Institution: The University of Edinburgh

Unit of Assessment: UoA 4 Psychology, Psychiatry and Neuroscience

A. Context

Edinburgh Neuroscience is a vibrant, integrated, and interdisciplinary research community working at all levels of neuroscience from molecules through synapses and networks to cognition and behaviour. We have focussed our basic and translational research on two key challenges for 21st century Neuroscience: **how does the human brain develop and function across the lifespan,** and **how can it be protected and repaired?** As we show in our 13 case studies, our research has led to impacts that include *annual* cost reductions of £412M for the NHS alone, over 5,000 lives saved per year, and improved outcome or hospital experience for 48,000 people with stroke annually in the UK. More globally, our research has impacted on millions of individuals by influencing and defining healthcare practice, national governments and global bodies.

The focus of *Edinburgh Neuroscience* on research excellence underpins all our activities and also all our impacts. Our work is organised under two overarching cross-disciplinary themes: **Regeneration, Physiology and Degeneration** and **Healthy and Impaired Cognition and Behaviour**. By bringing together high-quality fundamental research into the physiology underlying perception, language and cognition across the lifespan of the healthy individual and the neurobiology of degeneration and regeneration, our impacts span a range of normal human function as well as disease states.

Our impacts-to-date fall into four groupings:

- Protection of the Individual: e.g., improved outcomes following stroke (case studies A–F)
- Protection of Society: e.g., detection and diagnosis of vCJD (case studies G–I)
- Contribution to the Commercial Environment: e.g., successful market authorisation of new treatment (case studies J & K)
- Informing and Improving Society: e.g., enhancing public understanding (case studies L & M)

User groups and beneficiaries include:

- public bodies (healthcare guidelines have been influenced)
- patient and carer groups (first-line treatments have been improved)
- society generally (diagnostic screening tests have been created)
- vulnerable social groups (where needs have been identified)
- commercial research sector (where new treatments have been shown to be effective)

B. Approach to impact

Researchers in *Edinburgh Neuroscience* are encouraged to embed impact into research planning and to engage beyond their initial research environment to ensure that impact is achieved on many levels. From communicating research findings to the public to interaction with policy-makers, patient groups, carers and vulnerable groups, the dialogue that results is part of our culture and informs not only the public, but the researcher as well. For instance, the Patrick Wild Centre for Research into Autism, Fragile X Syndrome & Intellectual Disabilities has direct contact with 100 patient families, maintaining a dialogue that keeps them abreast of current research and allowing researchers to gain an understanding of their needs and aspirations for research. Dialogue is also fostered with online resources such as neurosymptoms.org (created and maintained by Stone, 30,000 hits per month, translated into 10 languages), which allows feedback from patients and direct responses from neurologists. In other examples, demonstrations of human memory to over 250,000 people worldwide, and engagement with very long-term follow-up of birth cohorts have resulted in changes to our understanding of how healthy ageing affects cognitive abilities and how cognitive abilities interact with lifestyle choices to predict health in old age.

The University of Edinburgh (UoE) provides an environment where a diverse range of impact approaches can all receive institutional support and expertise for the development of ideas coupled to readily available seed-corn funding within the University (e.g., for knowledge exchange, for innovations and for pilot studies). As a result, each approach can thrive even though their requirements may be very different. As examples of the excellence of the facilities provided for translation of research, there are new facilities for the support and development of the commercialisation of research ideas (e.g., Edinburgh BioQuarter (EBQ), MRC Developmental Pathway Funding Scheme). To enhance entrepreneurial activity, UoE has also embedded

experienced pharmaceutical industrialists within research centres to drive translation and commercialisation. Initially, an 'Entrepreneur in Residence' was funded through one of the first two MRC Translator Awards in 2007. Supported by Scottish Funding Council knowledge-transfer funds, the Entrepreneur in Residence team grew rapidly. An early success for the team was the granting of an MRC Development Pathway Funding Scheme (DPFS) award; pilot portfolio of £2.0M (with further £0.3M), one of only five in the UK. Latterly the formation of EBQ has transformed our approach to commercialisation (see below).

As an example of the entrepreneurial spirit that is now being fostered at all levels, Andrews (Cat C) was a BioQuarter Innovation Competition 2nd round winner in 2011 with the development of CEREBRAID™, a device for cooling the brain after traumatic injury, and one of our PhD students [Mark Hughes, clinical PhD student with Shipston] was a finalist in this Competition in 2012 with an invention for surgeons to 'warm-up' their skills prior to an operation. This has subsequently been developed for commercial production and has already been sold in 21 countries.

Supporting effective translation of research to improve protection of the individual and society

Translation of our clinically based research into treatment and diagnostics aims to improve individual patient outcome and protect society. This is primarily achieved via interaction of academics with healthcare professionals and by providing access to outstanding clinical trials design, rapid access to patients admitted through the hospital emergency department (as well as routine admissions), availability of large database storage capacity and experienced trials management teams, all of which have been fundamental to the success of the trials. As a result, *Edinburgh Neuroscience* is internationally recognised for the excellence of its leadership in global clinical trials and for its clinically relevant imaging research: since 2008, of the >20,000 research MR scans performed, over 80% addressed a direct clinical question, 19% of researchers in this REF return are actively involved in clinical trials and in excess of 33,000 patients worldwide have been recruited in the case studies presented here. Furthermore, Sandercock has chaired the Data Monitoring Committees of 13 international multi-centre randomised controlled trials since 2008. The subsequent translation of the findings into new treatments, health economic benefits and revised policies is illustrated in the case studies: '*A. Reducing the global burden of stroke'*, '*B. Graduated compression stockings'* and '*G. Diagnostic criteria for human prion disease'*).

Relevant strengths include 1) access to four major hospitals, including the 1000-bed teaching hospital with a Medicines and Healthcare products Regulatory Agency **(**MHRA)-approved clinical research facility providing access to patients willing to participate in studies, and an additional Wellcome Trust Clinical Research Facility at the Western General Hospital, both underpinned by the expertise of the Edinburgh Clinical Trials Unit and MRC Clinical Trials Methodology Hub), 2) MRC Centre for Regenerative Medicine (CRM) in a £56M new build designed for the discovery and delivery of cell- and drug-based regenerative medicines, 3) two other MRC Centres (Inflammation Research and Reproductive Health), 4) BHF Centre of Research Excellence, 5) Wellcome Trust- and MRC-funded human research imaging facility with MR, CT, CT-PET scanners and a cyclotron, 6) £12.8M development in regenerative neurology funded by a private donor for the purpose-built Anne Rowling Regenerative Neurology Clinic and a large database resource unit for the processing and storage of anonymised clinical trials information.

Encouraging the commercialisation of ideas

To facilitate the promotion and use of ideas and technologies generated within the academic environment as a result of the emphasis on entrepreneurial work (e.g., case study '*K. Invention and commercialisation of Saccadic Vector Optokinetic Perimetry')*, the University provides professional units that support the conversion of these ideas into commercial reality:

Edinburgh BioQuarter (EBQ, www.edinburghbioquarter.com) is a UoE-led organisation that supports spin-out companies and interactions with the pharmaceutical sector. It provides assistance in the writing of applications for Translational Awards, brokering collaborative research programmes (and associated funding) between academics and pharmaceutical and/or biotechnology companies, it runs commercialisation workshops to encourage a more entrepreneurial approach amongst academic/clinical staff and hosts an annual Innovation Competition open to all University staff encouraging ideas for new products or services that could be used to improve animal or human health (see above for neuroscience examples). Grow-on space for early-stage rapidly expanding companies is crucial and the University provides a range

of options at its BioQuarter and Technopole science park. Here, the University's maturing spin-out and start-up companies can rub shoulders with multinational blue-chips in an environment specifically designed to encourage innovation and collaboration.

The success of this dual strategy of professional support for spin-out generation and dedicated space adjacent to University academic institutes is evidenced by the fact that, while in the 5 years prior to the inception of EBQ there was a one spinout company from neuroscience research, during the past 3 years, EBQ has spun out seven companies (ipSOX, Cytomos, NeuroOrg, Pharmatics, Coolgenics, Aquila BioMedical, i2eye Diagnostics). At the same time, disclosure activity has increased by 230%, and collaborative research agreements with industry have increased by 32% and we currently have collaborative projects with at least 8 companies including Mitsubishi, Novartis, Pfizer, Roche, Seaside Therapeutics and Wyeth.

Support for informing the public, policy-makers and politicians

By providing an environment that fosters and supports relationships between organisational users and academics, UoE facilitates the impact of academic research on strategy, policy and guidelines. It enables strong links with policy-makers and influential organisations (at least 23 members of our research community sit on 56 policy-related panels, at regional, national and global levels).

Edinburgh Neuroscience also works closely with professional public engagement organisations such as the Beltane Public Engagement Network (initially funded by the Wellcome Trust and RCUK, now based at, and supported by, UoE) which provides opportunities for engagement with policy-makers and the Scottish Parliament through its contacts with Scotland's Futures Forum, researcher placement scheme, Fellowship programme and workshops educating academics in how to work with policy-makers. Drawing on these resources, in 2010 *Edinburgh Neuroscience* members [Lawrie, Sandercock, Wardlaw] instigated and organised a series of debates on the current, and potential future use, of brain imaging technology outside the medical and research spheres. Working in partnership with the Scottish Universities Insight Institute, SINAPSE (Scottish Imaging Network) and Scotland's Futures Forum, international imaging and law experts instigated direct dialogue with 60 members of the public and policy-makers at the Scottish Parliament. An online public survey (completed by 660 people) aimed to determine public awareness of, and attitude to, this technology and the findings were published in *PLoS One* (2011). They also worked with Beltane PhD Fellow Oliver Escobar to study the dialogue process and his findings have been published in *Science & Public Policy*. He now provides advice to *Edinburgh Neuroscience* and other organisations on approaches to science-public-policymaker interchange.

At the same time, the University Press office enables professional engagement with all forms of media. Since 2008, *Edinburgh Neuroscience* has had 128 research studies covered by print and online media; this route has also been used successfully for public engagement (e.g., case study '*M. The Lothian Birth Cohorts*'). The reputation of staff, from academic publications and public-engagement activities, has led to spontaneous requests from the media to become involved in large-scale public dissemination of science from very large cohorts of the general public, such as when 0.5M people worldwide (251,757 since 2008) undertook an online memory test designed by Logie for the BBC (case study '*L. Enhancing Public Understanding of Human Cognition*').

In addition to working with healthcare professionals, companies, policy-makers and the media, an equally important part of our strategy for impact is extensive communication directly with the public. To this end, in 2007 *Edinburgh Neuroscience* commenced a broad programme of public activities that enables researchers and students to engage with the wider community within a supported structure. This programme covers an array of activities designed to appeal to different groups within society and allows researchers to engage in a manner that suits those groups. The success of the programme is seen in both the range of activities and the numbers of people attending. The programme has also been recognised with awards: 2008 - the inaugural Tam Dalyell Prize for Excellence in Engaging the Public with Science [Della Sala], 2011 - the inaugural Royal Society of Edinburgh Beltane Innovators Award for Public Engagement [Joanna Brooks, PhD student in Psychology with Della Sala/Logie] and 2013 - British Neuroscience Association Award for the Public Understanding of Neuroscience to Jane Haley, *Edinburgh Neuroscience* Coordinator.

In the REF period at least 4,165 school pupils and 6,571 members of the public have directly participated in one of our events. In addition, as part of the annual Edinburgh International Science

festival, we receive a further footfall of ~5,000 visitors per year who participate in our activities, and the high-profile university-wide '*Our Changing World*' lecture series co-organised by Dutia (this UoA) has been attended by ~10,000 people since 2010 (downloaded online >0.6M times worldwide). Other activities include (numbers since 2008):

- Workshops for schools: Brain Awareness Week workshops at the University and getBRAINY workshops for primary and high schools (4,165 pupils)
- Public lectures: e.g., Christmas Lectures (also live webcast), Encounters discussions (2,489 attendees plus 4,400 online views)
- Annual Science Festivals across the UK (estimated 33,000 people)
- Edinburgh International Film Festival 2011 and other film screenings (462 attendees)
- Theatre productions & contributions: *Dementia Diaries* (2011), *2401 Objects* (Edinburgh 2011, 2012), *Captain Ko and the Planet of Rice* (2012), *Still Life Dreaming* (2011) (1,940 attendees)
- Art-science collaborative exhibitions: *Represent, Present, Re-Present* (2013), *Transformations* (2010) (320 visitors plus 1,300 downloads)

These activities take place in a framework of support from the University, with dedicated University staff working with the Science Festival and also to coordinate engagement activities at College and University level. In addition internal funding sources are made available to support specific activities (e.g., the Small Project Grants from UoE Development Trust supported creating the getBRAINY workshops). The recent addition of minimal cost automated recording and live-streaming facilities in the majority of the lecture theatres in the University has transformed our public lectures: since 2009 we have been making these available to view online and in 2012 we started live-streaming via the British Neuroscience Association website.

C. Strategy and plans

Our strategy for the next 5 years is to strengthen, extend and enhance our impact in four ways.

First, we will strengthen the translational research that underpins future impact by our planned consolidation around our two major University campuses: the hospital, medical school, and clinical research facilities at Little France, a site that is only 15 minutes journey time from the second campus at George Square, the location for core human cognitive and systems neuroscience work together with informatics and linguistics. The major impacts from the existing resources and expertise on these sites (described above and in REF5) will increase with further consolidation of clinical research facilities at Little France, so increasing interactions from basic research through translation to clinical delivery. In parallel, greater interaction among researchers in the central area will expand the links between theoretical and empirical research on cognition across the lifespan and translation to links between lifestyle and life outcomes, to new cognitive assessments for neurodegenerative diseases, and to the design of information technology for human use.

Second, we will develop innovative ways of enhancing the impact of our research in the public domain. By building on the extensive outreach programme we have created, we will continue to develop and engage new audiences and researchers in innovative ways, thereby stimulating new directions for possible impact. As an example, in 2012 we established a new collaboration with the Edinburgh College of Art (UoA's 16, 34 & 35). By bringing together researchers & artists, with both benefitting fully from the activities, we aim to create novel areas of exploration. We have already held a public exhibition of neuroscience-inspired artwork ('*Encounters: Represent, Present and Re-Present*', May 2013) and been awarded a £1M EPSRC-led cross-funders joint grant to members of *Edinburgh Neuroscience* [Deary, Starr, Mead (UoA26)] and the Edinburgh College of Art [Coyne, Scott, Ward-Thompson (all UoA16)] for '*Mood Mobility and Place: a user-centred approach to design of built environments to make mobility easy, enjoyable and meaningful for older people'.*

Third, we will increase our commercially relevant activity, as was previously achieved before the REF census period with the Morris water maze (now the standard *in vivo* investigative tool for the pharmaceutical industry) and as in our case study '*K. Invention and commercialisation of Saccadic Vector Optokinetic Perimetry*'. Key here will be EBQ, and NHS Lothian, for establishing strategic alliances and enabling company formation. We will also take advantage of our juxtaposition on the Little France campus next to the new £20M bioincubator building, which provides space for spin-outs alongside incoming Pharma and biotech companies. As well as enabling joint projects receiving commercial funding, the consequent interactions between CRM investigators and those working in small and medium enterprises (SME) and Pharma environments will foster translational

collaborations, generating an environment in which commercialisation is seen as a priority.

Finally, we will extend the impact of our work on public policy and education. For example, our research on ageing & cognition provides information of importance in planning healthcare provision and so we will substantially increase our engagement with Scottish and UK government ministers and educators, in particular by increasing inputs into parliamentary committees. Our investigators have already presented to members of the Scottish and UK parliaments and we have created support materials for the new Higher Human Biology curriculum for the Scottish Qualification Agency (2011; http://www.educationscotland.gov.uk/highersciences/humanbiology/unitthree).

D. Relationship to case studies

Protection of the Individual

Many of our impacts are related to healthcare issues, protecting the individual from untreated disease by providing improved healthcare outcomes. These result from the excellence of the multi-national clinical trials design and coordination led by Edinburgh, from our commitment to research excellence and from our willingness to work with partners within the higher education sector and external to UoE. These case studies rely on contact with patient groups and policy-makers.

- A: Reducing the global burden of stroke by using aspirin and avoiding heparin use in the treatment of acute stroke
- B: Graduated compression stockings do not reduce the risk of post-stroke deep vein thrombosis
- C: Immediate CT scanning in acute stroke improves outcomes for patients and is very cost effective, whereas arteriography & MR scanning are not cost-effective in secondary prevention
- D: The FOOD trials: feeding policies in hospitalised stroke patients influence patient outcomes
- E: Evidence-based identification and cost-effective treatment of depression in cancer patients
- F: Medically unexplained symptoms including chronic fatigue syndrome can be accurately identified and treated

Protection of Society

From determining diagnostic criteria and identifying transmission routes for transmissible diseases, to providing detailed information about patterns of online child abuse, our research has resulted in changes in policy and legislation and contributed to the protection of society. Once again, this is built on the foundation of excellent research, coupled with strategic investment (e.g. £3.2M by UoE in a dedicated CJD research unit) and planning (e.g., incorporation of the Roslin Institute (UoA6) into the University in 2008 resulting in close communication between the two prion communities).

- G: Diagnostic criteria for human prion disease enable case ascertainment and underpin international policy on prion disease
- H: Identification of transmission risk of variant Creutzfeldt-Jakob Disease (vCJD) via blood and blood products defines critical changes to health policy
- I: Defining the scale and demographics of technology-mediated crimes and illegal images of children, leading to new international accord and changes to sentencing guidelines

Contribution to the Commercial Environment

By providing an excellent research environment that encourages innovation and an entrepreneurial outlook, our researchers are attractive collaborators for industry.

- J: Thrombolysis for acute ischaemic stroke is effective for a wide range of patients, including those over 80 years, and improves long-term function and quality of life
- K: Invention and commercialisation of Saccadic Vector Optokinetic Perimetry: development of visual-field testing technology and its translation to clinical practice and the marketplace

Informing and Improving Society

By providing relevant information to the public we enable them to make informed choices about their lives. Built on the foundation of excellent research and on investment in the MRC Centre for Cognitive Ageing & Cognitive Epidemiology, we have impacts that genuinely help people make important lifestyle choices. These studies result from contact with the public and aging cohorts.

- L: Enhancing public understanding of human cognition
- M: The Lothian Birth Cohorts: informing and changing policy and public perceptions on what is and is not associated with normal cognitive ageing