Institution: The University of Edinburgh

Unit of Assessment: 5

a. Context

Biologists at the University of Edinburgh engage with non-academic audiences and users nationally and internationally to deliver impacts and benefits of global significance and reach. Our impacts are in four main areas (many of our 12 selected case studies have impact across more than one area):

- **Delivering benefit to industry and the economy** through life sciences companies, pharmaceutical companies, and the agri-biotech industry. We have created IP leading to new products or new company formation, and we have developed tools and techniques to improve productivity of agricultural and biotechnological industries. (6 case studies.)
- **Improving human and animal health and welfare and environmental sustainability** through working with the pharmaceutical industry, SMEs and public bodies. We have revealed the mechanisms and processes of human and animal disease at molecular, cellular, organismal and population levels, leading to the development of new drugs, therapies, welfare regimes and environmental interventions. (9 case studies.)
- **Influencing public bodies** through policy and advisory groups, including charitable, healthcare and environmental bodies. We have addressed policy questions in health, welfare and the environment, and have created new understanding that has changed approaches taken by public and philanthropic organisations. (8 case studies.)
- **Engaging with the public** through programmes that deliver broad cultural impact and stimulate debate. We have undertaken in-depth engagement to stimulate awareness of the outcomes, benefits and risks of our research. (3 case studies.)

We have generated impact across all three Research Themes described in UoA5 REF5: **Cell and Structural Biology; Evolution, Infection and Immunity; Systems and Synthetic Biology**. We have also delivered impact through a fourth Research Theme, **Stem Cell Biology,** which now forms part of the Centre for Regenerative Medicine and for which the research activity is included in UoA1. This grouping was part of UoA14 in RAE2008 when the underpinning stem cell research leading to the described impacts was carried out.

b. Approach to impact

Our approach to achieving impact is informed by our overall research strategy and by our successful exploitation of intellectual property. Our aims are to:

- Carry out world-class fundamental research that drives future innovation;
- Invest strategically in target areas of translational science to deliver research outcomes that directly address societal need;
- Identify, protect and develop opportunities for impact wherever they arise;
- Promote future impact through developing partnerships with users.

Our commercialisation statistics demonstrate a healthy level of activity over the REF period: our researchers have made 92 invention disclosures, filed 10 new patent families, and secured 50 licences. Our researchers have also been responsible for one spinout and 4 start-up companies. Typically, we have 10 consultancy arrangements in place at any one time. Our main commercial impacts are with life science reagents companies, large and small agri-biotechnology businesses and pharmaceutical companies (including many SMEs); we also work with the energy, defence and food & drink sectors and we deliver impacts in health, public policy, society and culture.

We employ three embedded **Business Development Executives** (BDEs) within the School with expertise in commercialisation and knowledge transfer, who work closely with central University services to provide the most appropriate support for researchers. Our BDE team has three functions: to identify, protect and develop IP assets for commercial outcomes; to engage with industry to foster long-term research partnerships; and to work with University services to provide specialist expertise in licensing, consultancy and company formation. We expanded this team from

one to two people in 2007 and created the third post in 2012. The BDEs are members of a wider support team managed by the University's commercialisation arm, **Edinburgh Research and Innovation (ERI)**. Having the BDEs based within the School ensures that they are integrated with our research structures and guided by our strategy, and can more easily identify opportunities for impact arising from our research. The School has a public engagement coordinator and we employ four dedicated science communication and public engagement staff. The **Edinburgh Beltane** public engagement network hosted by the University provides training and support in public engagement.

b1. Carry out world-class fundamental research that drives future innovation. This key aim underpins everything we do. We have described in REF5 our structures and strategies to support research. Our track record in translating excellent fundamental science to innovation and impact stretches back well before the current REF period, exemplified by the global economic and health impact achieved through formation of biotech company Biogen in 1978 and development of the hepatitis B vaccine, based on Ken Murray's pioneering work in genetic engineering. More recent examples are described in our case studies.

b2. Invest strategically in target areas of translational science to deliver research outcomes that directly address societal need. In areas of research with direct applications to healthcare, we have created interdisciplinary Research Centres that include both basic and biomedical or clinical researchers, in order to facilitate translation of basic discoveries into benefit for health. Our **Centre for Immunity, Infection & Evolution (CIIE)** was established in partnership with the College of Medicine and Veterinary Medicine in 2008 to accelerate understanding of infectious diseases. As well as biological scientists, it includes biomedical researchers operating as **translational facilitators** in 'close-to-clinician' positions within the medical and veterinary research communities. The University's integrated global health focus is reflected in our approach to this area, which delivers impact across both human and animal health. CIIE researchers and BDE staff hold events to facilitate translation (e.g. an **Industry Day in Neglected Diseases** in Nov 2012 with speakers from **DfID**, **GSK** and other pharmaceutical and charitable groups). Recent research includes studying disease transmission between livestock and humans in Kenya (translatable into impact by links with **Vestergaard Frandsen** who make disease containment products) and identifying a parasite-based vector for delivery of vaccines/proteins/hormones to cattle (developed with an industry partner via a BBSRC industry partnership award). We fully integrated our stem cell biology with medical researchers in 2011 to form the **MRC Centre for Regenerative Medicine,** a 'bench-to-clinic' co-location of researchers created specifically to maximise the translational impact of the fundamental research (research now returned to UoA1). Our **Centre for Translational & Chemical Biology (CTCB),** created in 2006, is a joint enterprise with Chemistry which places a strong emphasis on translating discoveries in basic science to potential drug applications. CTCB provides core facilities for protein production and characterisation, and expertise to enable the discovery of new therapeutics. For example, CTCB has recently been awarded a £2M grant from the Wellcome Trust (WT) to seed drug discovery for trypanosomiasis. Our BDE staff work closely with CTCB to maximise impact (e.g. analysis of drug candidate structures from the pharmaceutical company, **Debiopharm**, to inform their lead optimisation). We are now developing **synthetic biology and industrial biotechnology**, with expected impacts in sustainability and economic development, as described in section **c2**.

b3. Identify, protect and develop opportunities for impact wherever they arise. To help our staff and students recognise the potential for impact of their work, we provide a programme of training and networking in entrepreneurship and public engagement through the **Institute for Academic Development (IAD)**. This has a particular (but not exclusive) focus on early-career researchers, developing capability in our future research leaders. The University's **Launch.ed** programme provides comprehensive support to postgraduate students who wish to develop their research in commercial directions. Our BDEs collaborate with BBSRC and others to run life science-specific events such as **Bench to Boardroom**, **Knowledge Transfer Networks** and **Knowledge Exchange and Commercialisation** focused workshops. These promote awareness, interaction with user groups and access to knowledge exchange funding streams. Researcher engagement in commercialisation is strongly encouraged and incentivised. 50% of any income generated through licensing (below £50,000) and 35% thereafter is provided to the

inventors. 70% of all consultancy income is given directly to the researcher. Many staff choose to put this directly back into funding further research, creating a virtuous circle.

Recognising the early-stage nature of many of our discoveries, we progress work with commercial potential through disclosure and IP protection, followed by focused development towards IP that has commercial value. Our BDE staff work with inventors to identify relevant translational funding opportunities. Examples in the REF period include use of a **BBSRC Industrial Partnership Award** to work with the animal health company **Intervet/Schering Plough**; **Technology Strategy Board**-funded collaborations with Scottish SMEs **Marine Biopolymers**, **Ingenza** and **Synpromics** and a **Scottish Enterprise**-funded ubiquitin drug discovery programme.

At later stages of development we seek to license our IP, or to create new spinout companies. Examples of successful licencing include a method for separating methylated and non-methylated DNA, which led to seven evaluation licences, and from these to two royalty-bearing licences (awarded to **New England Biolabs** and to **Active Motif** in 2012). Other examples are GeneProf Software for interrogating and analysing gene expression data, licensed to **Qiagen Inc** in 2013; media formulations licensed to **StemCells Inc**., with the first product launched in 2009; and a range of antibody licences to **Millipore, Santa Cruz, Abcam** and other companies during the REF period. Company formation includes **Sesmos**, a start-up company developing a screening platform for drug discovery from our IP, in collaboration with **Scottish Enterprise** and **Siemens** (started in 2011, now employing 6 staff with a CEO and COO appointed in 2013); a consultancy project to oversee development of DNA assembly technology which has gone into the start-up company **GeneAbler;** and IP arising from our ubiquitin drug discovery programme which is likely to go into a new pharma company. We offer space to start-up companies within our own buildings and the University provides larger incubator facilities. Start-up and spinout companies based within our buildings during the assessment period include **R Biomedical**, **Sesmos, Stem Cell Sciences** and **Advanced Pest Solutions** (**APS**).

We aim to develop therapies and welfare approaches in human and animal health directly from our basic research and via collaboration with clinical scientists. For example we have used our **MRC Development Pathway Funding Scheme** to support drug discovery targeting cyclophilin proteins, and **WT** funds to identify inhibitors of an RNA ligase for treatment of African sleeping sickness. We also deliver impact through collaborative research programmes with industry: for instance with cancer drug discovery company **Cyclacel** on use of software tools; and with **Landcatch** applying next-generation sequencing to identify disease-resistance traits of farmed fish (impacting welfare and value of salmon breeding programmes). Recently, we have developed research with more direct links to clinical evidence and outcomes (e.g. using biobank samples to develop diagnosis and treatment tools for muscular dystrophy). Such research activities are still at an early stage but offer significant impact potential for the future. Importantly, these have been disclosed early and expertise is being provided to establish appropriate development pathways.

Consultancy and service work is another important route to economic, societal and policy impact. Examples of the success of these types of interaction, particularly for SMEs who can tap into our extensive expertise and equipment, in delivering commercial impact include: the use of mass spectrometry facilities by University spin-out **Destina**; the use of our specialist greenhouses by locally-based pest control company **Xeroshield**; expert consultancy and use of protein production facilities for **Alba Biosciences**; and consultancy resulting in impact on the productivity of the UK dairy industry. We achieve impact on society and on policy through a range of instruments including consultancy, work with special-interest groups (e.g. patient groups such as Rett syndrome families), and advice to government and NGOs (particularly in animal and human health). Organisations include the **World Health Organization** (disease burden and economics); the **Deer Commission for Scotland** (deer management); **Scottish Natural Heritage** (wildlife management); and the **Forestry Commission** (conservation of native pinewoods). Two staff have acted as expert witnesses in civil litigation and criminal trials where identification of virus strains has been critical to the case outcome.

To increase the dissemination of our research and engagement with the public, our **Press Gang** is a volunteer group of staff that identifies current research of public interest and works with the researcher and the University's press office to develop accurate and engaging stories (20 press releases produced by the Press Gang received media coverage in 2012). Our **BioPod** group

creates podcasts on current research (5,700 downloads in the last year). We host the **Scottish Institute for Biotechnology Education (SIBE),** a programme that works with schoolteachers to improve classroom practice. A large-scale public engagement programme around our stem cell research, with an audience of more than 1M people, is featured in a case study. A selection of the creative ways in which we present and discuss our research ranges in scale from '**From Another Kingdom',** a public exhibition on fungi in collaboration with the Royal Botanic Garden Edinburgh (2010) which attracted 40,000 visitors; engagement with school children and public in the city and in rural and economically-deprived areas through **Edinburgh International Science Festival** (c.16,000 visitors annually to our activities) and **Midlothian Science Festival** (estimated 3500 visitors in 2013); '**Life through a Lens',** which focuses on the process of scientific discovery (reaching approx. 700 schoolchildren and members of the public each year); to researchers performing '**Bright Club'** stand-up comedy shows based on our current research (e.g. food-borne pathogens) and leading in-depth topical discussions (e.g. the host-pathogen 'arms race' at Edinburgh's **Café Scientifique,** or the use of HeLa cells with local **book groups**).

b4. Promote future impact through developing partnerships with users. We develop and support academic-industry partnerships using RCUK and other funding schemes. These include **BBSRC's CASE** studentships (19 in the REF period), and the **BioSKAPE** industry-led studentships organised by the Scottish Universities Life Science Alliance, SULSA (6 in the REF period). These schemes have enabled us to develop links with large pharmaceutical and agri-biotechlology companies (e.g. **Astra Zeneca, Pfizer, UCB, Bayer Crop Sciences**), SMEs and smaller biotechnology companies (e.g. **Antoxis, Selcia, Deliverics, CelluComp**). **NERC CASE** studentships (6 in the REF period) have included links with Scottish Natural Heritage, the National Trust for Scotland, the Hutton Institute, the Centre for Hydrology and Ecology and the Woodland Trust. We also run two PhD training schemes that develop students' ability to build impact: the **Principal's Career Development Scheme Entrepreneurship Strand** has provided business skills training and an industrial mentor to 4 students, and the **BBSRC EASTBIO DTP** supports training on 'Making an Impact' and includes a professional internship scheme.

Researchers work with our embedded BDEs and the wider ERI team, including a specialist consultancy team, to market and promote our capabilities to potential users at special events (e.g. **Analyse This** in Dec 2012; **Get Your Kit Out** June 2012 and 2013) and through relevant networks such as **Knowledge Transfer Networks** and **Interface**, a Scottish Funding Council (SFC) funded initiative to promote industry-academic interactions. We have developed training programmes directed at transferring technical skills to company staff (e.g. CTCB secured funding via SULSA to develop a protein-production training programme for SMEs). We also host and train company researchers (e.g. from the defence company **Selex Galileo** and from the biotechnology company **Synpromics**, both interested in synthetic biology), to transfer knowledge for economic benefit and future impact. We develop collaborative research with companies (e.g. Korean biotechnology firm **Unhwa Corp**.) to build research capacity, and links with user groups (e.g. **Rett Syndrome Research Trust**) to influence opinion and policy.

c. Strategy and plans

Our strategic plans have been designed to build on the approach outlined above. Following our success in winning the **2013 BBSRC Activating Impact Award** we are now implementing the action plan set out in our entry to the **BBSRC's Excellence with Impact (EwI)** competition (2013-2015). In this, we are working closely with the University's Roslin Institute (UoA6) to maximise benefit and share good practice. We have appointed an **Impact Officer** who leads in recording and evidencing our impact and we have commissioned an **Economic Impact Study** to help focus effort in the most productive areas.

c1. Carry out world-class fundamental research that drives future innovation. Our Research Themes facilitate both core basic science and the interdisciplinary crossovers that so often drive the most innovative discoveries (see REF5).

c2. Invest strategically in target areas of translational science to deliver research outcomes that directly address societal need. In our **EwI** plans we have identified priority impact themes shared with the **Roslin Institute** (RI) including global health, synthetic biology and

industrial biotechnology, which map to our Research Themes. In health we have invested in new academic appointments and infrastructure in host-pathogen interactions and the co-evolution of infection & immunity, of strategic importance in light of global challenges such as the impact of climate change on disease distribution and the emergence of drug-resistant bacteria. We will continue to develop this strand of our research in collaboration with medical and veterinary colleagues through **CIIE** and will build on our growing interactions with global health organisations (e.g. **Gates Foundation** funding to three groups) to translate research into impact. We have also created new academic posts to strengthen our drug discovery capabilities, with significant infrastructure investment, and will continue to work through **SULSA** to attract inward investment to Scotland in this field. We have significantly expanded our capacity in synthetic biology and in 2012 created **SynthSys**, an interdisciplinary Research Centre with engineering and other physical sciences. This comes from understanding that synthetic biology will provide the technology to deliver new products that underpin economic opportunity offered by industrial biotechnology, and will address societal demands for green energy, sustainable biosynthetic products and environmental remediation. SynthSys also involves social scientists with expertise in responsible innovation and public attitudes to research; this makes us an attractive partner for industry and will ensure that our research reflects and influences policy development in this new and potentially controversial area. We are also a key academic partner in an SFC-backed initiative to establish an **Industrial Biotechnology Innovation Centre (IBIC),** an industry-academia consortium to develop and deliver key technologies to drive the Bio-Economy (£10M from SFC and up to £25M from industry).

c3. Identify, protect and develop opportunities for impact wherever they arise. Through our **EwI strategy** we have created a single integrated team linking our BDE staff and those of RI within a unified management structure. This will enhance the embedded BDE support available to staff and students, enabling us to provide common frameworks for researchers at all academic levels to deliver commercial impact. We will coordinate training and support with RI, ERI and IAD to embed a shared knowledge exchange culture. In our EwI plans we are implementing a new public engagement strategy that will focus on supporting researchers to identify appropriate public engagement plans for their research through a portfolio of opportunities and tailored advice.

c4. Promote future impact through developing partnerships with users. We created a third BDE post in 2012 specifically to develop industry links in the areas of industrial biotechnology and synthetic biology. To improve the overall promotion and marketing of our research capabilities in target areas and encourage commercial interaction we now run outreach events such as **Industry Days** for target external audiences (two such events in 2012 and 2013) and will continue with this strategy. These events will focus on our shared priority impact themes with RI.

d. Relationship to case studies

Our selected case studies reflect the range of users and beneficiaries of our research, and show how our approach and strategy (sections **b** and **c**) deliver impact. All of our case studies stem from our aim to carry out world-class fundamental research (**b1**, **c1**). Particularly clear examples of this are **BEAST**, which shows how evolutionary phylogenetics expertise has informed global health policy; and **DNA Methylation**, which demonstrates translation of fundamental cell biology into both commercial and health impact. The studies **Schistosomiasis, Malaria assay, Stem cells engagement** and **Stem cells products** illustrate how our development of targeted translational research areas in infectious disease and regenerative medicine has delivered impact through protecting and exploiting IP or through changing public policy or influencing opinion. This targeted approach to translation (**b2**, **c2**) is a strategy we have developed during the REF period, informed by our successes, and we expect a higher proportion of our impact to relate to translational target areas in future. The **Hen welfare, Fish pain, Dairy productivity,** and **Native woodlands** case studies are examples of how we have developed opportunities for impact identified across various research fields and with diverse users (**b3**, **c3**), producing a range of impacts from influencing commercial development to enhancing animal welfare to shaping environmental policy. The **Unhwa** and **Rett Syndrome** case studies demonstrate how we have worked in strategic partnership with others to identify and pursue cultural, health and commercial impact with relevant users; this partnership approach (**b4**, **c4**) will be a major part of our future impact strategy.