy in the International Whaling Commission (***Hoelzel***). Other examples include links with UK and EU governments, RSPB, WHO.

Realization of Impact (Fig. 1 'Impact'): Working with the media, public outreach. A further aim is to engage with a wide range of outreach activities, from participation in *Cafes Scientifiques*, *SET for Britain*, *YES* competition, the *Celebrating Science* and *North East Big Bang* Science Fairs, the *Durham Science Festival*, talks and workshops at Durham's Botanical Gardens (linked with the outreach association '*Friends of the Botanical Gardens'*) and at the Newcastle *International Centre for Life*, and in local schools. One staff member has participated in national TV programmes (***Twiss***, BBC's *Coast* and *The One Show*), and one is a regular contributor to the Guardian's *Country File* and the BBC magazine *Gardener's World* (***Gates***). Others have contributed to popular publications (e.g. *Time Magazine*, *Discover Magazine*, *World Birdwatch Magazine*, *BBC Wildlife Magazine*, ***Willis***), radio (*BBC World Service, Radio 2, Radio 4, CNN*; ***Huntley, Willis***) and have written a number of popular science books (***Gates***). Advice has been provided to the BBC Natural History Unit (Andrew Dawes of the *BBC Natural History Unit Radio*) and independent film maker Andy Torbet, and to *Natural England* in relation to seal ecology and behaviour; fieldwork blogs have been established to promote awareness of seal ecology amongst the public (*http://www.smru.st-andrews.ac.uk/newsItem.aspx?ni=216*); and a video produced on seal ecology is shown at the *Scottish Seabird Centre*, which enjoys 300,000 visitors and 1 million downloads per year (***Twiss***). The *Africa Climate Exchange Portal* website (*http://www.africa-climate-exchange.org/*), developed by *BirdLife International* and SBBS, serves as a one-stop locality for information on climate change, mitigation and adaptation in Africa to allow the general public access to scientific information in an easy-to-reach and readily interpretable format. This proved to be an excellent way to summarize results from a recent Durham project modelling climate change impacts for all sub-Saharan African birds. The *Biodiversity Impacts of Climate Change Observation Network (Bicco-Net)* web-site has been developed to provide the general public with easy access to information on recorded recent trends in British species that are being affected by climate change (***Huntley, Willis***). ***Hutchison*** gave the 2010 *Society of Biology* Charter Lecture on Stem

Cells and Ageing. ***Benham's*** research on fertility has been highlighted on BBC World and the national and international press, and ***Chazot*** and ***Quinlan*** organized the *Well Brain* and *It's a Pain* Lecture series for the public, in conjunction with *The Centre for Life*, Newcastle and the Durham & Darlington NHS Trust and accredited by Royal College of Anaesthesia respectively.

c. Strategy and plans: Future development of the Impact Strategy at Durham will involve the following:

- To continue to provide an environment to develop high quality and multidisciplinary research and training, which underpins and gives rise to projects that lead to socioeconomic impact; achieved through continued investment in new staff and infrastructure;
- To continue to map industry needs with Durham expertise in the life sciences;
- To build on current major impact-oriented research projects, exemplified by those funded by The Bill & Melinda Gates Foundation (malaria control), ERC (disease resistance in rice), BBSRC/P&G (novel antimicrobials), industry (novel insecticides);
- To encourage and support participation in BBSRC's 'Excellence with Impact' and similar competitions, thereby involving more staff including ECRs and PG students in the impact agenda at Durham;
- To encourage staff to participate in training programmes to enhance awareness and involvement in impact activities (e.g. workshops on entrepreneurism and IP, run through DBIS);
- To promote interaction with industry, through joint workshops, discussion meetings and site visits;
- To encourage staff to develop spinout and engagement activities, including embedding in promotion reward criteria;
- To further refine methods to identify and capture impact

d. Relationship to case studies: The strategy for Durham biology's impact is to work across a wide range of areas, including spin-out development, technology transfer to agricultural and healthcare applications and international policy development. Two spinout companies, *ReInnervate Ltd*. and *ClarinnisBio Ltd.*, illustrate how we have promoted the exploitation of multidisciplinary programme of basic science (in neural and skin stem cell biology in the labs of ***Przyborski*** and ***Jahoda*** respectively). The research underpinning *ReInnervate* has involved collaborative links between SBBS and Durham's Department of Chemistry, illustrating the importance of our multidisciplinary science strategy to provide expertise essential for product development. Research facilities have been provided in *Biophysical Sciences Institute* laboratories, which have allowed the development of underpinning research, while Netpark facilities have provided infrastructure for business development and production. *ClarinnisBio* has established business links with *Intercytex, Fujifilm Diosynth Biotechnologies* and *Aderans Inc.* to take forward developments in skin models in a commercial partnership. Investment and IP advice has been facilitated by DBIS.

Impact in agricultural biotechnology, a research strength at Durham, is exemplified by the work of ***Gatehouse***, focusing on the molecular biology and biochemistry of plant defence mechanisms. This work has had a significant impact in the establishment of commercially important GM strategies for crop protection against insect pests, particularly in the Far East. A third spinout (*Creative Gene Technology Ltd.*) is also developing IP in the agribiotech sector (***Slabas, Lindsey***). The research by ***Hoelzel***, ***Lindsay*** and ***Huntley*** illustrates how our ecological research supports our strategy to translate science to environmental and conservation policy. Understanding the population genetics of killer whales by ***Hoelzel*** has led to policy change, through the listing of a specific population, resident in the inland waters of Washington State, as endangered under US law, governed by the Endangered Species Act, ESA, of 1973. This led to the establishment of a Recovery Plan for Southern Resident killer whales, whereby new regulatory policies were proposed and published in the Federal Register. ***Lindsay's*** work on malaria transmission has led to the adoption of insecticide-impregnated bed nets in sub-Saharan Africa, with major impact on disease spread. ***Huntley's*** research on the effects of climate change on species diversity has been used by government agencies, international bodies and environmental groups, resulting in an international shift in public policy and biodiversity conservation.

These examples illustrate Durham Biology's approach to impact, whereby basic science has led to company development, agricultural strategy and employment opportunities, through to the development of policy promoting biodiversity and species conservation.