Institution: University College London/Birkbeck College

Unit of Assessment: 5 - Biological Sciences

a. Context

UCL's Division of Biosciences (including the MRC Lab of Molecular Cell Biology, or LMCB) and Birkbeck's Department of Biological Sciences (which has a joint Institute of Structural & Molecular Biology with UCL) carry out research of enormous breadth, spanning neuroscience, physiology, pharmacology, cell biology, developmental biology, structural biology, molecular biology, genetics, evolution, ecology and the environment. The insights thus generated have led to a wide spectrum of impact, including:
(i) improvements to healthcare through the introduction of new drug therapies arising from an improved understanding of biological processes and how to modify them;
(ii) improved clinical practice through the introduction of new research-based guidelines;
(iii) commercial benefits resulting from the adoption by the pharmaceutical industry of new knowledge and technologies - an essential prerequisite for the generation of candidate drugs;
(iv) the development of new genetic approaches to disease diagnostics and forensic analyses;
(v) growth of the biotechnology sector through our development of novel analytical techniques and computer software to understand molecular interactions and protein structure, which is providing new approaches to designing chemicals to affect biological processes; and
(vi) improved public awareness and understanding of science, and stimulation of public debate about science, which is essential for society to embrace the scientific progress that underlies economic growth and improved healthcare.
Our research thereby impacts on a wide range of user groups, as shown by our Impact Case Studies and other examples below, including drug companies, policy makers in many areas, bodies defining health care guidelines, clinical practitioners and patients, and the public in general.

b. Approach to impact

UoA5 employs several systematic approaches to generating impact, as follows. Specific examples of how each of these approaches has generated impact are given in section d below.

Translating basic science research into healthcare

UoA5 strongly encourages its researchers to apply their basic science research to solve clinical problems. This is emphasised at the university level through the Grand Challenge of Global Health (www.ucl.ac.uk/global-health). Exceptionally broad opportunities for collaboration with clinicians are available through UCL's School of Life and Medical Sciences (of which Biosciences is part) and its partner hospitals (including UCH, National Hospital for Neurology & Neurosurgery, Royal Free, Moorfields and Great Ormond St: see e.g. Case Study UCL05-FIT2), and are being enhanced by the development of the Francis Crick Institute (with which we already have 6 joint appointments, see below). Translation of basic research into therapy (see Case Studies UCL05-BEC, BUR, LAT, WOO1, WOO2, WOO3) requires an interdisciplinary approach, which is reinforced by cross-faculty PhD programmes that include UoA5 scientists and often require supervisors from 2 different disciplines. Translation is facilitated by UCL's Translational Research Office (TRO, www.ucl.ac.uk/translational-research, also used by Birkbeck), which was established in 2009 with MRC funds. The TRO guides researchers, at the early stages of moving research into translation, to establish robust project plans and funding applications; its experienced, industry-background research support staff also provide dedicated project management support for successful grants. Recognising a barrier to the progression of exploratory research into therapeutic development, due to a gap in funding between basic research and the main translational schemes, UCL also established a Therapeutic Innovation Fund in 2009, which provides seed funding for the development of potential therapeutics: UoA5 has received 2 awards totalling £85K from this fund.

UoA5 has used these sources of centralised support to secure translational funding of £4.01M from multiple sources (MRC, Cancer Research Technology, NHS) since 2008, £2M of which funded the Translational Research Resource Centre in the LMCB that provides high throughput screening

resources. It has also made use of internally-distributed funding, including that stemming from the University's successful £0.7M application to the 2012 MRC Confidence in Concept scheme, £0.3M of which has been used to support projects within UoA5 on anti-viral compounds, autophagy inhibition and therapeutic modulation of nicotinic receptors.

Collaborative and commissioned research with industry

The strength of our cell biological, physiological, structural, pharmacological, biochemical, genetic and neuroscientific research - made visible by our research papers and conference presentations - provides a major alternative route for impact generation, via our research being used as a basis for the development of new products or processes (see Case Studies UCL05-BEC, BUR, WOO1, WOO3), and our staff being invited to collaborate in joint research projects with companies (or public bodies, see below). The commitment of our staff to collaboration with industry is demonstrated by the facts that, since 2008:
(i) research income totalling £4.99M has been generated from industry grants, from companies such as Dow Chemicals, Bayer, GSK, AstraZeneca and Hellenic Mines, for research on topics as diverse as brain glutamate receptors, arsenite detectors for mining, insecticides and fungicides;
(ii) 50 PhD studentships were funded wholly or partly by industry or other outside enterprises, including 37 CASE studentships from companies such as Eli Lilly, Eisai, Pfizer, Unilever, Biotech AG, GSK, Takeda and Novo Nordisk, to work on topics as diverse as carbohydrate digestion, algal biofuels, mitochondrial function, DNA profiling, and breed identification in crossbred dogs.

Commercialisation and entrepreneurship

UCL has a strong culture of entrepreneurship, as shown by the publication of an institutional enterprise strategy in 2011 (www.ucl.ac.uk/enterprise/files/enterprise-strategy). In line with that culture, UoA5 has a strong track record of technology transfer to industry by forming spin-out companies. These include Fonaxa (www.fonaxa.com), set up in 2010 partly by Steve Wood (Structural and Molecular Biology Department, SMB) to provide X-ray crystallography services for drug discovery, and Synthace (www.synthace.com) set up in 2011 partly by David Jones (a joint appointment with SMB) which is the UK's first dedicated synthetic biology company. We also maintain strong links with previous spin-outs, including CoDa Therapeutics (formed in 2003, www.codatherapeutics.com) which is benefitting from further patents produced since 2008 on a therapy for wound healing based on Dave Becker's research in the Cell & Developmental Biology Dept (CDB, see Case Study UCL05-BEC), and Biovex (formed in 1999) which has developed a viral cancer therapy based on the work of David Latchman (see Case Study UCL05-LAT) and was sold to Amgen for $1 billion in 2011, the largest ever cash sale of a UK biotech company.

A notable feature of the transfer of expertise to industry by UoA5 is the licensing of patented technology and software (see Case Studies UCL05-ORE, UCL05-WAL and UCL05-MAR). This is supported by our highly successful technology transfer office UCL Business PLC (www.uclb.com, also used by Birkbeck; the LMCB has similar expertise via MRC-T, www.mrctechnology.org). UCL Business also supports drug and diagnosis development (see Case Studies UCL05-STA & STO).

The efficacy of our support for translational activity and impact within UoA5 is shown by the scale of our entrepreneurial outputs: since 2008, UoA5 academics' interactions with UCL Business have led to 57 invention disclosures, 22 instances of IP protection granted (covering topics as diverse as animal models of disease, tendon prostheses, antibiotic conjugates and image analysis techniques), and 88 licences on intellectual property being granted (covering topics as diverse as novel cell lines, transgenic mice, computer software and nanocomposite polymers). The strength of this portfolio of commercialisation is demonstrated by UCL Business making 10 proof-of-concept awards (totalling £395K) over 2008-13 to promote product development; financing to spin-out companies reaching £28M (£25M to the spin-out company CoDa Therapeutics in 2012, and £3M to Domainex [Case Study UCL05-SAV] spun-out in 2001), and 19 priority patents being applied for.

This active culture of enterprise is reinforced by UCL Advances (www.ucl.ac.uk/advances), UCL's centre for entrepreneurship and business interaction, which offers training, networking and business support for staff, students and external entrepreneurs starting new enterprises. This includes courses such as London Business School electives and the London Entrepreneurship Challenge, and mechanisms to support PhD students and early career researchers, including UCL Bright Ideas Awards (up to £25K loans as business seed funding) and Student Business Tutorials.

Consultancy and the provision of expert advice to industry and policy-making bodies

The strength of our research regularly leads to outside bodies seeking expert advice from our academics. Impact from this is facilitated by UCL's policy of allowing academics 40 days of paid consultancy per year, and by UCL Consultants Ltd (www.ucl.ac.uk/enterprise/consultants), which connects UCL experts with organisations seeking a critical advantage to their operations through expert advice. From 2008-2013, staff from UoA5 engaged in 123 advisory interactions, 50 of which were with pharmaceutical companies (38 of these were mediated by UCL Consultants). In addition to advising commercial organisations, UoA5 staff have also provided expert knowledge to policy-makers, as a means of maximising the benefits of their research. External commissioning by UK and foreign governments resulted in 22 academics from UoA5 contributing to a diverse range of policy-influencing initiatives through their provision of advice, for example to US congressmen for the Foreign & Commonwealth Office, to the US Social Services on fast-tracking certain patients' claims, to DEFRA on ecosystems, to NGOs on climate change, to the Natural History Museum, to the Tate and other art museums (see Case Study UCL05-ODL), to the Royal College of Obstetrics & Gynaecology on abortion guidelines (see Case Study UCL05-FIT1), to the British Council, to the National Trust (see Case Study UCL05-NIC), to English Heritage, to a Nuffield Committee on Novel Neurotechnologies, to the UK government Natural Capital Committee, to the European Medicines Agency, to the United Arab Emirates government on cloning their national bird (the Houbara bustard), to the government and RSPCA on animal legislation, to the Advertising Standards Agency on the (lack of) science underlying some claims, to companies disputing patent claims, to the House of Lords on ageing issues, and to the government on forensic genetics.

Public, media and schools engagement

UoA5 staff have made significant contributions to the debate on the importance and role of science in public life. An important example is the initiation by Jenny Rohn (in the Lab of Molecular Cell Biology) of the grassroots movement Science is Vital (scienceisvital.org.uk), which has played a significant part in maintaining science funding from the government. Similarly, Steve Jones' major inquiry into the rigour of science presentation on the BBC has led to significant changes in their policies, as noted in the BBC's response to his report (www.bbc.co.uk/bbctrust/assets/files/pdf/our_work/science_impartiality/science_impartiality.pdf). Another notable example is David Colquhoun's sustained criticism of "alternative medicine", based on his outstanding research expertise in the field of drug-receptor interactions (see Case Study UCL05-COL). This was presented largely through his *Improbable Science* blog (www.dcscience.net), which was voted best Science Blog for 2012 by the Good Thinking Society. In 2012 there were 949,224 page loads from his blog (with 2,959,425 page loads since the blog started). His very widely read comments have undoubtedly helped to create a more evidence-based climate for the assessment of alternative and complementary therapies.

Staff in UoA5 have also had significant, albeit less easily quantified, impacts on public understanding of science by working with TV companies, writing books, giving public lectures, meeting patient groups (see Case Study UCL05-SHE), appearing at festivals of science, and other public outreach activities. Some of this work was funded by the Beacons for Public Engagement scheme, via UCL's Public Engagement unit, including working with Batten's disease patients (Sara Mole, LMCB, see UCL05-MOL) and promoting awareness of the decline of primate populations (Helen Chatterjee, Genetics, Evolution & Environment, GEE). Between 2008 and 2013, 61 academics took part in events improving the public understanding of science, ranging from school

visits through TV and science festival appearances to writing books. Those books have included Steve Jones' magisterial presentation of the operation of evolution through texts published since 1993 (*The Language of the Genes*; *In the Blood: God, Genes and Destiny*; *Almost like a Whale: the Origin of Species Updated*; *Y: the Descent of Man*; *Coral: A Pessimist in Paradise*; *Darwin's Island: The Galapagos in the Garden of England; The Serpent's Promise)*. Many of these, which arose from his scientific background in snail genetics research, are still having impact today: to date they have sold 215,000 copies. Similarly, Nick Lane's outstanding books on mitochondria, based on his research on the evolution of cellular energy generation, are dealt with as Case Study UCL05-LAN. Furthermore, UoA5 scientists are actively engaged in encouraging the next generation of scientists by hosting internships for school children in science labs. Notably, Rebecca McKelvey, a PhD student in Maria Fitzgerald's lab, has developed the In2Science UK programme (in2scienceuk.org), which brings gifted A level students from underprivileged backgrounds into research labs for 2 weeks to encourage them to study science at university. Preliminary analysis of 3 years' students in the programme (104 students) suggests that participants' chances of going to university are significantly enhanced by this experience.

To facilitate the development of this kind of impact, UCL puts on a wide range of courses (see Domains D2 and D3 of http://courses.grad.ucl.ac.uk/list-training.pht), to improve how academics communicate with the media, which were attended by 140 participants from UoA5 in 2008-2013.

Structural and institutional support for impact

Since 2008, UoA5 has emphasised the use of the institutional facilities detailed above as part of its strategy for maximising research impact. Academics are made aware of the usefulness of these agencies through annual presentations at departmental and faculty staff meetings, e-mailed information sent to all staff, and the agencies' own websites. Since 2008, UCL established a Vice-Dean for Enterprise for Biosciences, and individual departments appointed enterprise champions as liaisons to UCL Business. The School of Life & Medical Sciences Enterprise Board was also established and meets 6 times per year, to ensure that UoA5 activities are coordinated with those in clinical subjects. In addition, impact-generating activities were assessed in bi-annual (now annual) career appraisal meetings for academics, and heads of departments gave individual academics who were developing translational work significant relief from their normal teaching and administrative duties (for example this approach was used to facilitate the work described in Impact Case Study UCL05-BEC). Furthermore, UoA5 received five awards in 2013 for Knowledge Transfer: a BBSRC Sparking Impact award (CDB, for e-learning), a NERC Impact Accelerator (GEE, for a dedicated Knowledge Transfer officer), and 3 Higher Education Innovation Fund awards for Knowledge Transfer champions in CDB, SMB and UCL Biosciences as a whole.

Engaging young scientists with impact

Since 2008, UoA5 has set up Early Career Networks to foster the careers of young neuroscientists and developmental biologists, and encourage them to develop activities that generate impact. In an initiative demonstrating the interest of our young researchers in generating impact outside academe, UoA5 post-docs have arranged for an external body (Oxbridge Biotech Roundtable) to run two meetings discussing biotech developments and encouraging translational research, which were each attended by ~140 people. To facilitate the development of translational research, UCL and Birkbeck also put on a wide range of courses aimed at encouraging PhD students, early career researchers and established academics to develop the translational aspects of their research (see Course List at http://courses.grad.ucl.ac.uk). In the period 2008-2013, these courses were attended by 79 academics, post-docs and PhD students from UoA5.

c. Strategy and plans

Our approach to impact since 2008 has generated a wide range of translational projects, as well as outputs that increase public understanding of science. Our strategy for maintaining and increasing this success, over the next 10 years, has two key strands: facilitating engagement of academics with the world outside academe and making impact an important aim of every academic.

Facilitating external engagement

(1) Maintaining those aspects of our impact strategy that have been successful.
We will continue to encourage the use of UCL Advances, UCL Business and UCL Consultants, the Translational Research Office, the Public Engagement Unit, and Graduate School courses (available to anyone at UCL to attend) which foster interactions with business and promote interactions with the general public. Awareness of these bodies and courses will be ensured by more frequent presentations by these bodies at staff meetings, and by circulated e-mails.

(2) Facilitating interactions with industry
We will develop a new modality for interacting with industry, in which academics propose projects to a joint industry-UCL committee that selects projects for pump-priming funding by industry, with UCL providing basic science and clinical expertise, and industry providing drug discovery resources, assay development capabilities and medicinal chemistry expertise. To trial this idea, a pilot arrangement of this nature has been established with Eisai. The goal of the collaboration is to identify and validate novel drug targets for neurodegenerative diseases such as Alzheimer's and Parkinson's, develop new therapeutics and evaluate them in proof-of-concept clinical trials. If successful, UCL will receive milestone payments and royalties on drugs brought to market.

(3) Enhancing the role of enterprise champions
We will increase the number of knowledge transfer enterprise champions within departments. These will provide financial support to help academics undertake enterprise activities, assist knowledge transfer activities, and promote Continuing Professional Development courses.

(4) Increasing translation of our research
The £700M Francis Crick Institute will open in 2015 and will have 1250 researchers working on the biological bases of a wide range of diseases. UCL was chosen as the founding academic partner for the Crick because of its broad research excellence in Life and Medical Sciences. Over the next 5 years we will invest in collaborations with the Crick by adding to the 6 existing joint appointments in UoA5 (Oates, Luscombe, Goehring, Margrie, Schafer and Yardimci), and allowing researchers to move their labs there to promote the application of our basic science approaches to address clinical problems. Similarly, the UCL-wide Centre for Drug Discovery is being developed to exploit the therapeutic potential of our basic biomedical and clinical sciences across a range of therapeutic areas, including CNS and cardiovascular diseases, inflammation, infectious diseases and oncology. The Centre will be focussed on the School of Pharmacy (which has recently become part of UCL), with significant contributions from medicinal chemists and UoA5 researchers. Finally we will expand the Translational Research Resource Centre in the LMCB. All of these inter-disciplinary initiatives are expected to lead to a wide range of translational outcomes.

Embedding impact as an important aim of every academic

Many academics view their core business (other than teaching) as mainly being the production of high quality research papers. This reflects the fact that most UoA5 academics do basic science research, and suitability for promotion and the status of academics are assessed largely on the basis of the papers they publish and grants they obtain. To maximise the impact outside academe of the research we do, academic opinion has to be encouraged further towards recognising that translational research and interactions with the public are an important part of academic life.
To achieve this we will do the following.
(i) Ensure that the induction for new academics includes a session on translation and impact.
(ii) Make translational research and impact a regular agenda item for staff meetings (as this will make them assume a higher priority for academics).
(iii) Require academics to document their own impact-related activity more thoroughly; at present this is not documented in an easily accessible form, hindering the assessment of trends in our impact-related activity. To address this, we will request that UCL and Birkbeck introduce into the Institutional Records system (http://iris.ucl.ac.uk) an extra component to record activity with

industry, health service agencies, patient groups, the general public, UCL Advances, UCL Business and UCL Consultants, and to log participation in impact-related courses.
(iv) Increase the role of impact-related activity in decisions on promotion and salary increases.
(v) Introduce a formal procedure by which impact-generating work is explicitly considered, as well as research, teaching and administrative load, so that when assigning tasks to academics a reduction in other activities can be arranged to facilitate the generation of impact.
(vi) Assess the effect of these changes by carrying out two surveys of academics' attitudes to impact-related activities, one in 2014 and one in 2017.

d. Relationship to case studies

The proactive approaches described in section b above have led to a broad range of impacts. Labels in brackets below relate to the relevant Impact Case Studies, which often benefitted from more than one of the approaches described above.

Translating basic science research into healthcare
Translation of our basic science research is having healthcare impacts in many areas, including healing chronic wounds (UCL05-BEC), diagnosing Batten's disease and trimethylaminuria (UCL05-MOL & UCL05-SHE), diagnosing and treating cancer (UCL05-STO & UCL05-LAT), analgesia in newborn infants (UCL05-FIT2), as well as drug development for ADHD (UCL05-STA), for purinergic receptors and voltage- and proton-gated ion channels to prevent blood clotting and pain (UCL05-BUR, UCL05-WOO1 & WOO3), and for treating amyloidosis and fibrosis (UCL05-WOO2).

Collaborative and commissioned research with industry
Collaborative and commissioned research has had wide impact, including work with industry on drug development (UCL05-MAR & UCL05-BUR), work with museum curators on methods for analysing damage to cultural artefacts (UCL05-ODL), and work with Kew Gardens and the National Trust on the use of micro-organisms as biological agents for pest control (UCL05-NIC).

Commercialisation and entrepreneurship
We have produced significant impact through the provision of databases and software to the biotech industry, including for structural classification of proteins (UCL05-ORE), analysis of protein circular dichroism (UCL05-WAL), and analysis of antibody structure for drug design (UCL05-MAR). Licensing of technology was crucial in a wide range of impacts, including exploitation of our understanding of ADHD (UCL05-STA) and cancer diagnosis (UCL05-STO), whilst spin-out company formation was used to improve technologies for drug discovery (Domainex, UCL05-SAV) and for healing chronic wounds (CoDaTherapeutics, UCL05-BEC).

Consultancy and the provision of expert advice to industry and policy-making bodies
The provision of expert advice to policy bodies, based on our research, has had wide impact, including for the underpinning of abortion guidelines (UCL05-FIT1), for patient groups (UCL05-MOL & UCL05-SHE) and in expert witness work (UCL05-MAR).

Public, media and schools engagement
Our impact strategy since 2008 has been to encourage all types of impact outside academe, including numerous engagements with the general public. Impact from the latter is inherently difficult to quantify in the manner required for submission as Impact Case Studies, but they constitute an important fraction of our impact outside academe. Two notable examples form case studies: David Colquhoun's sustained criticism of "alternative medicine", based on his outstanding research expertise in the field of drug-receptor interactions (UCL05-COL), and Nick Lane's outstanding books and other public presentations on mitochondria, based on his research on the evolution of cellular energy generation (UCL05-LAN).

These impacts, and the strategies that led to them, are all described at greater length in our Impact Case Studies.