Institution: University of Birmingham

Unit of Assessment: A5 Biological Sciences

a. Context

Research within UoA5, which comprises the School of Biosciences (a member of the College of Life and Environmental Sciences), is organised into four themes: BioSystems and Environmental Change (BEC), Microbiology and Infection (IMI), Molecular Cell Biology and Signalling (MCB) and Plant Genetics and Cell Biology (PGCB). This subject breadth enables our research to impact on a wide range of Private and Public sector non-academic beneficiaries and the General Public. Impact arises from Biosciences' research via four primary routes:

First, aspects of research undertaken in BEC, PGCB and IMI are designed to impact on the ***Environmental Sector*** by influencing policy and engagement with private and public stakeholders and the general public. Examples include: Research on non-native biological control agents which has influenced UK and EU policy via DEFRA and the European Plant Protection Organisation (EPPO) in the development of environmental risk assessment policy; The development of new non-toxic paints for ships' hulls to reduce environmental impact has involved engagement with both the public sector (Office Navel Research, US Navy) and private sector companies (Nanocyl, Sharklet Technologies Inc., Teer Coatings Ltd., International Paint Ltd.); Studies to assess the toxicological impact of various compounds have been conducted in conjunction with the MOD, DFID and companies such as Monsanto. Environmental research also engages with NGOs such as the British Trust for Ornithology.

Second, work in PGCB impacts on ***Production in relation to Food security***. Our research is being applied to develop the first systematic approach to the formulation of policies for agrobiodiversity conservation to protect crop wild relatives and landraces. Engagement and impact occurs via National, European and International Public Institutions and policy-makers (eg UN Food and Agriculture Organisation). The development of computational methods for QTL (Quantitative Trait Loci) mapping, study of meiotic recombination and self-incompatibility has resulted in on-going engagement with a wide range of Plant Breeding Companies (eg. KWS, Limagrain, Sesvandehave, Plant Bioscience Limited, Biogemma, Seminis Monsanto, Rijk Zwaan).

Third, research in MCB and IMI has impact within the ***Health and Welfare sector***. This includes the Pharmaceutical Sector (eg. GlaxoSmithKline (GSK), Hoffman le Roche, BioCryst Pharmaceuticals Inc., R.W. Johnson Pharmaceuticals, Gilead Sciences Inc.) via routes such as: The identification and validation of novel drug targets for possible therapies and vaccines; Improvement of antibiotics; Validation of new anti-viral drugs against influenza virus. Identification of new indications for existing drugs through drug repurposing screens to treat leukaemias and lymphomas has impact on the ***Public Health Sector*** including the NHS and overseas organizations. Novel approaches to health related issues based around our technical infrastructure and expertise is having impact in Diagnostics and Biotechnology. For example, mass-spectrometry has been applied in the improved detection of haemoglobin variants in neonatal blood; linear dichroism has provided the basis for a diagnostic tool for pathogens developed in collaboration with Abingdon Health; Development and commercialisation of an innovative stopped-flow cuvette for FTIR spectroscopy in conjunction with TgK Scientific Ltd

Fourth, a major challenge for the scientific community is the increasing importance of ensuring that the ***General Public*** has a better understanding and awareness of our research. A key aim of Biosciences is to capitalise on our broad range of research expertise to inform the general public about science in the 21st century, explaining the challenges and how scientists are tackling these challenges and allaying misconceptions in controversial areas such as genetic modification. Finally, research in Biosciences has impact on the General Public as stakeholders and end-users as they are ultimately the beneficiaries of improvements in the environment, health and welfare and greater food security.

b. Approach to impact

Overview of approach

The approach taken by the School of Biosciences to deliver impact is centred on the development and fostering of long term relationships with public and private sector organizations and the

general public. In the past, impact delivery was largely dependent on the traditional route of achieving impact via research dissemination. This remains an important mechanism for creating and maintaining awareness of Biosciences research. This occurs through presentations at relevant national and international conferences and workshops which are attended by academics and non-academic beneficiaries. Publication in the peer-reviewed scientific literature and popular press is an important approach to maximise impact of Biosciences research and where feasible this is coupled with press releases to generate further public impact. Nevertheless impact arising from this "traditional" approach is often dependent on the occurrence of serendipitous contacts.
Hence, in recent years a more ***proactive approach to foster impact*** has been developed as part of the activity of the Biosciences and LES Research Support and Knowledge Transfer Committees. The overall aim is to encourage academics to build pathways to impact in research projects at an early stage; to identify possible opportunities to develop impact and to provide an over-arching infrastructure that facilitates impact delivery. The Research Facilitators of the **LES Research Support Office (LES-RSO)** enable academics to achieve effective targeting of beneficiaries, via existing routes and the identification of new routes of engagement. The LES-RSO is proactive in Biosciences academics fostering UK, European and International impact by providing an interface with the **UoB Research and Innovation Services (RIS)** group which coordinates Institutional support for enterprise and provides specialist research support. Staff are also encouraged to make use of the UoB Follow on Funds scheme aimed at facilitating translation of fundamental research. In addition, schemes such as the Medici Enterprise Training Programme and UoB Knowledge Transfer Secondment Scheme provides staff with an understanding and opportunity to develop commercial benefits and economic impact from their research.

Engagement with the Private Sector to achieve Impact
The private sector is a key beneficiary of Biosciences research and is engaged through a variety of routes. ***Early engagement leading to sustained interactions is encouraged and achieved through industry-linked Doctoral training programmes*** (eg. BBSRC-CASE). As an illustration, work on G-protein coupled receptors in relation to rational drug design to modulate the activity of hormones such as vasopressin has led to sustained engagement with a number of pharmaceutical companies including Ferring Research; Organon; Merck, Sharp & Dohme (MSD) and AstraZeneca. At the Institutional level, Alta Innovations Ltd (housed within RIS) provides advice on Intellectual Property, through logging of a "Record of Invention" to filing of patents. Using this route, Biosciences academics have logged 54 Records of Invention and filed 13 patent applications; 3 licence agreements, 1 assignment agreement and 1 option agreement have been granted to third parties since 2008. RIS helps academics to initiate links with the private sector to enable academics translate their research. Work on self-incompatibility to control plant breeding systems is a typical example, where RIS advised on filing a patent and established a link with PBL (Plant Bioscience Ltd) who financially supported on-going translational studies.
The strategy of making Biosciences's research facilities and associated expertise (genomics, mass-spectrometry, advanced light microscopy) available to external users has led to engagement with a variety of private sector beneficiaries through the provision of services and technical development. Examples include, Novozymes Biopharma UK Ltd., Nanotherics Ltd., Oxford Biodynamics, Phillips Oral Healthcare. The development of close working relationships with companies for knowledge transfer and technical development is encouraged. A recent example is the selection of Biosciences as the sole Thermo Fisher Scientific Alliance Partner for Europe.

The ***development and exploitation of links with industrial-academic consortia*** enables Biosciences academics to highlight their research to commercial organisations. For example, the TB Consortium has been used to develop collaborative links with pharmaceutical companies (eg GSK). Participation in the BBSRC Bioprocessing Research Industry Club (BRIC) has facilitated contracts with pharmaceutical companies including GSK, Lonza, Trojantec, Touchlight Genetics and Novartis to overcome the problems associated with the expression of certain classes of recombinant proteins in bacteria.

Collaborative research projects are an effective route to engaging with industry. Links with NIAB-Innovation Farm through participation in an ERDF (European Regional Development Fund), BBSRC Lola and EU-FP7 projects (MeioSys and Marie Curie ITN COMREC) coordinated by academics in Biosciences provide interaction with plant breeding companies who are also represented on the project steering committees (eg KWS, Sesvanderhave, Keygene). Similarly, a

recently awarded Marie Curie European Industrial Doctorate project will further strengthen links between the IMI Tuberculosis group and industry (GSK).

As a further approach to engagement, ***secondments between academia and the private sector*** funded by the UoB Knowledge Transfer Scheme has contributed to work aimed at producing hybrid antibiotics from marine bacteria to treat MRSA with the Japanese pharmaceutical company Daiichi-Sankyo; the development of a novel diagnostic platform for pathogenic organisms with Fleet Bioprocessing; and production of biohydrogen from waste in conjunction with United Utilities.

We aim to commercialise research activity where possible. Academic awareness of opportunities for commercialization and the routes to achieving this are promoted at the School/College level by the LES-RSO. This involves organization of workshops to promote awareness and stimulate links. One example was a recent Research and Industry Day involving a number of KTNs and the TSB. Where opportunities for commercialization are identified the LES-RSO provides an interface with the UoB Research Innovation Service who provide further expert advice and support in achieving commercialization. During the REF period 3 spin-out companies were formed: Plasgene, Stemtrax, Linear Diagnostics Ltd. These cover respectively: Antibiotic resistance and methodology for removal of unwanted antibiotic resistance plasmids; stem cell amplification and a diagnostic platform for the detection of infectious agents established as a joint enterprise between the UoB's technology transfer company Alta Innovations and Abingdon Health, a venture capital organisation.

Engagement with the public sector

Biosciences impact in the public sector has been developed through engagement with the Environmental stakeholders, the Health and Welfare stakeholders and through direct interaction with beneficiaries. The approach to achieve public sector impact in relation to Environmental issues has been to develop direct links with the UK, European and International policy making bodies which have led to sustained engagement. As a result significant impact is being achieved as evidenced by two impact case studies relating to biocontrol agents and the conservation of biodiversity (Bale and Maxted). Biosciences Health and Welfare related impact in the public sector is based on engagement with the National Health Service, Charitable Organizations such as the Leukaemia and Lymphoma Research Fund and Institutions in Developing Countries (University of Malawi). This has led to trials of novel, more accessible approaches to treat leukaemia and lymphomas based on drug repurposing (Bunce case study) and in conjunction with the Birmingham Children's Hospital, the development of a novel method to identify haemoglobin variants in neonatal blood (eg sickle cell). There is also close involvement with the NIHR Surgical Reconstruction and Microbiology Research Centre (Queen Elizabeth Hospital) centred around IMI work on fungal pathogens (May).

Engagement with the General Public

Biosciences engagement with the General Public aims to stimulate awareness and promote understanding of our research and important science-related issues and is promoted via a variety of routes. School visits (25-30 p.a.) and events on campus aim to bring up-to-date research to the attention of School children and stimulate an interest in science. Interactive opportunities include a Summer School for 6th formers; master classes and laboratory work experience; the annual Biology Big Quiz involving ~500 pupils. Engagement occurs through the traditional broadcasting and news media. For example, work from the Biosciences Centre for Ornithology and IMI featured on BBC's Springwatch and BBC local news respectively; animal behaviour work has featured on TV in the UK and overseas (eg BBC, Discovery Channel, the Canadian and Australian Broadcasting Companies); radio appearances on programmes such as the Naked Scientist, Material World and In Our Time; a briefing for journalists on Synthetic Biology. Press releases via the University and external (eg BBSRC) publicity offices are used as a further route to engage with the General Public, enabling the dissemination of research in an accessible form. Examples include: Insights on ageing gained from work in nematodes; the enterohaemorrhagic *E. coli* O104:H4 outbreak; work on meiotic recombination and self-incompatibility in relation to Food Security. Web-based media (eg. Podcasts, Twitter) is an increasingly important route for engagement. Typical examples include: a podcast on biohydrogen production which featured on the New Scientist's web-site and the pathogenomics blog; Exhibitions and public engagement events at museums and International Conferences provides a further route to engage. These are promoted through the activities of individuals or groups of Biosciences academics and via the UoB

Public Engagement Working Group, which involves the School's Research Director. Specific examples of events include: Interactive displays at Big Bang fair at the National Exhibition Centre and ThinkTank (Birmingham Science museum); Organization with support from BBSRC of a "Flower Power for the 21st Century" public event during the 23rd International Conference on Sexual Plant Reproduction. Dr Thorpe has acted as a consultant for North of England Zoological Society, Dudley Zoo and Twycross Zoo for enclosure design and innovation to enhance physical and psychological welfare of great apes through facilitating naturalistic locomotion.

c. Strategy and plans

Biosciences Research Impact Strategy aims to create a research environment where academics are cognisant of how to build impact into their research programme, the opportunities to achieve impact from their research and the routes that are available to implement delivery of impact and to facilitate effective access to these routes.

Plans for supporting and enabling impact from current and future research

The development and implementation of Impact Strategy is embedded within the overall research management infrastructure at the School and College levels through the Research Support and Knowledge Transfer Committees. Plans to enhance impact include:

i. A continuing role for the LES-RSO to create awareness, promote best practice and encourage early interactions with beneficiaries through an on-going programme of events.

ii. The inclusion of a review of research impact within the annual Personal Development Review process. Potential new impact will be further developed and coordinated via the Biosciences and College Research and Knowledge Transfer committees.

iii. Pathways for achieving impact, public engagement and dissemination to end-users will be considered as part of the internal grant application approval process for new grants to ensure they will be effective.

iv. Effective use of the recently appointed College Business Engagement Partner who will report in line to the University Director of Business Engagement based in Research and Innovation Services, to strengthen research commercialisation.

v. Capitalising on the acquisition of new technology and new links to deliver new impact and additional impact from current research. Examples include: The Birmingham Drug Discovery Facility a high-throughput drug screening facility will enable translation of IMI and MCB themes research; the Joint BGI-Birmingham Environment and Health Centre offering high throughput DNA sequencing and informatics analysis; and the Thermo-Fisher Scientific alliance will have impact in environmental protection and human health.

vi. Promotion of greater public engagement through the recently appointed academic champion and LES-RSO deputy, who will be members of a cross University Public Engagement Working Group which is co-chaired by Alice Roberts, Professor of Public Engagement in Science and Professor Ian Grosvenor, Deputy Pro-Vice Chancellor for Cultural Engagement.

d. Relationship to case studies

The Biosciences impact case studies are drawn from across the range of the School's research activities and provide evidence of how this generates impact via a variety of routes across our different stakeholder groups. Fostering links with UK and overseas regulatory agencies over a period of years has enabled significant impact to arise in the formulation and application of policy in the areas of biological control and conservation of biodiversity (Bale and Maxted). The benefit of encouraging early engagement with stakeholders through Doctoral projects, such as CASE awards is clearly seen, as this route contributed to 4/5 of our studies. Building on early links through network projects such as EU Marie-Curie ITN projects has also proved effective and is now encouraged in our future impact strategy (section c). The drug repurposing case study (Bunce) has arisen from engagement and appreciation of the needs of the Health sector both in the UK and overseas and is providing a template for future development of this strategy through developments such as the Birmingham Drug Discovery Facility and Joint BGI-Birmingham Environment and Health Centre. Finally, the Wharton case study is an example of exploiting technology development to fill a market gap. Although, this has not been a particular strength in the past, the importance of this route is now appreciated and support for this route is now being strengthened.