Institution: University of Glasgow

Unit of Assessment: Unit 5; Biological Sciences

a. Context

The 62 staff returned in UoA5 (60.34 FTEs) come predominantly from the Institute of Biodiversity, Animal Health and Comparative Medicine (BAHCM) and the Institute of Molecular, Cell & Systems Biology (MCSB) in the College of Medical, Veterinary and Life Sciences (MVLS); staff submitted in UoA5 are in **bold**. The common philosophy is that innovative basic research can lead to impacts in a wide range of areas from the pharmaceutical and agrochemical industries to conservation and environmental, public and animal health. Research in BAHCM is characterized by the study of organisms in their natural habitats; a significant fraction of the research has direct relevance to policy. Research in MCSB is carried out mainly on model organisms and addresses strategically important questions, albeit at some distance from translation. The impact agenda in BAHCM is delivered through a broad range of researchers with applied expertise in ecological, epidemiological, physiological, behavioural, evolutionary and genetic research as well as mathematical modelling. In MCSB impacts flow from basic and applied work in the research groups Plant Science and Cell & Molecular Biology. The main non-academic user groups and beneficiaries of research outputs in UoA5 are:

- UK and international conservation agencies
- Public and animal health agencies
- Assessors of environmental impact
- Fisheries managers
- Bioindustry, particularly pharmaceutical and agrochemical industries

Here we provide a general description of how our research influences these groups with illustrative examples that are distinct from our full impact case studies.

Conservation agencies are influenced through research, reports and education. For example **Hopcraft** worked closely with the Frankfurt Zoological Society to construct a report to the Tanzanian Government on the likely impacts of road construction in the Serengeti, a summary of which appeared in Nature (http://www.nature.com/nature/journal/v467/n7313/full/467272a.html). **Monaghan** was PI on a Knowledge Transfer grant funded by Scottish Natural Heritage (SNH), the RSPB and NERC entitled 'Turning population ecology into conservation strategy - development of a natural care scheme for red-billed choughs in Scotland'. This provided the demographic and ecological understanding of an internationally important protected population that underpinned the chough-specific management options in the Scotland Rural Development Programme (http://www.scotland.gov.uk/Topics/farmingrural/SRDP). The IBIS project at the Scottish Centre for Ecology and the Natural Environment (SCENE, http://www.loughs-agency.org/ibis) covers not only direct research but also provision of Continuing Professional Development courses and Knowledge Transfer workshops that will leave a legacy of expertise in sustainable management of aquatic resources in western Scotland, Northern Ireland and the border region of Ireland.

Some of our research on animal health affects **public and animal health agencies** and their policies. For example **Hampson** worked closely with agencies in the Philippines and Bangladesh to promote the use of vaccination over dog culling as a means of rabies control and her research provided the evidence platform that resulted in $10m of funding for rabies elimination projects from the Bill and Melinda Gates Foundation in South Africa, Tanzania and the Philippines. The impact of **Ferguson**'s work on malaria in Tanzania (funded by a David Philips Fellowship) was recognized by BBSRC: http://www.bbsrc.ac.uk/research/impact/david-phillip-fellowships.aspx). Staff trained in this project now work in local communities to develop and implement malaria control measures.

Research on population and ecosystem health has strong implications for **assessment of environmental impacts**, such as the work of **Furness** described in a case study, and **management of fisheries**. **Bailey**'s work with BP is improving our scientific understanding of the deep sea and providing long-term environmental monitoring using biological observatories: the Deep-ocean Environment Long-term Observatory System (DELOS, http://www.delos-project.org/index.php) project has installed two observatories in an oil and gas exploration region off Angola at a depth of 1400m.

Impacts on **bioindustry** cover the identification of new targets for appropriate intervention and the development of new tests, materials or processes. For example, **Milligan**'s extensive

fundamental research on G-protein-coupled receptors has provided the basis for novel drug screens, including DIMERSCREEN™, which is licensed to and utilised by Cara Therapeutics to identify and assess the potential of novel molecules that selectively target receptor heteromers and therefore provide improved tissue selectivity. Cara recently announced an Initial Public Offering of its stock to fund Phase III clinical trials. **Milligan**'s work on the development of novel approaches to target diseases ranging from schizophrenia to type 2 diabetes and obesity has resulted in funding from Astra-Zeneca, Servier, Organon/Merck, Viviabiotech and Medical Research Council Technology. Cell engineers **Berry**, **Dalby** and **Riehle** are providing the tools for production of new biomaterials with a range of uses from joint replacement and nerve conduits (via interactions with clinicians, chemists and engineers) to plasticware optimised for the growth of specific cell types in association with several SMEs.

b. Approach to impact

Use of University and College resources

The University has implemented its Impact and Knowledge Exchange (KE) strategy (see http://www.gla.ac.uk/media/media_277897_en.pdf) which demonstrates the importance placed on embedding KE across the full range of our research, teaching and training activities. Our environment encourages and supports impact delivery and KE in a variety of ways including:

- Infrastructure and networks to support KE and collaborations (internally and externally)
- Delivery of appropriate training and mentoring courses
- Human Resources policies that encourage and reward KE
- Direct support of promising ideas
- Sharing intellectual property (IP) with industry through the University's innovative Easy Access IP scheme (http://www.gla.ac.uk/services/rsio/ipcommercialisation/easyaccessip/) which offers free licensing to industry to facilitate exploitation of early stage technology

To capitalise on this environment MVLS has implemented policies that embed the drive to impact in our activities and secure the links between researchers, business development and communications staff. Annual Performance & Development Reviews are used to reward staff who have delivered impacts. Many research staff take University training courses in areas such as public engagement, entrepreneurship and commercial awareness, and a wide range of industrial placements is available, for example for BBSRC-funded PhD students. A College Research & Business Development team facilitates all steps from first discovery to commercial development.

The University supports early stage KE activities in several ways. Its own KE fund provided funding for **Milligan** and Mountford to enhance the scope of a patent on a stem cell survival factor. First Step Awards aid early collaborations between academics and Scottish SMEs; **Dalby** has received three awards, one of which led to follow-on funding. A First Step Award to **Berry** on the use of nanoscale heaters in cancer cells led to an EPSRC Innovation Acceleration Account (IAA) award; recent BBSRC funding will take this forward, in conjunction with **Dalby's** nanotopographies, and broaden its translational scope. An MCSB research assistant (McKenna), working on a BBSRC/EPSRC project with staff in our College of Science & Engineering, developed techniques to improve the accuracy and precision of micro and nanoarray technology. Support from the University's EPSRC Knowledge Transfer Account (KTA) allowed McKenna to construct a prototype device and secure proof-of-principle data that led to a BBSRC/RSE Enterprise Fellowship and second place in the 2012 Converge Challenge event. The resultant IP is now licensed to McKenna's company Dynamic Bioarrays, facilitated through the Easy Access IP scheme. The company recently obtained a SMART award from Scottish Enterprise to advance product development.

Strategic development of our research portfolio

KE and impact depend on high quality research. The shared vision of BAHCM and MCSB is to maintain a portfolio of excellent basic and pre-competitive research with more applied projects, some of which will have grown out of fundamental research. Our overarching approach to KE and impact is therefore to encourage staff in UoA5 to **obtain funding** with impact potential, to **exploit** the research by whatever means of KE is appropriate to the end users and to **engage** with policy makers and the public wherever possible. We appreciate that much of the research leading to impacts is cross-disciplinary; the structure of MVLS as a fully integrated biomedical college and our close links with colleagues in the College of Science and Engineering, particularly in Chemistry and Engineering, explicitly supports research of this type. For example, MVLS has identified **synthetic biology** as a developing cross-disciplinary area with great impact potential and is building our

capacity by investment in both staff and infrastructure (see REF5).

Our culture allows staff to fund applied research with impact potential in a variety of ways. Some projects are funded directly by the end user, such as much of **Houslay**'s applied research on phosphodiesterases which has led to an impact case study. Others are funded in partnerships such as the BBSRC Industrial Partnership Award (IPA) scheme. **Dow** and **Davies** have identified novel targets for insecticides with direct funding from BASF and Pfizer and a BBSRC IPA and CASE studentships with Pfizer. They have recently received funding from the University's BBSRC Excellence with Impact grant to screen for molecules that dissolve kidney stones using their insect model. **Amtmann**'s basic research on abiotic stress tolerance has provided insight into strategies to alleviate drought stress and led to a BBSRC IPA on histone deacetylation with Bayer CropScience. **Stark** and **Rosser** hold a BBSRC LoLa grant with support from SMEs Ingenza, Lucite and Biotica. **Jenkins** used his ground-breaking work on perception of UV-B light to obtain support from BBSRC's Crop Improvement Research Club in a project to underpin the development of new oilseed rape varieties with increased resistance to insect herbivory. This club involves 14 industrial members and the Scottish Government. **Macleod** led charity-funded research in Bolivia identifying the most important conservation site for the critically endangered Blue-throated Macaw. The outcomes supported an international conservation fundraising campaign that has led to a tripling in size of this protected area, and 40% of the world's population is now protected in the expanded reserve. Several PhD studentships funded by SNH, for example on cumulative impacts of wind farms on seabird demography, are directly relevant to policy development. Some research has been commissioned following direct discussions with stakeholders, for example the IBIS project at SCENE funds research projects arising from consultations with over 35 different stakeholders with interests in the management of freshwater ecosystems.

Education and public engagement

Impact can be delivered through education such as the professional development courses that are part of the IBIS project, through policy evaluation and development by involvement with government or other agencies and through public engagement activities in general. Staff are encouraged to interact with policymakers at appropriate levels to ensure that they are aware of our research and its implications. For example, Adams and **Furness** have both served as members of the Science Advisory Committee of SNH which provides advice to ensure that key policy decisions are well founded in science. Examples include guidance on assessing the cost-effectiveness of eradication of alien mammals on Scottish islands (being taken forward under EU LIFE+ funding) and on the selection of Sites of Special Scientific Interest. **Cogdell** was instrumental in the development of both the joint BBSRC/NSF Photosynthesis Ideas Lab Initiative and the ESF Solar Fuels Initiative, and in promoting public awareness of this area (http://www.telegraph.co.uk/earth/energy/9088263/Artificial-leaf-will-convert-sunlight-into-fuel.html).

Public engagement activities are focused on increasing awareness and understanding of a wide range of exciting science. **Milligan** collaborates with Mountford in a project on the production of 'synthetic blood' by appropriate treatment of stem cells. Early human trials may involve patients with thalassaemia, and the project has recently been featured on Al Jazeera TV (http://www.aljazeera.com/programmes/thecure/2013/09/20139121426484277 75.html) owing to the prevalence of the disease in the Middle East. UoA5 staff are regularly engaged with the Glasgow Science Festival (http://www.glasgowsciencefestival.org.uk). For example, in 2013 **Monaghan** contributed to a celebration of the 200th anniversary of the death of the Paisley-born ornithological hero Alexander Wilson, and the **Boyd Orr Centre for Population and Ecosystem Health** (which is managed from BAHCM and has recently won a Queen's Anniversary Prize for Higher and Further Education) ran a display on Scottish epidemiology. **Bulleid** and **O'Dell** are both editors of and contributors to the Biological Sciences Review, a magazine specifically aimed at encouraging AS or A level students into a career in the biological sciences. We are increasing our use of social media to promote international awareness of our science. For example **Page**'s biodiversity blog (http://iphylo.blogspot.com) had some 35,000 visits in the year ending 30/09/2013, 85% of which were from outside the UK; 81 of the top 100 visitors came from non-academic sources. The Boyd Orr Centre runs a blog to promote discussion of Ecosystem Health (http://boydorrblog.wordpress.com/) that received some 3000 visits in the five months 05-09/2013, 50% from outside the UK.

c. Strategy and plans

Our overall strategy is to support a **range of activities** providing pipelines through which

fundamental research can be translated to **impact** via the infrastructure provide by the University's Impact and KE strategy.

An important part of the strategic approach in BAHCM is a focus on **international development**. Many of the planet's most pressing and interesting research challenges are to be found in developing countries. The vast numbers of people affected by health and environmental issues in developing countries, combined with their growing economies and global presence, highlights the opportunity for research leading to impacts. Effective research is critically dependent on collaboration with local partners who possess first-hand knowledge of the background and impact of their own problems. Our experience, such as research led by **Hampson** and **Ferguson,** shows that these collaborations result in the employment and training of numerous young scientists from developing countries, many of whom go on to take influential positions in government and research institutions in their home countries while maintaining close links to the University. We therefore aim to develop and maintain credible and equitable national partnerships to further our research in the **ecology of infectious diseases**, for example by making more progressive use of international graduate student fee waivers.

In more general terms, our strategies depend heavily on the nature of the research, with a major focus placed on the cultivation of promising *projects* and *contacts*. Strategic targets for MCSB staff include **food security**, aspects of which are addressed by our strong Plant Sciences group (see REF5), **synthetic biology** and **cell engineering**; staff are encouraged and supported in applications to relevant research clubs and strategic initiatives. For example, **Blatt** is funded by the BBSRC/NSF Photosynthetic Ideas Lab aimed at achieving a step change in the efficiency of photosynthesis, with potential impact for the next Green Revolution. **Amtmann** obtained support for an innovative biodesalination project, aimed at improving water availability, through an EPSRC 'sandpit'. **Cogdell** is the PI on a BBSRC grant under the ESF Solar Fuels initiative with Cronin (Chemistry). **Bulleid** and **Dalby** have grants from the Bioprocessing, Research and Industry Club (BRIC). These are examples of **projects that may have impact by 2020** or beyond. The first step in developing contacts towards impact is often at the level of CASE studentships or the Industrial Partnership studentships offered by MVLS, and these may develop into collaborative or fully funded projects. Staff are encouraged to develop and exploit these contacts, for example via support from First Step Awards, EPSRC IAA awards and the BBSRC Sparking Impact scheme.

A key objective is that the culture of impact becomes self-sustaining. To achieve this we need to capture our impact activities from the planning stages to outcomes in order to learn from our experiences and improve our procedures. MVLS is putting in place a small team with this remit.

d. Relationship to case studies

The detailed case studies in UoA5 illustrate the general principles outlined above. The work of **Houslay** and Griffiths shows, in very different areas, how basic research can lead to impact via the identification of targets; one case involves drug development and validation and was supported directly by an industrial partner, the other describes the target for a test used in sex determination of birds. The work of Haydon/Townsend and **Mable** illustrates two very different types of impact on health and conservation. In one case the research led to the development of an island-wide dog vaccination strategy in Bali that controlled the spread of rabies in dogs, and reduced the incidence of human rabies deaths by over 90%; this illustrates the importance of our strategic focus on international development. In the other, research on genetic diversity in African wild dogs (an endangered species), funded by a NERC CASE studentship, resulted in implementation of a new plan for managing animals in European zoos using captive populations as a source for re-introduction. The work of **Furness** illustrates the value of our strategic mix of basic and commissioned research; his expertise led to research commissioned by SNH and Marine Scotland that provided data contributing to the Environmental Impact Assessment process both for developers and for statutory bodies. The work of **O'Dell** illustrates impact via public engagement in science; basic work on fly genetics was applied dramatically to capture the imagination of secondary school students and enhance their interest in science. The case study of Neil illustrates the exploitation of Knowledge Transfer Partnership awards; here a simple approach to the assessment of metabolic stress led to improved practice in langoustine fisheries. This theme is reinforced by the examples of McKenna, **Berry**, **Dalby** and **Riehle** above, in which KTA and IAA funding and Easy Access IP play key roles in the next generation of impacts. Overall, resulting from application of our general principles we now have both a range of projects at various stages in the pipeline leading from basic research to impact and the environment needed to exploit these.