Institution: The University of Leeds

Unit of Assessment: UoA5 Biological Sciences

a. Context

Each of the groups in this Unit (**Structural Molecular Biology, Integrative Membrane Biology, Plant Science, Ecology and Evolution, Virology** and **Medical Engineering**) conduct excellent fundamental, applied and interdisciplinary research, the results of which have impact in a number of areas of national importance, notably economic growth, food security, living with environmental change, health and wellbeing. The main non-academic beneficiaries are UK and global businesses; health services, health professionals and patients; UK and overseas governments and policy makers; charities and non-governmental organisations; and the general public. Research in the Unit delivers a number of HEFCE types of impact, and these are displayed in the text below using the following key: *[1]Health and wellbeing, [2]Attracting R&D investment from global business, [3]Commercialisation of scientific knowledge, [4]Evidence based policy-making, [5]Environmental protection.* Reference to impact case studies is denoted by CS1 (case study 1), CS2, etc.

Impact has been delivered in a number of ways through research in Biological Sciences, including:

(i) Contributing research findings to underpin the **development of existing companies**[1, 2, 3] e.g. Ingham (Medical Engineering), DePuy, CS1; Atkinson & Urwin (Plant Science) Sinochem, Monsanto, CS2; Ashcroft (Structural Molecular Biology), AstraZeneca, GSK, MedImmune, Union ChimiqueBelge (UCB), Waters UK.

(ii) Fundamental science underpinning technologies which have led to the **creation and growth of new companies**[1, 2, 3]. The research of Radford (Structural Molecular Biology) into the structure and behaviour of peptide and protein molecules laid the foundation for the formation of the novel dental product company Credentis ag (Switzerland) in 2010 (CS3). Similarly, Bojar founded Leeds Skin Care Ltd. in 2008 (subsequently Evocutis plc) based upon research in skin microbiology. Other companies were founded on research from this Unit prior to REF and continued to grow with the support of new research findings throughout REF (Ingham (Medical Engineering), Tissue Regenix, CS4; Radford (Structural Molecular Biology), Avacta, CS5; Brown, Photopharmica; Colyer, Badrilla; Millner (Medical Engineering), Elisha Systems Ltd.).

(iii) **Influencing governments and policy makers**[4,5].This has been delivered in a number of ways, including research on biosecurity in the Galapagos Islands, which led to changes in policy that are now implemented (Goodman (Ecology and Evolution), CS6). Further impact has been delivered through the work of Benton et al. (Ecology and Evolution, CS7), where research into sustainable agriculture has influenced UK, EU and global policy makers. The work of Atkinson & Urwin (Plant Sciences) into nematode resistant crop plants has altered policy concerning the biosecurity of GM crop trials and has built GM agriculture capacity in developing countries (CS2).

b. Approach to impact:

The delivery of impact from our research has been a priority in this Unit since 2003, when a Director of Innovation (0.4 FTE professorial appointment) was appointed to lead this and to ensure that impact was central to strategic planning in the faculty. Prior to REF, the Unit evaluated its existing attitudes and achievements in impact, created the support services needed to enhance the delivery of impact and secured an investment of £500k (from both Unit and HEIF funds) to deliver impact in the REF period. Additional resources were made available from 2012, with the creation of 14 university-wide Innovation Hubs (or Sector Hubs) to coordinate interdisciplinary activities focused on major societal challenges (£6M, from HEIF). The Hubs, which employ experienced business development managers (BDMs, from the relevant industrial sectors) and have appropriate financial resources, interface with external partners and accelerate the translation of research into impact. Four of these Hubs are germane to this Unit (Food Security, Medical Technologies, Pharmaceuticals & Biopharmaceuticals, and Stratified Medicine) and researchers in this Unit work collaboratively with Hub and local innovation staff to deliver impact from research.

Impact takes many forms (section a), and we have developed a three-pronged approach to deliver impact.

1. Approach to economic benefits: The Unit has developed an entrepreneurial culture resulting in the identification of intellectual property, its protection and licensing to companies and its use in the creation and growth of companies. This culture is fostered through a series of activities. **(a)** A comprehensive training programme in impact (ranging from the induction programme for new Ph.D. students to an 8-day course for company directors). **(b)** The celebration of the success of individuals in the delivery of impact (personal promotion, BioEnterprise web-site, an impact

seminar series). **(c)** Mentoring of staff by colleagues with commercial experience (e.g. Chopra, Colyer, Ingham, Withington, Hames, Atkinson), and the active encouragement of staff to develop the opportunities arising from their research (secondments to new companies - Bojar, Colyer: personal Enterprise Fellowship - Ponnambalam). **(d)** We have created the physical facilities necessary for the establishment of spin-out companies by opening a bioincubator facility (550m^2 lab & office space) in Nov 2007. This facility has been occupied at 80% capacity throughout REF, accommodating 8 companies including two spin-outs from this Unit (Tissue Regenix, ELISHA Ltd.) and one company relocating to Leeds to access research in this Unit (iQUR 2008-9). The entrepreneurial culture has resulted in the creation of several new companies during REF (Leeds Skin Care (2008), Credentis ag (2010), Aptamer Solutions Ltd. (2012), Aptamer Diagnostics Ltd. (2012)). A further 7 companies, created from this Unit at earlier dates, have grown with our assistance in the REF period (Tissue Regenix plc (2006-date) CS4), Avacta Group plc (2006-date CS5), Science Warehouse Ltd. (Hames: 1999-date), Syntopix (Cove & Eady: 2003-2011: sold to Evocutis plc), Photopharmica Ltd. (Brown: 2001-date), Badrilla Ltd. (Colyer: 2003-date), ELISHA Systems Ltd. (Millner & Gibson: 2007-date)).

Economic impact has also been delivered by supporting existing companies. Ingham & colleagues supported DePuy in product development by performing fundamental research into patterns of wear and the biological response to wear particles in the medical prosthetics industry (1999-date, DePuy, CS1). Atkinson and Urwin (CS2) licensed GM strategies for nematode resistance in food crops to multinational companies (SinoChem, Monsanto) and performed collaborative research with these companies to accelerate product development. Rowlands (Virology) created an efficient vaccine technology, which was licensed to UK biotechnology company iQur and became their main focus of business. Colyer created a calibration technology for immunoassay applications which was licensed to Badrilla and McPherson invented a recombinant protein aptamer technology (antibody-alternatives) that has been licensed to Avacta plc and formed a major part of their recent fund-raising activity (£4.7m share placement, 2013).

2. Approach to impact – dissemination as a tool to build new partnerships: Wide dissemination of our capability and research achievements was identified as a key tactic to identify partners able to collaborate to deliver impact (the foundation of several long-standing academic-industrial relationships – Ingham-DePuy, Chopra-Leo Pharmaceuticals, Holland/Bojar-Cosmetics industry). Learning from the tactics used by these individuals, we have explored the use of a variety of channels for dissemination to non-academic audiences [trade magazine articles (Plant Science, 2012), direct marketing via BioscienceKTN (Plant Science, 2012-13), HealthKTN (Structural Molecular Biology, 2011-12), and a public relations agency (Campus PR, 2006-2012, thereafter press office of University)]. Considerable success was achieved with the latter two. A campaign of industrial engagement assisted by the HealthKTN led to networking, the creation of an industrial advisory board and the establishment of several collaborative programmes of research with pharmaceutical companies (more below). The use of a public relations agency led to over 100 press releases from this Unit during the REF period, creating several hundred news items across the world. In response to one press release, Benton (Sustainable Agriculture) was encouraged to prosecute the further dissemination of this research at the end of his term as ProDean for Research. This strategic investment by the Unit contributed significantly to his appointment as the Global Food Security Champion for the UK (0.8FTE, 2011-date). This cross-Research Council role has enabled Benton to inform governments and policy makers (UK, EU and G-20), food producers and retailers of the scientific evidence for sustainable food supply (CS7) and is changing the policy debate and industrial practice.

3. Approach to networking: Networking has proven to be an essential element of strategies to engage with end-users to deliver impact. It has resulted in the collaborative definition of new programmes of research, and in the communication of critical (research) evidence to key decision-makers. To encourage networking at the appropriate level, the Unit has sponsored groups to host events and campaigns (open days, industry days, open innovation workshops, and to run campaigns of engagement with industry). These networking events have been highly significant. They have engaged a large proportion of staff in the impact agenda (>40 of ~60 staff) and have initiated the delivery of impact in many different areas. Outcomes include: **(a)** the foundation of the Yorkshire Dales Environment Network (a consortium of 24 companies and conservation organisations involved with the development of the Yorkshire Dales; led by Dunn and Altringham (Ecology & Evolution) with funding from NERC: 2012-present). Similar consortia have now been

established by Leeds' researchers in other national parks (Lake District, North York Moors, Northumberland). **(b)** The construction of a research network of 28 biopharmaceutical and related companies, an Industrial Advisory Board (19 industrial members plus members of the Structural Molecular Biology group) and £3.4M of new collaborative research (2011-present: £3M shared with chemistry). **(c)** Networking is just as effective in policy and public good areas of impact: Goodman used networking, and a sustained collaboration with conservation lobbyists, to inform key decision-makers of the biosecurity threats to the Galapagos. This resulted in a change in Ecuadorian law and commercial aviation to protect these islands (Goodman 2004-date (CS6)). **(d)** Goodman also used networking to bring together industrialists and governmental representatives from the Caspian Sea States in a consortium evaluating the impact of industrial activity on the environment (Caspian seal conservation). **(e)** Networking is fundamental to the success of "Africa College", an interdisciplinary consortium that was formed by the University in 2009 to address food and nutritional security in Sub-Saharan Africa. It is led by staff from this Unit (Benton, Atkinson, Foyer) and between 2009-2011 employed an operations director seconded from Dept. for International Development (Howlett) to optimise alignment, leverage and consortium building in the delivery of impact from this project to the people in sub-Saharan Africa. Africa College brings together researchers from many disciplines in Leeds, African agricultural research organisations (the International Institute of Tropical Agriculture (IITA), the International Centre of Insect Physiology and Ecology (ICIPE)) and farmers in Africa to define new programmes of research and to disseminate new food security practice in Africa. Impact is being delivered through: the engineering of membrane transport proteins to develop crops which are more tolerant of acid soils and better able to take up phosphorus (Baker and Baldwin, BBSRC (BBS/B/14418, BB/F007299/1), and the establishment of GM field trials in Africa (Atkinson and Urwin, CS2). Furthermore, we are collaborating with many African-based academic and private sector partners to assess the effectiveness of community-based payment for ecosystem service schemes for climate-smart agriculture. It has stimulated the formation of new research partnerships in the UK and Africa, each focused on research capable of addressing the food security challenges of Africa (British Council DelPHE programme (led by Bunda College of Agriculture, Malawi); the NERC/DFID ESPA programme (Beismeijer); NERC PhD studentship (joint between School of Earth and Environment and Faculty of Biological Sciences at the University of Leeds); ESRC White Rose DTC PhD).

In summary, the policies of wide public dissemination of research achievements and active networking with external parties have created collaborations between researchers and end-users at all levels (PhD student to professor). This has informed some of the research questions being addressed in the Unit, and has influenced key decision-makers in industry and government.

Impact is also delivered through the work of individuals as consultants. Advice is provided to public bodies, NGOs, governments and companies. Examples include Altringham (expert witness in public enquiries; member of National Trust's National Environment Panel); Benton (CS7), Goodman (CS6), Atkinson and Urwin (CS2) advising policy makers; Ingham *(*DePuy*,* CS1), Colyer (AstraZeneca), McPherson *(*AstraZeneca, Eluceda Ltd.), Radford (Avacta plc, CS5)*,* Millner (ELISHA Systems Ltd.), Hamer (Seagreen Wind Energy) advising industry. Staff also support companies through membership of science advisory boards (Chopra, Leo Pharmaceuticals; O'Neill, Blueberry Therapeutics). The Unit facilitates consultancy work by active promotion of opportunities, allocation of time within staff contracts for such activities (up to 30 days per year), and by providing back office support for the delivery of consultancy contracts (contract negotiation, invoicing, legal, insurance).

c. Strategy and plans

Our commitment to the impact agenda is long-standing, pre-dating the REF period with the appointment of a Director of Innovation in 2003. The Director shaped both local and University-wide policy for knowledge transfer (Institutional Strategy http://strategy.leeds.ac.uk) to ensure that the support services needed by this Unit for the delivery of impact were in place. The Unit championed the creation of a bioincubator facility (2007/8) and has made full use of the University support services throughout REF, namely: Sector Hubs–industry-focused BDMs, networking, proof of market funds, proof of concept funds; ConsultingLeeds– a consultancy support company of the University of Leeds (2008-13: Hamer, Ingham, Millner, Knox, Colyer, McPherson, Radford); Commercialisation Services– a unit that manages patent protection, licensing and exploitation of IPR (Ingham, Colyer, Ponnambalam, Urwin, Harris, McPherson, Stockley); Techtran/IP Group– a venture capital company that partners the university for the creation of new companies

(investments deployed during the REF period into Tissue Regenix, Ingham; Evocutis, Bojar; Photopharmica, Brown).

Our goals are clear– to deliver to Society substantial benefits from our research, promptly and efficiently. This has enabled the articulation of a strategy to realise these goals. The strategy is for individuals to connect with the users of their research, to define the critical problems faced by these user-groups and to perform (funded) collaborative research to address these; to protect new discoveries, where appropriate, and to exploit these discoveries in partnership with external organisations for the benefit of society and the collaborators. The strategy has been in place for the last few years, resulting in the achievements described in section b (above). Individual elements of the strategy, and areas for future growth are described below:

1. Embed impact in the culture of the research community Achieved to date through training, promotion criteria, protected time, enterprise fellowships and entrepreneurial mentors (section b). Beyond 2013, we plan to enhance these activities, to create an Early Career Researcher Club (PDRA, fellows, new lecturers) that supports the development of research and impact plans of individuals, and to provide personalised training in the delivery of impact to increasing numbers of research staff. These activities are central to our BBSRC Excellence with Impact Vision.
2. Rigorous market assessment of opportunities and early investment program for suitable opportunities Funds to accelerate translation of research to impact are available. These funds are actively managed to permit early disinvestment in "failing" projects and the reallocation of resources. We are investing in GM agriculture, regenerative medicine and ion channelopathies.
3. Defining, performing and disseminating collaborative research with end-users We will develop academic/non-academic research networks to help define our research, for example, with industry and government agencies to address food, nutrition and health (capitalising on our research farm and distinctive expertise). With governments and NGOs, we will exploit soil microorganism diversity in Africa to enhance agricultural output, and with the pharmaceutical sector we will explore ion channelopathies in human disease. In addition, we will expand our range of collaborative research in all areas through, for example, industry clubs, direct marketing, etc.
4. Build research collaborations with non-academic organisations into long-term strategic research partnerships To date we have strategic partnerships in medical technologies (DePuy) and food (M&S). We plan to build lasting relationships with key partners in other areas, for example, with particular pharmaceutical companies and, in the case of ecology, land management research with particular National Parks and other land owners.
5. Exploiting research discoveries, tools and resources Effective support systems are in place to exploit research assets (in REF period: 5 patents filed, 16 patents assigned to external companies, 3 new licences, 7 active licences, 4 spin-out companies formed). We anticipate growth in these outputs beyond 2013, particularly in biopharmaceuticals, medical engineering and ecology-land management.

d. Relationship to case studies

The Unit aims to deliver the highest level of impact from research in the shortest possible time. The seven case studies submitted represent the most advanced examples delivered by the Unit, which possess the greatest reach and significance. They are drawn from 4 of the 6 research groups within the UoA: Structural Molecular Biology (2), Plant Science (1), Ecology and Evolution (2), Medical Engineering (2). In all cases, impact is achieved through the utilisation of IP arising from excellent research. In three cases this is based upon patent-protected advances in technology which have formed the foundation of new companies (CS4, Tissue Regenix, Ingham; CS5, Avacta, Radford; CS3, Credentis, Radford). One case study relates to the utilisation of IP through a long term strategic partnership with industry, driven by an explicit strategy from the lead academics (CS1, DePuy, Ingham) and one relates to IP having been licensed to existing multinational companies (CS2, Urwin & Atkinson). The case study (CS7) by Benton et al. involves dissemination of excellent research by an individual in a high profile national role to policy makers and industry and consumer groups, and that of Goodman (CS6) relates to research informed policy making resulting in a change in legislation and commercial aviation practice to prevent harm to a unique ecosystem (Galapagos: a World Heritage Site).