Institution: Imperial College London

Unit of Assessment: 04 Psychology, Psychiatry and Neuroscience

a. Overview

Since RAE2008, we have invested heavily and strategically in our neuroscience and mental health research. We have recruited 12 new academic staff and invested more than £3M in redevelopment of their environment to create a new, stronger and realisable vision for neurosciences, within the Faculty of Medicine, at Imperial College London.

With the creation of a **Division of Brain Sciences**, we have aligned expertise and facilities on the rebuilt and refurbished Hammersmith campus to create a dynamic multi-disciplinary research environment to address national priorities for the life sciences and health.

b. Research strategy

A major change in the research strategy and environment since RAE2008 has been to develop Brain Sciences as a principal theme in the Faculty of Medicine. Following an external review in 2011, we made neurosciences one of our major areas of development with substantial *new* investment already totaling more than £8M.

The strategic plan for Brain Sciences is to develop and sustain a unique portfolio of translational research in neuroscience and mental health recognised internationally for scientific excellence, for leading innovation in patient care and for creating a dynamic environment for training research leaders of the next generation. Significant management changes were implemented to enable this. Neurosciences, Neuropsychopharmacology, Mental Health, and Neurology were integrated into a single Division of Brain Sciences under a new Head of Division (*Matthews*). The previous five research groupings were re-focused into three strategic areas, each with the critical mass for delivery of high quality translational science:

- Neurodegeneration and Neuroinflammation (NN)
- Brain Plasticity and Recovery (BPR)
- Neuropsychopharmacology and Mental Health (NMH)

With more than £5M in new committed support, since 2008 we have recruited internationally and attracted new senior research leaders for each research grouping: (*Matthews*, NN; *di Giovanni, Gunn*, *Knopfel*, and *Veltkamp*, BPR; *Lingford-Hughes and Nutt*, NMH). Appointments of promising younger researchers have been made in molecular neurodegeneration (*Alavian*, *Perneckzy*, NN), cognitive neuroplasticity (*Hampshire*, BPR), stroke epidemiology (*Geraghty*, BPR) and neuropsychiatric genetics (*Need*, NMH). Our Early Career Researchers are underlined; staff returned within other UoA submissions are not italicised.

£3M additional College investment created 2500m^2 of new facilities, offices and laboratory space (described in detail below) for Brain Sciences research in the Burlington Danes Building on the Hammersmith campus, above the Imanova pan-London imaging facility and near the discovery science of the Medical Research Council (MRC) Clinical Sciences Centre (CSC) and the MRC/National Institute for Health Research (NIHR) National Phenome Centre. Further renovations are planned for our larger NHS Trust-embedded clinical research facilities during 2014.

The framework for translation of our UoA4 research is provided by our integrated Academic Health Sciences Centre (AHSC), created in partnership with Imperial College Healthcare NHS Trust (ICHNT) in 2007 and formally designated by the Department of Health in 2009. The AHSC has facilitated alignment of research with service. Establishment of the Hyperacute Stroke Unit with parallel academic appointments in Stroke Medicine (*Veltkamp, Geraghty*) and the creation of the academic Brain Injuries Centre as part of the St Mary's Hospital Trauma Unit (*Sharp*, NIHR Professor, 2012) provide good examples of our AHSC vision of research/service synergy.

The AHSC is nested within the Imperial College Health Partners (ICHP; established 2010, Darzi [UoA1, Chair]), incorporates13 trusts in northwest London and 8 clinical commissioning groups and is designated as an Academic Health Science Network (AHSN). The AHSN enables both early and late stage translation and delivery of innovation impact to the NHS and to patients. ICHNT were recently awarded the Local Clinical Research Network (LCRN), a £75M award that will expand to build clinical research and trials activity. Mental health is one of four AHSN research priorities.

Renewal of our NIHR Imperial Biomedical Research Centre (BRC, £113M, 2012-2017) provides the major translational research engine for the Unit through its Neuroscience (*Brooks* [lead]) and Neonatology (*Azzopardi* [lead]) themes and platforms in genomics, stratified medicine, molecular phenotyping, biobanking and imaging. The NIHR BRC now supports 11 projects in UoA4 (£3.4M).

Research groupings, activities, rationale and main achievements

The **Neuroinflammation and Neurodegeneration** research grouping investigates mechanisms of neurodegeneration common to multiple brain disorders (e.g., Alzheimer's disease, Parkinson's disease, amyotrophic lateral sclerosis and multiple sclerosis) particularly as related to neuroinflammation. Our integrated co-located research groups have capabilities for new model system development, therapeutic target validation, early experimental evaluation and clinical trials. Areas of interest include fundamental cellular and genetic mechanisms of neurodegeneration (*Alavian*, *de Belleroche*, *Dexter, Festenstein*), mechanistic validation through neuropathological studies (*Reynolds*, *Roncaroli*), biomarkers and advanced neuroimaging methods for assessment and monitoring (*Bell, Brooks, Pavese*, *Pernecsky*, *Piccini*, *Politis*, *Matthews*) and the development of stratified medicine for the brain sciences (*Dexter*, *Festenstein*, *Kinali*, *Matthews*, *Mazarakis, Muraro*, *Reynolds*). Management and scientific coordination is facilitated by integration of laboratory based and neuroimaging staff into a single administrative Centre (Centre Head, *Piccini*; Deputy Head, *Gavins*) reporting to the Head of Division (*Matthews*).

Achievements over the last 5 years for this grouping include:

- Identification of novel gene FUS and characterization of TDP 43 and C9ORF72 as common genetic determinants of ALS (*de Belleroche,* Science 2008, 2009, Eur J Hum Gen 2013);
- Discovery of genetic stratification for the new generation of TSPO PET biomarkers and filing of a first patent for stratification of patients for diagnostics and treatments based on this (*Gunn,* J Nucl Med 2013; *Owen,* J Cereb Blood Flow Metab 2010, 2012, J Nucl Med 2011);
- Identification of meningeal inflammation as a main driver of progression in MS (*Reynolds,* Ann Neurol 2010, Brain 2011, 2012);
- Renewal of the £2M joint award from the Parkinson's Disease Foundation and MS Society for a national tissue bank for PD and MS, establishment of consensus diagnostic criteria for neurodegenerative disease (*Dexter, Reynolds*);
- Significant industry collaborations with GSK, Biogen IDEC, Novartis, GE Healthcare, NeuroRx, Genzyme, Merck, Roche;
- *Matthews* awarded OBE for Services to Neuroscience (2008);
- *Brooks* recognized as one of the 400 most influential global scientists based on analysis of >20,000 citations of his 340 papers published from 1996-2011 (Eur J Clin Invest 2013).

Scientists in the **Brain Plasticity and Recovery** research grouping undertake "bench to bedside" research directed towards validating targets and developing therapies for acute CNS injury (stroke, traumatic brain and spinal cord injury) and recovery through an integrated programme linking cognitive, molecular and cellular neuroscience. Studies of stroke risk factors and outcomes (*Bentley*, *Geraghty, Sharma, Veltkamp*) are supported by the Hyperacute Stroke Unit (*Geraghty, Veltkamp*) with associated research focusing on attentional and language processing in recovery (*Hampshire*, *Malhotra*, *Soto*, *Wise*), further by activities of the Computational, Cognitive and Clinical Neuroimaging Laboratory (*Bentley, Sharp, Wise*) and its methodology group (*Gunn, Leech, Waldman*). An internationally leading hypoxic-ischemic injury research programme developing novel therapeutics in neonates has continued (*Azzopardi*), while in nearby laboratories and in the Wellcome Trust/NIHR Clinical Research Facility, investigators are studying somatic genomic variation (*Lovett*), brain circuit organisation (*de Paola*, *Knopfel*, *Ungless*) and neural tissue regeneration (*di Giovanni, Parrinello*). There is a focus on short-term translation (*Anand*, *Bentley*, *Bronstein*, *di Giovanni*, *Hampshire, Sharp*), e.g., in specialised testing laboratories of the Movement and Balance Unit (*Bronstein*). Research is coordinated with most investigators in a single administrative Centre for Restorative Neuroscience led by *Wise* (Head) and *Sharp* (Deputy Head).

Achievements over the last 5 years for this grouping include:

- Development, validation and translation of brain hypothermia as treatment for neonatal hypoxic-ischaemic injury (*Azzopardi,* N Engl J Med 2009, BMJ 2010, Lancet Neurol 2010);
- Elucidation of brain mechanisms of cognitive outcomes with closed head injury (*Sharp,* Ann Neurol 2011, Brain 2011, J Neurosci 2011, PNAS 2012);
- Characterisation of novel factors central to intrinsic regenerative capacities for peripheral (Ephrin-B/EphB2) and central (histone acetyltransferase p300) nerves (*Parrinello,* Cell 2010, Neuron 2012; *di Giovanni,* Brain 2011);

- £2M awarded from the Government of Qatar for identification of genetic determinants of stroke in the Qatar Biobank (*Sharma*);
- First UK trial of mesenchymal stem cell therapy for stroke (*Bentley*);
- Successful translation of novel neuropathic pain targets from pre-clinical studies to Phase IIa (e.g., for a Phase II P38 MAPK inhibitor, Dilmapimod; Angiotensin II Type 2 (AT2R) inhibitor EMA401 and a TrkA inhibitor CT327, *Anand*);
- Significant industry collaborations with GSK, Pfizer, Johnson & Johnson, AstraZeneca, Astellas, Grunenthal, Creabilis.

Our research grouping for **Neuropsychopharmacology and Mental Health** is focused on comprehensive, deep phenotyping of common and severe neuro-psychiatric disorders using both traditional psychiatric approaches and advanced imaging biomarkers. The scope of our work includes bipolar disorders and related psychoses (*Barnes*), cognitive and old-age psychiatry with a focus on dementia (Ritchie, [UoA2]), personality disorders (*Crawford, Tyrer*), the specific trans-diagnostic issues of alcohol and substance use (*Crawford*, *Lingford-Hughes*, *Nutt*) and developmental, childhood and adolescent psychiatric disorders with special reference to cultural and ethnic issues (*Ramchandani*). The broad remit exploits features and approaches shared across diseases. Our strategy closely integrates state-of-the-art genomic (*Need*) and imaging measures (*Nutt*) with traditional outcomes. Important developments over the assessment period include establishing the Centre for Neuropsychopharmacology (*Lingford-Hughes, Nutt*) and recruitment of new leads for child and adolescent psychiatry (*Ramchandani*) and for neuropsychiatric genetics (*Need*).

Achievements over the last 5 years for this grouping include:

- Influential assessment of treatment of severe personality disorders completed, which lead to a major policy shift to milder disorders and development of cognitive therapies (*Crawford,* Br J Psychiatry 2013; *Tyrer,* Lancet 2011);
- New concepts challenging the axiom that dopamine is the core of addiction (*Lingford-Hughes, Nutt,* Br J Psychiatry 2008) and re-conceptualising it as a disorder of endogenous opioid systems (*Lingford-Hughes, Nutt,* Eur Neuropsychopharmacol 2009, Biol Psychiatry 2012);
- Developing the first imidazoline receptor PET radioligands for assessing astrocytosis in dementias (*Nutt,* Synapse 2012, J Nucl Med 2013);
- First demonstration of brain mechanisms hallucinogens using functional imaging and magnetoencephalogaphry (MEG) (*Nutt,* PNAS 2012, J Neurosci 2013);
- Award of an Edmund J. Safra Chair in Neuropsychopharmacology and the 2013 John Maddox prize (*Nutt*).

Multi-disciplinary developments

Multi-disciplinary science has been central to our work and for realising benefits from being part of a world-leading technology university. For example, we have long-term collaborations with bioinformaticians and systems biologists of the MRC CSC and the National Heart and Lung Institute (e.g., for epilepsy genomics [*Johnson*] and somatic genomics [*Lovett*] or regeneration [*Parrinello*]). For molecular neuroimaging (*Gunn*, *Matthews, Nutt*), we have joined expertise in neuropharmacology, radiochemistry and modelling with that for advanced MRI neuroimaging already in the Computational, Cognitive and Clinical Neuroimaging Laboratory (C^3NL) (*Leech, Sharp*, *Wise,* and recently, *Hampshire*). We are reaching across faculties (Medicine, Bioengineering and Natural Sciences) with the Neurotechnology Initiative and specifically to Computational Sciences for advanced brain imaging analyses (e.g., Rueckart [UoA15] with *Wise*, *Sharp* and *Leech*) and clinical research employing new IT for "cutting edge" outcomes capture, imaging and molecular diagnostics in the College's new "Big Data" facility (Guo [UoA15, Director]). The Division's future aspirations will be supported by other College interdisciplinary research hubs, e.g., the "Chemistry in the Clinic" initiative of the Institute of Chemical Biology for generation of novel drug substance or process IP (*di Giovanni, Gunn, Matthews*, *Nutt*).

Responsiveness to national and international priorities and initiatives

Our approach to neuroscience and mental health research at Imperial is very well aligned with the Government's Life Sciences Strategy. Many members of the Division have a substantial

research interest in ways of accelerating development of innovative therapies, e.g., translational pain research (*Anand*) and dementia trials with novel imaging measures (*Edison*, *Brooks*) have generated more than £3M in new research activity over the assessment period. We have collaborations with industry partners including GSK, Pfizer, Johnson & Johnson, Biogen IDEC, Novartis, GE Healthcare, Astellas, Grunenthal Germany, Spinifex Australia, Creabilis Luxembourg, Max Healthcare India. Some staff are primarily addressing collaborative clinical science with industry (e.g., *Kinali,* who led Sarepta Therapeutics' pioneering Phase I/II study of oligonucleotide exon-skipping therapy of Duchenne Muscular Dystrophy [NCT01396239], *Anand,* who has developed an integrated electrophysiological/molecular neuropathological experimental medicine approach to Phase IIa therapeutic trials in pain; *Raymont*, who has created a "trial ready" community dementia study platform with Ritchie and *Mazarakis,* whose work led to engineering of the ProSavin gene therapy vector for Parkinson's Disease in a conceptually ground-breaking study sponsored by Oxford Biomedica [NCT01856439]). *Gunn* [Imanova, 20% Imperial] and *Matthews* [GSK, 50% Imperial] have directly combined appointments between industry and academia and we have engaged industry scientific leads as honorary staff (Hill [ex-industry, private consultant], Kolb [Lilly] and Richardson, Rubio, Zvartau-Hind [GSK]).

Our major areas of research prioritisation reflect healthcare priorities. They include, for example, the ICAMM Addictions Research Cluster (*Nutt),* the UK Dementia Platform (*Matthews*, Ritchie) and the PREVENT cohort (Ritchie), the TRANSEURO for neural transplantation in the treatment of patients with Parkinson's Disease (FP7 Programme, *Piccini*), PAMIR, the Parkinson MR Imaging Repository (Parkinson's UK) (*Brooks, Piccini*), ProBaND, the Parkinson's Repository of Biosamples and Networked Datasets (Parkinson's UK) (*Dexter*), and the INMiND European consortium on Neuroinflammation (*Roncaroli*).

We have supported staff in large, long-term initiatives. These include large, multi-centre study platforms such as the UK Biobank (*Matthews*, Steering Committee and Chair, Imaging Enhancement) and the UK Dementia Platform; creating deeply phenotyped patient cohorts such as the MRC Rapid Progressive MS Cohort (*Muraro*) and PREVENT Dementia Trials Network), with a Hyper Acute Stroke Unit recovery and secondary prevention outcomes database (*Geraghty*); establishment of an experimental neuroscience platform in the Imperial NIHR Biomedical Research Centre (*Brooks*); and a novel international stroke resource for the study of genetic isolates in the Qatari and Indian populations (*Sharma*).

Future national clinical needs are being supported by joint strategic hiring for clinical priority areas (e.g. stroke, to which we have recruited a leading German clinical academic, *Veltkamp*, and young Irish investigator, *Geraghty*) and by a clinical focus across all of our research groupings on improving healthcare service provision and policy, e.g., schizophrenia (*Barnes*, *Tyrer*), alcohol abuse (*Crawford*), addictions policy and care (*Lingford-Hughes*, *Nutt*), use of deep brain stimulation (Bain) and rational use of medicines and improved treatment for multiple sclerosis (*Matthews*, *Muraro*). Imperial UoA4 researchers lead locally in relevant NIHR clinical research networks, e.g., for Dendron (Ritchie [Director]), the Mental Health Research Network (*Tyrer*, [Director]) and the West London Mental Health Trust (Ritchie [Research Director]).

Division research plans

Brain Sciences has entered a major growth phase at Imperial with an integrated management model, new recruitment and major facilities development providing a framework for addressing an ambitious set of research goals:

- Enhancing our capabilities for dementia research and for better management of personality disorders and substance abuse. An external review of our Centre for Mental Health will take place in 2014 as a first stage of a new recruitment programme intended to support this;
- Strengthening of neurobiology across the groupings with further new recruitment to better develop conceptual "bridges" between molecular and cognitive neuroscience;
- Building on strategic alliances within Imperial (e.g., Chemistry, Bioengineering, Computing Sciences) and externally as part of a greater investment in interdisciplinary neuroscience;
- Enlarging our research training programmes, particularly for multidisciplinary and clinical research training, e.g., though the prestigious Wellcome Trust/GSK Translational Medicine and Therapeutics Clinical Research Training Fellowship Programme (2008-2016) and the recently awarded EPSRC Centre for Doctoral Training in Neurotechnology for Life and Health (2014-), and Medical Imaging (joint with Kings College London [KCL], 2014-).

Effective mechanisms for the development, promotion and dissemination of research

Research development planning occurs with strategic groupings within and across faculties to maximise opportunities for our researchers. Imperial catalyses interdisciplinary research through cross-faculty PhD awards. Wide dissemination of this research and public outreach are critical to our mission and actively supported by devolved funding from the College and by the Division of Brain Sciences. We have an active College Communications and Public Affairs Division supporting Brain Sciences that provides press and other media coverage either directly or through the Science Media Centre and we participate in both the annual Imperial Fringe and the Natural History Museum – Science Uncovered events. We also lead independent initiatives, e.g., for the Brain Sciences Annual Meet the Scientist event, we invite patients and their relatives into our laboratories (2012 event reported in the *Telegraph*). The UK Multiple Sclerosis and Parkinson's Disease Brain Bank runs an extensive national programme of patient centred events (*Dexter*, *Reynolds*), and the novel public engagement initiative of "Pint of Science" for informal scientific exchange in pubs across London. *Nutt* led the 2013 BNA Festival of Neuroscience. We participate extensively at Imperial Festivals 2012/2013 with popular talks and demonstrations open to the general public (*Gentlemen*, *Nutt*, *Seemungal*) and the most visited YouTube video in the College (Imperial Fringe 2013).

Mechanism and practices for sustaining and developing an active and vital research culture

All staff have annual academic appraisals for performance review. Junior faculty are supported by an Academic Advisor, who advises them and supports them in, e.g., grants strategy and pre-review of applications, finding collaborators, laboratory set up, accessing College support etc, during their probationary years. Staff across all groupings are brought together 4 times a year for Divisional meetings addressing all aspects of management, as well as science. There are active Divisional lecture series. A pro-active research administration office regularly advises staff on grant and training opportunities and provides administrative support for all stages of grants preparation. Research quality is supported by an active internal peer review system. The benefits if this investment are already being realised with an almost 30% increase in our MRC grant success rate.

c. People

Research strategy for the Division is coordinated within that of the Imperial Academic Health Sciences Centre, which has responsibility both for academic and clinical governance through an independently chaired Strategic Partnership Board and a Joint Executive Group. A medium term objective within the Division is to balance staffing to achieve critical mass in our 3 research groupings; new appointments in the REF period have been spread across groupings to strengthen each (*Alavian*, NN; *Hampshire*, *Geraghty,* BPR; *Lingford-Hughes* NMH). Some new appointments contribute to multiple areas (e.g., *Matthews* and *Knopfel* to both NN and NPR; *Nutt* to both *NMH* and *NPR; Need*, whose neuropsychiatric genetics interests extend across all themes).

A sustainable staff structure

The College's employees are its primary asset; we prioritise recruitment activities for academic, research and professional support staff highly. This fosters a strong intellectual community and inspiring environment; around 45% of the our staff and 60% of research staff are from outside the UK. Within 52 total returned staff, the unit has appointed 7 new professors (*di Giovanni, Gunn, Knopfel, Lingford-Hughes*, *Nutt*, *Matthews*, *Veltkamp*) within the return period. 12 *new* staff were appointed overall. 17% of researchers who had been in post at RAE2008 have been promoted with 3 staff promoted to Professorial rank (*Dexter*, *Sharp*, Gillies [retired, 2013]). All of our new appointments have been supported by highly competitive start-up packages and salaries, in addition to appropriate office and laboratory space and administrative support.

Arrangements for effective career development and support of research work of staff

Clinical and non-clinical researchers are governed within a common framework. Joint clinical and academic appraisals allow aligned setting of expectations. Newly promoted or newly appointed academic staff meet regularly with their Centre Head through the first year of appointment. Non-professorial staff undergo a supportive assessment panel halfway through their probation to review progress and then again at probation end. Staff new to Imperial are assigned an Academic Advisor to meet regularly with them on an informal basis and guide them through career and practical

issues during their probation period. To support their research development, newly appointed staff have minimal teaching and administrative duties at least during their first year and research active staff undertake no more than 15 hours of teaching per annum. The College Learning and Development Centre (LDC) also provide management and leadership programmes (e.g., for leadership, change management and personal development) to UoA4 staff and includes a Female Academic Development Centre.

Developing the research of early career researchers and support for integrating them into a wider, supportive research culture

Our early career researchers are actively supported through a range of mechanisms. 4 Early Career Investigators are returned in this submission. Imperial is the only university to have won the Times Higher Education Award for Outstanding Support for Early Career Researchers twice: in 2006 for its innovative and integrated approach to supporting young academics within the Graduate School, and in 2008 for initiating a course called "Finish Up, Move On", aimed at helping PhD students complete their PhDs and move on to the next stage in their careers. The College introduced its Junior Research Fellowship (JRF) Scheme during the REF period to provide competitive fellowships (salary plus research start up funds) to the very best junior researchers to support their research career development. These are three-year senior post-doctoral research fellowships with no obligatory teaching or administration, which provides a level of commitment and support that is rare in a UK university. 4 JRFs (representing more than £600,000 in investment from the College) have been awarded in neuroscience in the assessment period. Through both Wellcome Trust ISSF and earlier Wellcome Trust Value in People funding we have also provided bridging support for 6 early and mid-career neuroscientists.

Clinical researchers

Clinical researchers are core to delivery on the translational science objectives of the Division. Their work constitutes the largest fraction of our current research output. 26 clinical academics and 4 Cat C NHS employees are returned in this submission. The AHSC has been developed as an integrating structure to join governance and career development between the College and the Healthcare Trust. All NHS consultant and consultant clinical academic posts are jointly agreed by ICHNT and the College through the AHSC Joint Executive Group. Imperial acts as a nominating body in the Advisory Committee on Clinical Excellence Awards (ACCEA) scheme. Close working relationships with Central and North West London NHS Foundation Trust are maintained by *Crawford* and *Ramchandani*, *Lingford-Hughes* and *Crawford* through the Trusts Research and Development Committee and with West London NHS Trust with Ritchie as Research Director.

Supporting equalities and diversity

The College and the Division takes seriously its commitment to promoting equality and diversity across all aspects of its work. A Deputy Head of Division (Saffell) is the Equality and Diversity Champion for the Division and her work in this area forms a significant part of her performance objectives. The College resources a dedicated Equalities Unit and support networks. Its internal leadership programme for black and minority ethnic (BME) staff, iLead, has been so successful that Stellar HE (HEFCE sponsored) has been modelled on it. The Department of Medicine (of which Brain Sciences is a Division) holds an Athena SWAN Bronze award and runs a standing Academic Opportunities Committee to tackle barriers to appointment or advancement for women.

Implementation of the Concordat to Support the Career Development of Researchers

The College has implemented fully the Concordat to Support the Career Development of Researchers and was awarded the European HR Excellence in Research Badge in 2012. Each year, all researchers have a Personal Review and Development Plan to support and nurture them in their career development. Junior researchers work closely with the Postdoc Development Centre (PDC) which offers a tailored programme of support to postdocs, to help them meet their contractual obligation to spend 10 days per year on professional development. The PDC provides skills and career development training, a specialised personal development programme for women and other support, including coaching and mock interviews. Over the past 5 years, 21 1-to-1 coaching programmes were delivered to early career researchers and 12 mock interviews were held within this unit, in addition to those held at a research group level. We also provide

opportunities for broader development through College programmes, e.g., talent development (the Management Training Scheme, Horizon and Pegasus) and a Senior Academic Leadership Programme accredited with the Chartered Management Institute.

Effective and sustainable doctoral research training

UoA4 supports typically awards about 15 PhDs per year. We are committed particularly to strengthening our inter-disciplinary doctoral research training through major initiatives such as a new EPSRC Centre for Doctoral Training in Neurotechnology for Life and Health (Schultz [UoA15], *Matthews* [co-Directors] 2014-). We are signatories of the RCUK Concordat and provide a central comprehensive training and professional development programme for research students and postdoctoral researchers that provides an integrated programme of optional courses to improve basic skills such as "Time Management", through to "Advanced Writing" and "Career Planning" and a broad range of additional transferrable skills training courses including a special "Mini MBA". The Graduate School's Doctoral Training Governance Committee shares good practice across the College and coordinates additional training opportunities.

A strong and integrated research student culture

We have developed and maintained a vibrant research culture for our clinical students. The undergraduate Neuroscience and Mental Health BSc option of the medical degree is the most popular option in the medical curriculum at Imperial, illustrating the impact of the strong, joint provided together by faculty and research staff at all levels for creation of an exciting series of short projects for the research component. The highly-regarded MRes in Experimental Neuroscience gives students the opportunity to carry out a series of short research projects mentored most typically by senior research students or post-docs. Both of these programmes extend the culture of teaching and mentorship across levels of seniority in the Division; through "learning by doing", these and similar initiatives help trainees further consolidate our shared values and culture. Students and post-docs directly contribute to planning for the division with encouragement of their active participation in our quarterly Divisional meetings, which provide an open forum for discussion of divisional policies and planning. Important Divisional or Departmental committees include student and post-doc representatives, such as the Academic Opportunities Committee, which develops our strategy for support of diversity, career development and culture. Specific opportunities for independent leadership by students and post-docs are facilitated and help them strengthen their communities beyond labs or research groups. These sometimes have lead to rather high profile developments, such as for public engagement with the "Pint of Science" initiative for informal scientific exchange in pubs across London, which was conceived and is run by the students and post-docs. Our annual "Meet the Scientist" event is jointly organised by students, post-docs and faculty. Along with an active journal club and seminar series and the emphasis on broad skills training from the College, these Divisional efforts are creating a strong and integrated training culture that encourages students and post-docs to work together with faculty in delivering our vision, facilitating new "bottom up" initiatives and giving trainees confidence that they understand how they can move forward in their careers. Our strategy extends to undergraduate training, as well, through, e.g., support for the Imperial College Neurological Society, a student-led research initiative that has an active seminar series and also runs a summer internship programme (10 x 12 week internships) sponsored by industry. This important, student-run organisation (meetings for which typically attract 100 or more students) is helping us to foster the early emerging talent and integrate it with our broader research environment to sustain our vibrant and intellectually outstanding research trainee culture for the future

d. Income, infrastructure and facilities

Research income

UoA4 has been supported by >£51M in research awards over the period of assessment.

Research infrastructure and facilities

The Division of Brain Sciences has been a leading partner in the development of the Imperial Centre for Translational and Experimental Medicine, a £70M new build on the Hammersmith Campus that houses the Wellcome Trust/NIHR Imperial Translational Medicine and Therapeutics Centre, which supports early phase clinical trials/experimental medicine and deep phenotyping

studies. The NIHR Imperial BRC provides core infrastructure through its molecular pathology laboratory (Next Generation Sequencing facility, Hammersmith, NIHR Capital award, £2M) and a state-of-the-art biobank with its fluorescence-activated cell sorting facility. Significant capital investments for student facilities on the Hammersmith campus include the Wolfson Education Centre (£12M) as well as refurbishment of the Commonwealth Building.

Research resources have been enhanced additionally with renewal of the joint Multiple Sclerosis Society and Parkinson's UK Tissue Bank at the Hammersmith Hospital comprising the major national tissue collections, core pathological expertise and laboratory facilities supporting collaborative research. The new Imanova translational molecular imaging (PET and MRI) facility was established on the campus through a partnership between Imperial, KCL and University College London (UCL) and the MRC. This is complemented by a new College- embedded Clinical Imaging Facility including 3T MRI and PET that has been established nearby. Additional Brain Sciences laboratory development will be made in the animal sciences space over 2013-14 for an advanced optogenetics facility.

We have enlarged our footprint on the Hammersmith campus consequent on growing research effort. More than 500m^2 of new research space (adding to an additional approximately 1700m^2 already available) was opened for Brain Sciences in early 2013. 200m^2 in new office/computing lab space has been created in an adjacent building to bring together the molecular neuroimaging researchers in NN. Additional work is in progress for development of more space that will bring the entire NMH research grouping to the Hammersmith campus and for renovation of the Charing Cross Hospital clinical research and office space. We intend to begin work for a new acute brain injury research centre on the St Mary's campus from 2014-15.

Evidence of cross-HEI shared or collaborative use of research infrastructure

In an alliance with the MRC, KCL and UCL we have established Imanova, the pan-London centre for imaging sciences. Imperial is a partner in the new Francis Crick Institute, an interdisciplinary medical research consortium of the MRC, Cancer Research UK, the Wellcome Trust plus UCL and KCL. The MRC Centre for the Developing Brain is held jointly between KCL and Imperial (*Azzopardi*, Rueckert [UoA15]). Through the NIHR BRC Directors group, we have established extensive collaborations across the five major BRCs at Imperial, Oxford, Cambridge, UCL and KCL. This has created a jointly administered BioResource of healthy, genotyped subjects with consent to recall by genotype. In 2007, under the EuroBioFund initiative, *Nutt* (NHM) set up METPETS, an 8 centre PET research consortium across Europe.

Significance of major benefits-in-kind

The new Imanova PET imaging facility was underwritten (c. £45-60M) by GSK, who also made a significant contribution (donation of a 3T MRI and a PET scanner (c. £3M) to the new Clinical Imaging Facility. Many research sponsorships are found across the Division, e.g., for the Wellcome Trust/GSK Clinical Training Fellowships in Translational Medicine (c. £5M over 5 years), radiotracers and support for PET molecular imaging (GE Healthcare, *Brooks* and *Edison*) and recent support for development of the OPTIMISE Stratified Medicine Programme for MS (Biogen, GSK, Roche, Novartis and other, *Matthews*).

Policy and practice in relation to research governance

Brain Sciences benefits from a Joint Research Office (JRO) (established in 2008) that acts as a "one-stop shop" for clinical research governance across the College and the Trust. The JRO also provides advice and assistance with all aspects of research set up. Brain Sciences clinical studies and trials use the fully electronic InForm Integrated Trials Management System, a comprehensive service for compliant clinical trial data management.

e. Collaboration or contribution to the discipline or research base

UoA4 researchers make a full national and international contribution to brain sciences research. All staff are included in the following examples.

Interdisciplinary research

Interdisciplinary research is central to our mission. Examples of ongoing work include the McGill-Imperial Brain Sciences Neurotechnology research initiative (*Reynolds, Sharp)*; MENTSA, a

multi-disciplinary European effort to measure endogenous neurotransmitters (*Gunn, Nutt*); *Knopfel*, *Matthews* and *Sharp* are collaborating on circuit dynamics and protection for traumatic injury with researchers in Bioengineering (Schultz, Bull [UoA15]); *Brooks, Leech*, *Sharp* and *Wise* have been working with Computational Sciences (Rueckert [UoA15]) on MRI imaging measures; Brain Sciences (*Matthews*) is a first Medicine partner engaged for the new "Big Data" facility being established in the College (Guo [UoA15]); the "Chemistry in the Clinic" initiative is supporting novel radioligand, small molecule and assay development efforts (*Gunn*, *di Giovanni, Matthews*, *Nutt*).

Participation in the peer-review process

All of the division academic staff participate extensively in external peer review. A few highlights include: NIHR Research for Patient Benefit (*Crawford*); ERC FP7 Evaluators *(Crawford, Mazarakis);* Health Research Board Ireland Neuroscience Panel *(de Belleroche, Reynolds);* Big Lottery Fund Research Advisory Panel (*de Belleroche);* MRC Developmental Pathway Funding Scheme *(Gunn*); MRC Experimental Medicine Challenge Grant Panel *(Gunn);* NIH Genes and Genomes Review Group (*Lovett*); MRC Neuroscience Board and related activities *(Matthews, Nutt*); MRC Clinical Training and Career Development Panel *(Lingford-Hughes, Waldman);* NC3R "Crack It" Panel *(Matthews);* Broad Foundation (*Need*); Genome Canada (*Need*); MRC Centre Quinquennial Review Panel *(Reynolds);* Parkinson's UK Research Advisory Panel *(Piccini);* Princess Beatrix Foundations Neuroscience Panel *(Piccini*); Michael J Fox Foundation Advisory Panel (*Piccini, Dexter);* NIHR HTA Mental, Psychological and Occupational Health Panel *(Ramchandani);* NIHR HTA Commissioning Board *(Tyrer);* Royal Society Newton International Fellowship Panel *(Ungless*).

Fellowships, guest lectures and relevant awards

Both junior and senior staff have received numerous career development or recognition awards. For example, Hon. Order of the British Empire (*Matthews*, 2008); 2013 John Maddox Award (*Nutt*); six Fellowships of the Academy of Medical Sciences (*Azzopardi*, *Brooks*, *Grasby*, *Nutt*, *Tyrer*, *Wise*); Young Bioenergeticist Award (*Alavian,* Biophysical Society, 2012); Nylen-Hallpike Prize (*Bronstein*, Bárány Society, 2008); Fellowship in the Royal College of Pathologists (*de Belleroche*); Anaesthetic Research Society, Mapleson Medal (*Dickinson*, 2010); EU Geriatric Medicine Society Guest Lecture (*Edison,* 2013); ESC Young Investigator of the Year (*Geraghty*, 2009); British Association of Psychopharmcology 20 years Contribution Award (*Lingford-Hughes*); Van Bekkum Award (*Muraro*, 2012); the Edmund J. Safra Chair (*Nutt*); Lead, Royal Society Inaugural Debate (*Nutt*, 2010); Royal College of Physicians Lumleian Lecture (*Nutt*, 2013); Parkinson's Disease and Movement Disorders Investigator Award (*Politis*, 2012); Society of Nuclear Medicine Young Investigator Award (*Owen*, 2013); European Glaucoma Society (*Parrinello*, 2012); Royal Society Dorothy Hodgkin Fellowship (*Parrinello*, 2008); German Association of Psychiatry, Psychotherapy and Psychosomatics Imaging Prize (*Pernecky*, 2008); Australian and New Zealand College of Anaesthetists Michael Cousins Lecture (*Rice,* 2009); Hind Rattan International award, NRI India (*Sharma*, 2010); an NIHR Professorship (*Sharp*); Else-Kröner-Memorial Scholarship (*Veltkamp*); Royal College of Radiologists Roentgen Medal (*Waldman*, 2009).

Journal editorships

Staff hold multiple editorial positions, e.g., editors in chief of the Journal of Psychopharmacology (*Nutt*) and British Journal of Psychiatry (*Tyrer*); e.g., editorial boards for Frontiers in Biosciences (*Alavian*); Pain (*Anand, Rice*); Therapeutic Advances in Psychopharmacology (*Barnes, Lingford-Hughes*); Schizophrenia Research (*Barnes*); CNS Drugs (*Barnes*), Neuropsychiatry (*Barnes*); International Journal of Obesity (*Bell*); NeuroImage (*Bentley*); Brain (*Brooks*); Molecular Imaging and Biology (*Brooks*); Neurogenetics (*de Belleroche*); Neural Plasticity (De Paola); Nature Scientific Reports (*Dexter*); International Journal of Developmental Neuroscience (*Di Giovanni*); Current Gene Therapy (*Festenstein*); Epigenetics and Disease (*Festenstein*); Journal of Neuroinflammation (*Gentleman*); Journal of Nuclear Medicine (*Gunn*); Frontiers in Behavioural Neuroscience (*Hampshire*); Addiction (*Lingford-Hughes*); Addiction Biology (*Lingford-Hughes*); Nature Reviews Neurology (*Matthews*); Neuroimaging: Clinical and Guarantor of Brain (*Matthews*); Acta Neuropathologica (*Reynolds*); J Neuroscience Research (*Reynolds*); Frontiers in Cognition (*Soto*); and Acta Psychiatrica Scandinavica (*Tyrer*).

Unit academics have extensive external collaborations and governance roles

Our researchers actively collaborating with those in other institutions, e.g., the London Pain Consortium (*Anand, Rice*); the NutriTech consortium (funded by FP7) to quantify the effect of diet on phenotypic flexibility (*Bell*); for the FP7 review across 30 countries to assess relative drug and alcohol harms (*Lingford-Hughes, Nutt* [Lancet 2010]), in ICCAM; an MRC funded addiction research cluster across Imperial, Cambridge and Manchester (*Nutt*, PI); MRC- Wellcome Trust award of £36 million to the UK Biobank Imaging Enhancement for imaging phenotyping of 100,000 participants (*Matthews*, Working Group Chair); the Michael J Fox Foundation Parkinson's Progression Markers Initiative (*Pavese*); the Transeuro consortium (funded by FP7) for cell-based therapies for Parkinson's disease (*Piccini*); and joint award with UK and European Centres of European CommissionTheme "Health" FP7- "Neuronal transplantation in the treatment of patients with Parkinson's disease" (€12M, *Piccini*). Wider contributions also include releasing free software, for example, EPBscore, for the 3D automated analysis of axopnal and synaptic bouton morphology (*De Paola*, PNAS 2013).

Many of our academics also have major external governance roles, e.g., British Society of Neuro-otology (*Bronstein* [Chair]); Neuroscience Section, Royal Society of Medicine (*Bronstein,* [President Elect]); Prescribing Observatory for Mental Health, Royal College of Psychiatrists (*Barnes* [Co-chair]); Executive Committee of the EMBL Nordic Hub Aarhus University (*Brooks* [Chairman]); German Dementia Network (*Brooks* [Advisory Board member]); Austrian KLIF Science Fund (*Brooks* [Advisory Board member]); College Centre for Quality Improvement, Royal College of Psychiatrists (*Crawford* [Director]); MRC UK Brain Bank committee (*Dexter*, *Gentleman*, *Reynolds*); Lundbeck's International Neuroscience Foundation (*Lingford-Hughes*); Academic Faculty of Royal College of Psychiatrists (*Lingford-Hughes,* [Vice Chair]); Commonwealth Scholarship Commission Advisory Committee (*Johnson*); Royal College of Physicians Clinical Neurosciences Committee (*Malhotra*); Scientific Advisory Boards for the Italian Institute of Technology (*Matthews*); the Oxford Parkinson's Disease Centre (*Matthews*); Vice President of the London Health Forum (*Matthews*); Scientific Committee, European Society for Molecular Imaging (*Owen*); Network of European CNS Transplantation and Restoration (*Piccini* [Board Member]); European Federation of Neurological Societies Panel on Movement Disorders and Assoc. of British Neurologists- Movement disorders section (*Piccini* [Board Member]); Special Interest Group on Neuropathic Pain, International Association for the Study of Pain (*Rice*); British Neuropathological Society (*Roncaroli* [Programme Secretary]); National Brain Tumour Registry Neuropathology Panel (*Roncaroli*); Personality Disorders Section, World Psychiatric Association (*Tyrer,* [Co-Chair]); European Stroke Organisation (*Veltkamp* [Director]); German Stroke Society (*Veltkamp* [Council of Fellows]); British Neuro-oncology Society (*Waldman*, [Board Member]).

Work with industry and government agencies

There is active engagement with industry with multiple academics serving on advisory panels, but also through joint appointments between industry and the College for senior academics (*Brooks* with GE Healthcare until 2011, *Matthews* [ongoing] with GSK). Some staff are primarily addressing collaborative clinical science with industry (e.g., *Kinali, Anand, Raymont*, *Mazarakis*).

Our researchers have influential roles in shaping national and international initiatives in neurosciences and mental health including the Department of Health Dementia Antipsychotics Working Group (*Barnes*); Ministerial Advisory Group on Mental Health (*Crawford*); NICE panels (e.g., schizophrenia core interventions [*Barnes*], borderline personality disorder [*Crawford, Tyrer* {Chair}], psychosis with coexisting substance misuse [*Crawford, Tyrer* {Chair}], service user experience [*Crawford,* {Co-chair}], alcohol treatments [*Lingford-Hughes*]); NC3Rs (*Matthews*); the Association of British Pharmaceuticals Industry Stratified Medicine Panel (*Matthews*); UK Biobank (Steering Group and Imaging Working Group Chair) (*Matthews*); European Brain Council (*Nutt,* [Vice President]); Independent Scientific Committee on Drugs (*Nutt,* [Chair]).

Our researchers have been leaders in the research community responses to national and international priorities**:** UK Dementia Platform (*Matthews,*), NC3Rs (*Matthews*), ECNP international psychopharmacology nomenclature revision group (*Nutt*), European Council Network of Excellence for Brain Banking Board (*Reynolds*), and Work Group for Revision of Classification of Personality Disorders (*Tyrer,* [Chair]).