Institution: University of Dundee

Unit of Assessment:5 - Biological Sciences

a. Context

The main non-academic beneficiaries of our research are:

a) **The Pharmaceutical industry** through the identification and validation of drug targets and the provision of assays, reagents and expertise.
b) **Patients in Phase II clinical trials and beyond** through the efficacy of new chemical entities arising from our industrial collaborations.
c) **The Biotech and instrument manufacturing industries** through the provision of advanced software engineering solutions for image data.
d) **The local Biotech cluster** through the creation and nurturing of spin-outs and provision of technological support for companies.
e) **International and National policy makers** (e.g. the WHO and the UN), **UK water boards** and **environmental protection agencies** through our research into microbial toxins.
f) **Industrial/academic consortia** developing genetically modified crops optimised for biofuel production.
g) **Victims of crime and disasters, the police, Interpol, and the courts** from our anatomy and forensic anthropology research.
h) **Patients** suffering from inherited skin fragility disorders through our research into the causative mutations in these diseases.
i) **The general public and local schools** through the commitment of our scientists to public engagement and outreach activities.

b. Approach to impact

Our key approach to impact is to:

a) Support that which feeds impact, i.e. **internationally competitive blue-skies research**, with **strong and transparent recruitment**, **mentoring**, **career-development and retention policies** and access to **exceptional technology platforms**.
b) Provide and invest in substantive **translational engines** (like the *Division of Signal Transduction Therapy, Drug Discovery Unit* and our University-wide *Translational Medical Research Fund*) to promote the rapid and professional development of discoveries into commercial and/or charitable partnering opportunities or spin-outs.
c) Support **pre-incubation opportunities for spin-out companies.**
d) Encourage and invest in **interdisciplinary research** and **strategic partnerships**.
e) Deliver **Social, Legal and Humanitarian Impact** through research into forensic anatomy.
f) Embed a culture of **public engagement** and **outreach**

Our approach is backed by a culture that encourages and rewards industrial interaction and entrepreneurship. The success of our impact strategy has been recognised by receipt of two major prizes at the **2011 BBSRC Excellence with Impact Awards**. The College of Life Sciences won the award for '***Greatest delivery of impact***' while Prof. Jason Swedlow was named `***Innovator of the Year***' for his interdisciplinary (microscopy and software engineering) Open Microscopy Environment.

About our translational engines:

The Division of Signal Transduction Therapy, established in 1998, is one of the largest and longest running collaborations between the pharmaceutical industry and an academic institute. It is widely regarded as a model for knowledge exchange and for how academia should interact with industry (*Nat. Rev. Drug Discov.* 10, 561-562 (2011) doi:10.1038/nrd3526; Research Councils UK Study on the economic impact of the Research Councils. Part II: Case studies (2007)). The collaboration was renewed for the third time in 2008, and for the fourth time (for £14.4 million) in 2012. The consortium currently includes Astra-Zeneca, Boehringer-Ingelheim, GlaxoSmithKline, Janssen-Pharmaceutica, Merck-Serono, and Pfizer. In return for their investment, the Pharma partners benefit from access to unpublished results, technology, know-how and reagents in the participating academic laboratories and have first rights to license intellectual property generated in the collaborative programme. Three 3-day meetings each year are held between key scientists in the College and representatives in the Pharma companies to maintain this successful working relationship. The integration of expertise in protein ubiquitylation in 2012 was of particular interest to the corporate partners. Critical mass in Dundee in ubiquitylation research was acquired through

a £10 million investment in 2008 by the Scottish Funding Council and the University of Dundee to create the Scottish Institute for Cell Signalling, now strategically merged into the MRC Protein Phosphorylation and Ubiquitylation Unit in its 2013 £24 million renewal as a University Unit. This is a good example of how cutting edge research can feed innovation to our corporate partners. In addition, the exposure of post-docs and PhD students to consortium activities leads to many joining companies – providing further benefits to industry and effective knowledge exchange.

The Drug Discovery Unit is an integrated drug discovery team that aims to de-risk a portfolio of discoveries and provide a pipeline of validated partnering and licensing opportunities. The Unit, which currently has 75 dedicated staff with >500 years of collective industrial experience, is the only fully operational and integrated drug discovery team in the UK university system working across multiple therapeutic areas. It contains all the disciplines (compound screening, medicinal and computational chemistry, structural biology, pharmacokinetics and *in vivo* efficacy) required to produce drug leads and pre-clinical drug candidates. Our work in drug discovery for neglected diseases (African sleeping sickness, leishmaniasis, Chagas' disease, malaria and tuberculosis) benefits our charitable product development partners and involves intensely interactive collaboration with major Pharma partners (particularly GlaxoSmithKline) with substantial inward investment from international funders (e.g. the National Institutes of Health, the Bill & Melinda Gates Foundation, Medicines for Malaria Venture, Drugs for Neglected Diseases initiative, the TB Alliance). We have also developed innovative funding models to promote the discovery of therapeutic compounds to innovative drug targets emerging from fundamental research in other areas of unmet medical need. For example, in 2009, the University of Dundee was one of 5 institutions awarded £2 million under the *MRC Development Pathway Funding Scheme* to run a *devolved portfolio* to support goal-oriented translational research projects. From a sub-portfolio of 9 early stage drug discovery projects, three led to commercial partnerships. This successful portfolio model was sustained through investment of Drug Discovery Unit commercial income, University Research Excellence Grant income, Wellcome Trust Institutional Strategic Support Funds and by obtaining an MRC Confidence in Concept award. This approach enables 9 new innovative biological targets to benefit from first-rate medicinal chemistry each year. These projects provide data packages that stimulate significant partnerships with industry in about one in three cases, and provide useful probe compounds to advance the biology in all cases.

The University Translational Medical Research Fund assists interdisciplinary collaboration and translation. It provides 'pump-priming' to develop ideas and opportunities to a state where they are ready go forward for RCUK and charity translational programmes. This very successful initiative is funded by the University Strategic Investment Fund, augmented by the Wellcome Trust through their Institutional Strategic Support Fund (ISSF).

Support for spin-out companies through pre-incubation

Dundee hosts one of the fastest growing biotechnology clusters in the UK and the life sciences sector currently contributes 16% of the local economy, employing over 4,300 people. A major focus in the College is the creation, incubation and ongoing support of spin-outs, start-ups and spin-ins in the local Biotech cluster. During the REF assessment period, 4 companies have been successfully spun out (GlycoBiochem, e^{x}scientia, Kinetic Discovery, and Tissue Repair Technologies), 43 patents have been filed, 72 invention disclosures have been made and more than £1 million royalty income has been generated. One important means of support is to provide 'pre-incubator' space in the early days, so that small new enterprises have direct access to equipment and technological expertise. Several companies have benefited from this kind of support since 2008. For example, ***Glencoe Software*** (http://www.glencoesoftware.com), founded as a College spin-out to provide data management tools for biological light microscopy, has grown five fold since 2008 and ***Dundee Cell Products*** (http://www.dundeecellproducts.com), which provides life sciences services with a key speciality in SILAC-based quantitative proteomics has secured major research contracts with Pfizer and as of 2013 employs 10 people. A recent spin out ***e^{x}scientia Ltd*** (http://www.exscientia.co.uk/) has already signed contracts with three major pharmaceutical companies, worth $1.5 million, since spinning out in 2012. The development of research in ubiquitin signalling by the MRC Unit was a catalyst in attracting Stemgent Inc (https://www.stemgent.com) to form its first overseas company in Dundee called ***Ubiquigent Ltd*** (http://ubiquigent.com) in 2010. Currently housed in the College, this spin-in company has received £3 million in investment from Stemgent over 3 years, and markets biological products generated by the College and innovative screening services.

The College also provides support for companies by providing access to core facilities, such as advanced proteomics and mass spectrometry (13 corporate clients and research organisations since 2008), compound screening and pharmacokinetics (6 contracts since 2008) and, in the case of a programme to support ***TTP Global Developments plc***, full drug discovery capabilities. Other ways that the College of Life Sciences supports a culture of commercialisation of research include: i) CASE studentships for students to undertake research with an industrial partner; ii) funds for post-docs and graduate students to invite Entrepreneurs and Industrialists to speak in the College; iii) "Translational away-days" to stimulate collaborations and focus on translational research; iv) Generic Skills courses on commercialisation of research; v) provision of a College of Life Sciences "Innovator of the Year" award (launched 2010).

Strategic partnerships

As well as the partnerships with pharma previously described, the College of Life Sciences has maximised the impact of its plant sciences research through embedding staff in the ***James Hutton Institute*** (http://www.hutton.ac.uk), a national crop research institute on the edge of Dundee. This provides a research continuum from fundamental plant molecular biology and genetics through to plant breeding. Examples of translational success include our plant scientists becoming one of 6 'hubs' in the £3 million ***BBSRC Sustainable Bio Energy Centre*** (BSBEC), an academic-industry research partnership aimed at developing sustainable bio-fuels, involving two plant breeding companies, Limagrain UK and Syngenta. A recent breakthrough by the Dundee team (*Science* 341, 1103-1106) should pave the way to producing low-lignin crop plants providing enormously enhanced sugar extraction for bio-fuel production.

Social, Legal and Humanitarian Impact via the Centre for Anatomy and Human Identification

The Centre for Anatomy and Human Identification, headed by Prof. Sue Black, provides expertise in forensic anthropology. The centre has developed a number of novel physiological and anatomical procedures to identify or determine the age of individuals, which has growing impact on case law and criminal convictions across the UK, particularly of paedophiles. The Centre also plays a major role in providing expertise in ***Disaster Victim Identification***, and in 2010 collaborated with INTERPOL to develop a global database to link missing persons and disaster victims. Furthermore, the Centre provides a ***Virtual Anthropology Consultancy Service*** that quickly determines if bones are human when remains are found, for example during building works (http://www.lifesci.dundee.ac.uk/cahid/vacs). Courses delivered by the Centre have provided police officers from all over the UK with the skills and understanding to respond to disasters both on the UK mainland and abroad. The Centre is the first UK anatomy department to switch to and research ***Thiel soft-fix embalming***, which retains the life-like flexibility of cadavers, making them excellent for surgical training and for the development of new surgical procedures.

Public Engagement and Outreach

Sharing and explaining our science is recognised as an important part of the education and development of scientists in the College of Life Sciences. Structures in place that facilitate and support a culture of public engagement include: i) a substantial College public engagement fund of ~ £50,000/year; ii) generic skills training and support for post-doc and student initiatives in public engagement; iii) The Brian Cox Award for Public Engagement - our College award for public engagement named after our Rector; iv) development of an 'Impact' web site detailing College strategy and activities (http://www.lifesci.dundee.ac.uk/impact); and v) employment of a public engagement coordinator and a schools liaison officer. Engagement activities include:

• ***History Cold Case*** (seasons 1 & 2): The BBC forensic history series involving our Centre for Anatomy and Human Identification which examines skeletons of everyday people from across the ages in staggering detail.

• ***Sharing Science***: Six short films showing how scientists go about their quest to understand the nature of life (http://www.lifesci.dundee.ac.uk/gre/sharing-science).

• ***Doors Open Days*** (2008-2013): Gives members of the public free access to the College of Life Sciences, including a tour of the Drug Discovery Unit, organised by postdocs and PhD students.

• ***Magnificent Microbes***: In 2010 and 2012 microbiologists from the College held a two-day event at Dundee Science Centre to make children and adults alike aware of how fascinating microbes really are (http://tinyurl.com/lqnpzyz).

• ***Life Science Zone at The Dundee Science Centre***. A College-designed interactive zone in our local public science centre to promote the understanding of basic life sciences research, including

a stereo and compound microscope as well as scale models of anatomy, systems biology, cellular biology and DNA (http://www.dundeesciencecentre.org.uk).

Influencing Science Policy and Strategy

Our scientists serve on numerous committees and panels. For example, The Head of College, Doreen Cantrell, and Dean of Research, Mike Ferguson, sit on the MRC Strategy Board and Board of Governors of the Wellcome Trust, respectively.

c. Strategy and plans

The College of Life Sciences is committed to nurturing scientific talent, maximising its research impact and enabling this impact to reach through to society. The flagship of our long-term strategic plan to maximise future impact is the new ***Centre for Translational and Interdisciplinary Research (CTIR)***, which opens in 2014; http://www.lifesci.dundee.ac.uk/other/ctir/. It will enable translation of our research into solutions for unmet medical needs, foster collaboration across different research disciplines and maximise the impact of our world-class technology platforms. The Centre will house 180 researchers including an expanded Drug Discovery Unit allowing it to more than double its capacity. The expanded Unit will develop new candidate drugs and ways of tackling major diseases and focus on patient benefit. The Centre will also house a new Division of Computational Biology, including the Open Microscopy Environment team (responsible for the development of OMERO and Glencoe Software Ltd), the developers of JalView (a free open source program for multiple sequence alignment editing, visualisation and analysis, widely used both in academic and commercial settings; http://www.jalview.org), and theoretical biophysics groups. A new Centre for Quantitative Proteomics will be created around the expertise of Prof Angus Lamond plus corporate mass spectrometry and data analytics partners. The CTIR will also provide additional 'pre-incubator' space to house and support fledgling spin-out enterprises, helping us fulfill a key strategic priority to maximise the commercialisation of research originating from the College. The new building will also provide space for networking and art projects.

Another major development will be the new ***Centre for Dermatology & Genetic Medicine***, a collaboration with the University's medical school (http://dgem.lifesci.dundee.ac.uk). The aim is to rapidly expand our capability to find the causes of unsolved skin conditions using cutting edge genome sequencing technology and to expand our dermatology drug discovery programme, shortening the time to take our new therapies closer to clinical use.

In the area of anatomical research, the use of Thiel embalmed corpses for surgical training will be enhanced by expansion of a ***Thiel mortuary***, part funded by our 'million for a morgue' appeal (http://www.millionforamorgue.com). This will continue to place Dundee at the forefront of forensic teaching and research.

d. Relationship to case studies

The case studies reflect our commitment to provide a creative research environment for excellent science with access to translational infrastructure, which has served to catalyse innovation at many levels. They exemplify the College's approach to achieving impact in the following ways:

(a) All case studies stem from internationally competitive blue skies research and the policy of the College to recruit and retain the most talented researchers.
(b) All case studies have benefitted from access to cutting edge technology platforms. For example the Open Microscopy Environment has benefitted from investment in high performance computing and microscopy.
(c) Our approach of significant investment in translational engines is described in the Division of Signal Transduction Therapy case study.
(d) The stimulation of innovation by encouraging interdisciplinary working is exemplified by the cross-disciplinary research activity in the AMP-activated protein kinase (AMPK) case study. Moreover, mutually beneficial strategic partnership between the College and Top 10 Pharma companies is demonstrated in the Division of Signal Transduction Therapy case study. The success of our approach is evidenced by the 'repeat business' and commitment by satisfied industrial collaborators.
(e) The delivery of Social, Legal and Humanitarian Impact is evidenced by the perpetrator identification case study.

Although we feel our Public Engagement activities have had a significant impact, none of these have been used for case studies, as we think such activity should be a 'given' for any well - organised centre of research.