Institution: The Open University

Unit of Assessment: A3, Allied Health Professions, Dentistry, Nursing and Pharmacy

a. Overview

The context for our submission to UoA A3 is a strategic shift in The Open University's (OU) vision for health science with the aim of developing a pan-University interdisciplinary approach to research and teaching in the health sciences. In the 2008 RAE a submission from the Biomedical area of science was made to UoA14, Biological Sciences, but following a restructuring of the Faculty of Science, a Department of Life, Health and Chemical Sciences (LHCS) was formed in which health-related researchers were located.

The interests and expertise of our staff in health research match the objectives of the new Department. The focus on health sciences also embraces health-related research from the Faculty of Health and Social Care, for staff who are not involved in the Social Work and Social Policy submission (UoA 22) and whose work underpins clinical practice, and health care. The synergies with their research include our joint collaboration with the Oxford Academic Health Sciences Network.

Our submission emphasises management of health issues, and exemplifies collaborative research across The Open University. It demonstrates the changing research environment through the quality and impact of our publications across a range of health sciences, and via external collaborations with health providers.

b. Research strategy

Details of significant changes to strategy over the REF period

The broadening of multidisciplinary research interaction in health aligns with the mission and values of The Open University. A priority has been the establishment of links between researchers with related interests and with complementary expertise. This has the aim of enabling the effective and efficient pooling of intellectual resources and facilities to encourage and generate new collaborations, and align our research with national and international health initiatives.

External collaborations are a feature of our research, both within the UK (including industrial partners) and abroad (mostly, but not entirely, in mainland Europe). We have a significant involvement with a network of international Affiliated Research Centres (ARCs), which are linked to The Open University and where we are involved in collaborative research and the supervision of more than 240 PhD students.

During the present REF period, our research has built upon these aims, and we have focused on bridging research across three core themes that follow three broad health-related areas. Each theme is associated with research leaders and their groups; however, as staff are able to work freely across boundaries they may be involved in a variety of projects where their expertise can make useful contributions. This narrative focuses on research achievements in these three areas:

1. Neural dysfunction, mental health and long-term conditions
2. Cardiovascular disease, vasculature and inflammation
3. Diagnostics and therapeutics.

Neural dysfunction, mental health and long-term conditions

The research strategy in neural dysfunction and mental health research has been to focus upon ageing and degenerative disease, and on methods to enable analyses of neural systems using *in vivo* and *in vitro* 3-D neural systems (Stewart, Gabbott and Philips). This research has benefited from the opportunities provided by both UK and EU funding regimes in basic research underpinning ageing research. There is an emphasis on lifelong health and well-being. This focuses on the study of the genetic, biological and cognitive underpinnings of disorders across the lifespan, including autism, ADHD and dementia. The broader area of research into mental health management and rehabilitation from disease is directed by Barbour, Lloyd and Herron-Marx. A brief synopsis of the research by individuals in this area follows.

Neural dysfunction and mental health: **Stewart** and his group examine the influence of cell adhesion molecule mimetics on synaptic plasticity and their ability to alleviate neurodegeneration in ageing. His high quality publications provide evidence of the impact of this research, which has been supported by collaborations with both UK (Rusakov, University College London (UCL); Giese, Kings) and European partners (Schmidt, Munich; Doyere, Paris; Sandi, Lausanne; Kaczmarek, Warsaw and Bock, Copenhagen). This research in the area of Neuromorphology is supported by high levels of external funding, primarily from the EU (FP6 and FP7) and the Biotechnology and Biological Sciences Research Council (BBSRC), and continues to set the agenda in the development of 3-D reconstruction methods for analyses of hippocampal synaptic connections in both learning and neurodegenerative models. Stewart's research has been a feature of symposia organised at the biannual meetings of the Federation of European Neuroscience Societies (FENS).

Neuroanatomical research on connectivity and tract tracing in prefrontal cortex by **Gabbott** in collaboration with external researchers (Professor E. Rolls, Warwick University) is funded by Autism Speaks. It offers pioneering insights into how cortical networks involved in cognitive functions have the potential to simultaneously influence multiple brain centres involved in the autonomic functions underlying the processing of emotions. The genesis of this novel neuroanatomical framework presages significant insight into how the human prefrontal cortex processes and distributes information, in health and also in depression, schizophrenia and other neuropsychiatric disorders.

Research by **Philips** (case study 3) on cellular neuroscience and tissue engineered nerve repair has developed 3-D neural complex cell culture systems that have led to research into areas that would otherwise be inaccessible. It has also provided a basis for *in vitro* experimentation that will enable a reduction in the number of animals used in neuroscience research.

Hoekstra (autism; case study 1) and **Dommett** (ADHD) have focused on mental health, with Hoekstra involved in epidemiological studies of autism. Her research has contributed to the development and translation of the Autism-spectrum Quotient (AQ). This autism research has extended into developing countries and, supported by substantial funding from Autism Speaks (USA), studies the effectiveness of mental health training for rural health extension workers in Ethiopia on increasing autism awareness and decreasing stigma related to mental health problems.

Dommett, in collaboration with Professor Overton (Sheffield), has investigated the neurobiological basis of ADHD in an animal model, and examined how abnormal functioning may be rectified with ADHD medications. This research has been supported by the Brain and Behavior Research Foundation USA. A feature of Dommett's research is involvement in outreach activities in locations ranging from schools to the House of Lords.

Research by **Saffrey**, in collaboration with the Universities of Brighton and Northumbria in the BBSRC-funded 'Ageing Bladder and Bowel' initiative, employs a multidisciplinary approach to understanding the physiological and cellular changes that occur in the terminal bowel during ageing. This may contribute to faecal incontinence, which severely undermines the quality of life in the aged.

Long-term conditions: **Lloyd** (case study 2) and **Barbour** bring a critical social science perspective to bear in research work across a range of clinical conditions. Significantly, this work involves the development of new insights through bringing together separate clinical fields – cancer and reproductive/fertility issues (Barbour); diabetes and mental health/depression (Lloyd). The engagement of both these researchers spans clinical and psychosocial research, thus addressing the implications of treatment, service delivery and organisation, and the well-being of patients (including Barbour's research into the psychosocial consequences of stroke and obesity, and experiences of health promotion in pregnancy).

Herron-Marx's work also addresses the intersection of the social and the clinical, bringing systematic review techniques to bear on studying both the impact of patient and public involvement and delay in patient help-seeking, drawing on both quantitative and qualitative literatures. **Herron-Marx** has also critically evaluated professional models of care and decision-making in relation to stroke survivors and individuals with head and neck cancer. **Lloyd**'s work has been influential in informing development of diabetes services locally and she has been involved in a number of

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Lloyd's work has been influential in informing the development of diabetes services locally and she has been involved in a number of consultation exercises. **Barbour's** collaborations cover research into young women and problem drinking, and carer involvement in drug services, which have resulted in recommendations regarding policy and practice in these areas.

All three researchers also bring significant methodological expertise to bear in conducting research, covering a wide range of methodologies, ranging from RCTs and systematic reviews, to the development of participative qualitative methods, and innovative mixed methods applications. **Barbour** enjoys an international reputation with respect to qualitative research methods, with particular specialist knowledge of focus groups and issues of quality/rigour (as evidenced by publication of several books, papers in peer reviewed journals and a series of workshops and plenaries delivered throughout Europe, the USA and Canada).

Diagnostics and therapeutics

Our strength in analytical science is exemplified by diagnostics investigations by OU researchers submitted to UoA A3. **Turner's** work stems from her interests in non-invasive monitoring of markers of disease, and specifically monitoring volatile organic compounds (VOCs). VOCs or profiles of VOCs from clinical samples (breath, blood, urine, etc.) can be used to diagnose disease or monitor conditions and this analysis offers a simpler, quicker and more patient-friendly method than existing practices. Her group has made advances in the diagnosis of cancer, inflammatory bowel disease and tuberculosis and in the non-invasive monitoring of blood glucose in diabetes. In addition, the therapeutics work has involved design, and formulation of novel photosensitive materials for use in cancer treatment. Research by **Golding** examines augmentation of the anti-cancer properties of photodynamic therapy (PDT), by inhibiting various metabolic pathways and by designing novel targeted photosensitizers. In collaboration with CR-UK and Japanese researchers, the work of **Xu** compliments PDT by investigating the production of novel nucleic acid bases for use as UV-A sensitive anti-cancer agents.

Cardiovascular disease, vasculature and inflammation

The research strategy in this area is based on our previous work on the functional differences between the vasculature in different tissues. Expertise within this group covers the cellular biology of the vasculature, in particular the blood–brain barrier which is a major focus of the pharmaceutical industry and drives an increase in funding coming from the pharmaceutical and biotech sectors. The majority of this work uses human cells in culture and/or human tissue. The projects build upon our expertise in complex human tissue culture models and *in-silico* modelling of the vasculature. We aim to use the knowledge we have obtained to develop treatments for disease or to target systems for therapeutic agents. Engagement with the biotech industries is a key part of this strategy.

Hague models blood flow alterations during strokes, combining computational models of the cerebral vascular with *in vitro* experimental studies that measure the properties of emboli as they travel through the vasculature. This has led to the first *in-silico* model of transient ischemia during open-heart surgery (a novel method for embolus sizing using Doppler ultrasound) and an understanding of the trajectories of the emboli through the larger vessels in the brain (particularly the circle of Willis), which are being merged into a detailed virtual patient system suitable for real-time intra-operative monitoring.

Groups led by **Male** and **Romero** (case study 3) have focused on how inflammation is controlled in different tissues, in particular in the central nervous with an overall strategy of application of this knowledge to the control of inflammation and drug targeting at different sites. There is increasing evidence that there is a vascular component to neurological diseases of the central nervous system, and Male and Romero have worked in collaboration with the Migraine Trust to investigate the linkage between endothelium and electrophysiology of cells associated with the vasculature.

More recently identification of micro-RNAs that modulate adhesion molecules in brain endothelium has indicated how inflammation could be controlled by gene-therapy aimed at these endothelial micro-RNAs. This work is currently carried out in conjunction with the Multiple Sclerosis Society, Medimmune, The DANA organisation, Midatech and more recently with major funding from a

BBSRC project grant. It has been underpinned by two PhD studentships undertaken in collaboration with an external clinical collaborator, Dr Basil Sharrack, at the University of Sheffield Institute for Translational Neuroscience. The group also collaborates with Prof David Baker (QMC, London) as they provide *in vivo* models of multiple sclerosis, which support the studies on human tissue culture.

This group has been greatly strengthened by the recent appointment of **Bootman** and **Rietdorf**. Their work focuses on calcium signalling, using a variety of imaging methods. A particular emphasis has been on atrial myocytes and pulmonary vein sleeve cells, in order to understand the phenotypic changes that promote atrial fibrillation, the most common form of sustained cardiac arrhythmia. They also study the response of human vascular smooth muscle cells to nanoparticulate calcium crystals (present in atherosclerotic plaques in human patients). These crystals were demonstrated to cause an overwhelming calcium overload inside the cells, which eventually leads to cell death – an event that would lead to plaque instability.

Interactions between staff and support for research

Each of the research groupings relating to the three themes offers one or more regular (weekly and monthly) research theme meetings and journal clubs, at which current projects and the literature are reviewed and discussed. Financial support is available to support visiting scientists, and conference attendance, and interdisciplinary organising of research seminars with colleagues from Health and Social Care. Particular importance is placed on the development of key research and dissemination skills, with an emphasis upon supporting early career staff and researchers.

As an extension of this 'local' provision, the OU Research School provides a stable structure for sharing information, strategic planning and expertise sharing across the organisation, and for cross-boundary activity. For example, the Research School provides research development workshops, consultation on bidding for European funding, and expertise in knowledge transfer. The Enterprise Office within the Research School provides advice on IPR issues and commercial exploitation. This has enabled a patent to be obtained for Romero's *in vitro* model of the blood brain–barrier, which has generated gross income of £150k since 2008.

The OU Library with its online library services provides staff and research students wherever they are with online access to a world-class collection of more than 85,000 academic journals, half a million books and a vast selection of newspapers, images, video and sound, with 24-hour helpdesk support and a range of face-to-face and online training sessions available. Study and discussion spaces are also available for on-campus use.

Responsiveness to national and international priorities and initiatives

The ability of staff submitted to UoA A3 to respond to and participate in national and international initiatives in health and well-being is evidenced both by our presence and strong success in external funding, for example in funding initiatives on ageing by RCUK (from BBSRC, where we have been successful in obtaining funding for 3 recent project grants), in major EU FP6 and FP7 programmes, and in WHO initiatives in sub-saharan Africa. It is also demonstrated by the participation of staff on national and international bodies, including: NC3Rs, the Tissue and Cell Engineering Society and BBSRC, British Neuroscience Association, Federation of European Neuroscience Societies (FENS), Motor Neuron Disease Association, Autism Speaks, Multiple Sclerosis Society, Portuguese Ministry of Health, German Ministry of Health, Psychosocial Aspects of Diabetes Study Group, and Dialogue on Diabetes and Depression.

Development, promotion and dissemination of research

The Open University makes strategic investment in research targeted not only at maintaining and improving the research infrastructure but also aimed at capacity building. This enables us to pump-prime new areas of activity through investments in academic staff, especially early career staff, and to fund postgraduate research studentships, as well as provide support to attend/host conferences and initiate collaborative activities. In the biomedical health area this funding totals £230k per annum. Such institutional investment is subject to Faculty and University Research Committee approval.

Dissemination of research outputs

The University has developed a particularly wide range of online databases for dissemination of

information, available via the web and available to all staff and research students. Publications are freely accessible via the open access repository, Open Research Online (ORO). Moreover, the academics included in this submission spend great efforts communicating their research to a wider audience. For example, Hoekstra has produced several educational pages on autism that are published on the Open University's OpenLearn pages; Dommett frequently talks about her research findings during outreach activities at schools and in the House of Lords; and several of our academics are involved as academic advisers in health related BBC documentaries. Our public engagement activities are further detailed in the Impact template accompanying this submission.

Inter-and multi-disciplinary research
This is central to the strategic development of health science research at the OU with a signature emphasis upon blending 'fundamental' and 'practitioner' and 'user' interfaces. Thus multidisciplinary collaborative interactions are frequent and as evidenced in joint research e.g. Hoekstra with Ethiopian mental health experts and the Ethiopian Ministry of Health in her Autism Speaks funded autism research and Stewart with medical education training in Ethiopia supported by **Ethiopia Aid** and the Ethiopian government. Collaborative ventures exploit complementary skills and expertise in our industry links (e.g. Philips with TAP Biosystems).

Future plans and objectives
Our main objectives in the next five years are to increase capacity in health research and build upon and enhance our research expertise, from the laboratory bench with practical biomedical science, to the practitioner level where we translate our research into practice, relating our work to service users. We are particularly interested to show new insights from multiple perspectives of the varied expertise of our health researchers, especially where we can offer leadership based upon our experience, for example in developing health initiatives in Africa. Thus we aim:

- to maintain and extend a balance of internal and external research funding streams, with internal resources focused on new appointees with a view to enabling them to establish research programmes
- to ensure we continue to publish high quality publications that demonstrate impact from our research
- to extend our external funding from Research Councils, EU and medical charities, together with commercial enterprises (The aim is to ensure that every member of UoA A3 should have income at least commensurate with the present level of ~£30k per annum).
- to consolidate and extend links with clinicians at centres of clinical excellence in the UK
- to increase the number of postgraduate research students and to develop further links (both research and studentships) with our worldwide network of Affiliated Research Centres, where we have ~240 'life science' postgraduate researchers (mainly full time) in the UK and abroad, including the Wellcome Trust in Kenya, Thailand and Vietnam, and the Medical Research Council (MRC) in The Gambia
- to continue our research links with developing countries and to enhance capacity building.

c. People, including:

i. Staffing strategy and staff development
Following restructuring of the Science Faculty, we have engaged in a tightly focused appointment strategy in specific areas to consolidate and complement our collaborative framework of biomedical research by means of a recruitment profile balanced between senior and early career staff. Thus in Science, and in Health and Social Care, we have recently appointed Hoekstra, Rietdorf, Dommett and Turner, and at senior level, Bootman, Herron-Marx and Barbour. In addition, the University has appointed a senior administrator specifically to coordinate the research approach between Science and Health and Social Care.

The OU maintains an active programme of staff development, and all staff are formally allocated time for research and career development opportunities within their normal workload plans. The OU is a member of the Athena Swan Charter and institutional Bronze Award holder and reviews objectives and progress annually, taking into account staff feedback and key focus areas. All newly

appointed staff are assigned a mentor, and are allocated 'light' teaching and administrative loads for at least two years after their initial appointment. Supervisor training for new staff is mandatory to ensure best practice and compliance with the revised Quality Assurance Agency (QAA) code for supervision.

The Open University is a signatory to the Concordat to Support the Career Development of Researchers and actively works to implement its seven principles. Our commitment has been recognised with the European Commission HR Excellence in Research Award.

ii. Research students

Our research students are funded by the Research Councils (primarily BBSRC, EPSRC and MRC), the European Union and charitable bodies (such as the Multiple Sclerosis (MS) Society and ITP Support Association) and via industrial collaborations (e.g. Cyclacel, REGEN Therapeutics, TAP Biosystems). Each student is assigned two supervisors and a third-party monitor. Discipline-centred postgraduate tutors and the Associate Dean for Research (Science) undertake six-monthly reviews of student progress. Initial registration is for the MPhil degree, and upgrading to PhD registration is permitted only with satisfactory progress against probation benchmarks.

RCUK and HEFCE recommendations on graduate student training are fulfilled by a QAA-approved programme of training encapsulated in an intranet-structured system now adopted as a model by several other universities. This programme of training comprises aspects of experimental design and analysis, ethics, communication and transferable IT skills, aimed at nurturing research capability.

Student completion rates: The suitability and quality of our doctoral support is confirmed through the completion and award rates for full time (85% submit within four years in both the Science Faculty and in Health and Social Care), RCUK-funded students, which meet, or exceed, current HEFCE reported sector averages; comparable statistics apply for part-time postgraduate research students. Excluding our affiliated research centres (ARCs) (see below); we have had 36.25 students in the period 2008–13 with an average of 2.1 postgraduate students per member of staff in UoA A3.

Our doctoral training expertise reaches beyond the OU. For example, *Doing Postgraduate Research* (Sage), a best-selling book by OU academic Stephen Potter, and the development of a postgraduate study and training course, STM895 *Postgraduate research skills in science, technology, maths and computing,* are now used not only in The Open University but also in our Affiliated Research Centres.

We play a leading role in postgraduate training in the Affiliated Research Centres (ARCs). This programme extends to the (mainly full-time) 240 'Biomedical science' postgraduate researchers registered through the ARCs in the UK and abroad, including the Wellcome Trust in Kenya, Thailand and Vietnam, and the MRC in The Gambia, where research is focused on tropical diseases. Oversight and regulation of these students is on the same basis as our own internal, directly registered students, as is student induction, supervisor training, and examiner appointments. Contact is maintained by regular reports, visits to the ARC units by OU staff, and by the development of a Virtual Research Environment (VRE). There have been 330 students gaining PhD degrees from the ARCs in the period from 2008-2013. The submission rates for the ARC students are slightly higher than our FT internal students, with 89% submitting within four years.

The ARC programme supports the building of intellectual capacity in local environments through its outreach work, and by supporting able research students in doctoral training and establishing them in academic careers. Where there is relevant complementary research expertise between the ARC and The Open University, some students may be directly co-supervised by Open University academic staff and researchers at the ARC, for example with the Wellcome Trust in Kenya, MRC Molecular Genetics at Harwell, and Roskamp Institute, Florida. In addition, a number of collaborative research engagements take place between members of OU staff in UoA A3 and the ARCs. For example, the €4 million FP7 Memstick award included collaboration between Stewart and the Max Planck Institute of Psychiatry in Munich.

d. Income, infrastructure and facilities

At our main campus in Milton Keynes, the OU is committed to providing a research environment of the highest international quality. Capital investment in the OU research infrastructure has totalled £206m over the last 10 years. This has resulted in a 46% increase in laboratory space and state-of-the art research facilities, ensuring that research groups in biomedicine have access to necessary equipment that meets their research needs. Our laboratories have also benefited previously via funding of £2.5m from SRIF2 and SRIF3, and by Open University investment funds.

Our facilities include imaging laboratories, wet labs and tissue culture laboratories to class 3 level. An extensive animal facility is available, supported by three members of staff, and has containment for models of animal disease that have included the TC1 mouse model of Down's syndrome, and a Huntington's disease mouse model. An advanced, cutting-edge electron microscopy (EM) facility (with three modern EMs) enables sub-cellular level analyses of biological samples and is supported by a dedicated technical team.

Facilities analysing biological materials using light and fluorescence microscopy include three confocal microscopes and 3-D image processing packages, as well as access to facilities to prepare a wide variety of cell and tissue cultures. We have a wide range of bio-analytical instruments, including chromatography and mass spectrometry (GC-MS, LC-MS, SIFT-MS, DNA synthesiser), Nuclear Magnetic Resonance and equipment for making biosensors.

There are also facilities for studies with human participants, including testing rooms for cognitive studies, qualitative EEG, and the Biomedical Online Research Network ('BORN'), comprising an online data collection facility and a research volunteer register.

In the period 2008–12, the total grant income was £2,503,180 from UK research councils, medical charities, and from industrial collaborators, which includes direct research funding and co-funding of studentships. For the 17 researchers submitted, this is an average of £147,246 per researcher over five years.

e. Collaboration and contribution to the discipline or research base

Collaborations and interaction of staff, and joint sharing of facilities are considered not only normal practice but also essential to the development of common interests in the health field.

The research areas for science are physically located in our large, modern, state-of-the-art laboratories. However, with the emphasis on our research broadening to areas such as mental health management and rehabilitation from disease, a considerable proportion of the research reported here involves field-based work (in the UK and abroad) with patients (autism), in hospitals or other health care facilities, or with hospital records (diabetes, stroke). For example, Turner's work involves collaborative projects with Addenbrooke's Hospital (gastrointestinal research) and Amersham Hospital (melanoma and bladder cancer research). Lloyd's work involves multidisciplinary research teams, including health care practitioners in both primary and secondary care, physicians, specialist nurses, psychologists and psychiatrists. Lloyd is also involved in the Pittsburgh Epidemiology of Diabetes Complications study, Hoekstra collaborates with mental health experts in Ethiopia (with colleagues from Addis Ababa University and the Ethiopian Federal Ministry of Health); and has research collaborations with Dr Angelica Ronald (Birkbeck College), Prof Simon Baron-Cohen (Cambridge Univ), Prof Francesca Happe (Institute of Psychiatry, KCL), and Prof Daniele Posthuma (VU University Amsterdam).

There is also a strong focus on service-user involvement, in both the design of research and its conduct. We have extensive external collaborations with industry and with health providers, including Milton Keynes Hospital. Both the Faculties of Science and Health and Social Care are major partners in the Oxford Academic Health Sciences Network (http://www.oxfordahsn.org/partners-and-affiliates/page/7/). The aim of the Network is to improve patient care by putting innovation at the heart of the National Health Service, linking health care with academia, research and business.