Environment template (REF5)

Institution: University of Leicester

Unit of assessment: 4 Psychology, Psychiatry and Neuroscience

a. Overview

The work presented in this submission is based in the **College of Medicine, Biological Sciences and Psychology** (CMBSP), which was established as one of four Colleges through a major reorganisation of the University in 2009. The College comprises ten Departments (four in Biological Sciences, five in Medicine and one in Psychology) which primarily reflect our teaching activities and provide administrative and management centres. Implementation of our research is organised through **nine cross-disciplinary Themes.** These provide the key organisational units for development and delivery of research strategy and form the basis of our submissions. The **Neuroscience & Behaviour (N&B) Theme** (led by **Forsythe)** is the core of this submission.

The Themes have produced a step-change in research activity by bringing together diverse expertise from laboratory, clinical and population-based sciences to address questions of complementary scientific interest and to facilitate the application and impact of that research. For UoA4, this has involved collaboration within the College between the Departments of Genetics, Cell Physiology & Pharmacology, Biology and Psychology, and more widely with the School of Engineering and with the **MRC Toxicology Unit,** which is co-located on the biomedical campus and with whom there are joint appointments included in this submission. We also have excellent relationships with local NHS clinicians in both the acute and mental health Trusts**.**

The work is presented under **three major research groupings: 1. Neuroscience:** Forsythe, Gibson, Giorgini, Grubb, Hamann, Luthi-Carter, Mallucci, Marra, Martins, McCutcheon, McDearmid, Panman, Steinert, Straub, Terunuma. **2. Cognition & Behaviour:** Barber, Carlisle, Duke, Fuggetta, Gerdjikov, Gottlob, Hammond, Hutchinson, Kyriacou, Matheson, Norton, Ott, Paterson, Prados, Proudlock, Shimozaki, Souto, White. **3. Social & Applied Psychology**: Brugha, Colman, Flowe, Holliday, Maltby, Vostanis.

b. Research strategy

In RAE2008 the School of Psychology was submitted in isolation, and indeed neuroscience did not exist at Leicester as a discrete entity. The key **strategic change** since then has been the creation of the **N&B Theme** to provide a platform for research co-operation and translation across the whole spectrum from molecular neuroscience to applied psychology. All UoA4 staff are members of the N&B Theme, which is overseen by a Steering Group chaired by **Forsythe**, and includes heads of participating departments and subtheme leads, together with dedicated administrative support. The Theme provides a platform for development and implementation of research strategy, including the recruitment of new academic posts. At an operational level, its activities include the coordination of staff mentoring (particularly for early-career researchers) in relation to grant applications and publications, and provision of information on funding opportunities. The Theme Lead is a member of the College Research Committee and its Research Implementation Group (RIG).

Key **infrastructure developments** since RAE2008 include: i) the establishment of the College's **Core Biotechnology Services** (see section d) which provide shared facilities and expertise in the "–omic" technologies and high-end cellular imaging; ii) the commissioning of our **£17M Central Research Facility (CRF)** which houses animal husbandry and research laboratories, together with experimental suites funded by a **£3.9M Wellcome Trust Capital Award** for *in vivo* imaging, transgenics, level 3 bio-containment and behavioural studies; iii) Additional funding by the **University Infrastructure Fund** (£2.5M p.a.) and the **Wellcome Trust Institutional Strategic Support Fund (WTISSF**, £500K p.a.) which has implemented transgenic viral facilities (Luthi-Carter), a locust behaviour facility (Ott), tinnitus testing (Hamann) and auditory suites (Forsythe).

Overview of current and future research

Researchers in UoA4 explore how nervous systems process information at synaptic, cellular and network levels to generate normal cognition and behaviour, and examine how these processes are disordered in developmental and acquired brain diseases. These and other questions involve research across the whole spectrum of biological complexity, ranging from single molecules,

through electrical and chemical communication between neurones, to the interplay between biological, genetic, psychological and social factors.

Our strategy is to build on existing strengths in fundamental neuroscience, cognitive psychology and behaviour, as well as applied psychology; but also we plan to exploit untapped synergies between these traditional fields and adopt and develop new research methods. For example, we will seek to enhance the use of mechanistic and biological approaches to cognition research, and to translate studies of brain dysfunction and neurodegeneration into novel preventative or therapeutic approaches. To enhance these strategies, we will further develop our links with the MRC Toxicology Unit, physical sciences departments in the University and the NHS.

Specific achievements and plans of research sub-groups:

1. Neuroscience (15 staff, 177 papers published since 2008): This group builds on studies of fundamental mechanisms of brain function, ion channels and synaptic transmission in order to understand sensory processing and neurodegeneration. There are three overlapping sub-sections: ***Plasticity***, ***Sensory Processing*** and ***Neurodegeneration***.

Plasticity integrates *in vitro* and *in vivo* methods with pharmacology and behavioural studies (**McDearmid, Gerdjikov, Hamann**) to investigate synaptic transmission and neuronal excitability. Learning mechanisms, including synaptic, homeostatic and intrinsic plasticity, are studied using transgenic zebrafish and murine models. The calyx of Held giant synapse (**Forsythe**) and other identified synapses permit pre- and post-synaptic investigation. Metabotropic signalling by dopamine, $GABA_BR$, mGluR (**Terunuma, McCutcheon**) and nitric oxide **(Straub, Forsythe, McDearmid)** are considered in terms of growth, development, behaviour and addiction. Synaptic function is explored in "real" networks and with new technology, including high-resolution imaging and high-throughput recording (**Marra, Luthi-Carter**) to generate novel mechanistic insights.

Key achievements. Demonstration that*: i) Persistent sodium current is key to the central pattern generator, reconfiguring motoneuron firing and stage-specific maturation in zebrafish in vivo,* ***McDearmid***[4]*; ii) Nitric oxide is an activity-dependent signal controlling neuronal intrinsic excitability via voltage-gated* K^+ *channels,* ***Forsythe***[1,3]*; iii) Efficient release at central synapses requires clustered recycling vesicles,* ***Marra***[1]*; iv) NMDA receptors trigger post-endocytotic sorting of* $GABA_B$ *receptors,* ***Terunuma***[1]*; and v) mGluR1 activation reverses cocaine-induced accumulation of* Ca^{2+}*-permeable AMPAR,* ***McCutcheon***[2]*.*

Plans: i) to develop *in vivo* super-resolution imaging and optogenetics to investigate synaptic function and intrinsic plasticity; ii) to study neural mechanisms of addiction and conditioning within mesolimbic circuitry; and iii) to integrate imaging, electrophysiology and trafficking studies to elucidate synaptic mechanisms and dysfunction in neurodegeneration.

Sensory processing research (which here includes integration with motor activity) is providing insights into neural codes and computation **(Gerdjikov, McDearmid, Matheson)** by combining *in vitro* methods with *in vivo* behaviour and modelling. Studies of the central auditory pathway (**Hamann, Grubb, Forsythe**) focus on auditory processing, ion channel function (e.g. Kv2.2 channels in the medial olivocochlear [MOC] system) and the activity-dependent plasticity underlying noise-induced deafness and tinnitus, explaining how the brain exacerbates hearing problems. These investigations have generated industrial collaboration (Autifony Therapeutics Ltd) that is testing new biomarkers and therapeutic agents. Although our focus is on auditory-specific functions, this work also has broader application in understanding the physiological role of specific ion channel proteins and genes in neuronal processing in general.

Key achievements. Demonstration that: *i) Loud sounds induce multiple forms of plasticity, changing excitability in the brain and contributing to hearing loss,* ***Hamann***[1]*; ii) Voltage-gated* K^+ *channel - type Kv2.2 - regulates central MOC excitability and mediates neuroprotection from loud sounds,* ***Grubb***[1]*; iii) Targeted expression of KCC2 chloride co-transporter and* I_H *channels allow IPSP signalling of the end of a sound – important in gap-detection and language perception,* ***Forsythe***[2]*; and iv) determining the neural code underlying vibrotactile perception,* ***Gerdjikov***[2].

Plans: i) To understand ionic mechanisms of neural compensation and adaptation to noise damage and the pathogenesis of tinnitus, including genetic susceptibility, using mice with known central genetic defects (collaborator: Karen Steel, KCL) combined with high-throughput genomic analysis (through CBS, see section d); ii) To extend collaboration on information processing with

the **Centre for Systems Neuroscience** (School of Engineering, **Quian Quiroga**, UoA15).

Neurodegeneration research on mechanisms and prospective therapies for neurodegenerative diseases (Huntington's, Parkinson's and Alzheimer's), prion, motor neurone disease and stroke is a major cross-campus research focus between the University (**Giorgini, Luthi-Carter, McDearmid, Gibson**) and the MRC Toxicology Unit (**Mallucci, Martins, Panman, Steinert**). Shared mechanisms (e.g. protein aggregation, oxidative stress, mitochondrial dysfunction, and synaptic failure) are examined at multiple levels, from molecular studies of causal and susceptibility genes, to the identification of novel disease modifiers and their potential to rescue disease-related phenotypes. The creation and use of disease models by **Giorgini**, including *S. cerevisiae* and *D. melanogaster*, is a particular strength. The group benefits from expertise in unbiased, genome-wide screening to identify novel therapeutic targets (**Luthi-Carter**) including high-throughput screens, gene expression analyses and statistical and bioinformatic approaches. Neuronal development and progenitor cell studies (**Panman, Steinert**) offer translational potential and integration of these studies with human genetics, gene regulation, synaptic plasticity, pharmacology and behaviour, across UoA4 is a strategic objective.

Key achievements. Demonstration that: *i) Translational repression (via eIF2alpha) underlies the cellular and behavioural manifestations of prion-induced neurodegeneration and provides a proof-of-principle therapeutic target for protein-misfolding disorders,* ***Mallucci***[1,4]*; ii) SIRT2 inhibitors are neuroprotective in Huntingdon's Disease (HD) by inhibiting sterol biosynthesis,* ***Luthi-Carter***[2]*; iii) Glutathione peroxidase and enhanced endosomal recycling protect in HD* ***Giorgini***[3,4]*; iv) Transcription factor-induced selection of dopamine neuron progenitors provides insight into potential stem cell therapies,* ***Panman***[2]*; v) Progesterone is neuroprotective in aged females,* ***Gibson****1; and vi) Elucidation of the structural basis of kynurenine monoxygenase inhibition and the therapeutic potential of the kynurenine metabolic pathway in HD,* ***Giorgini***[1,2]*.*

Plans: i) To explore means to enhance survival in neurodegenerative disease by intervention in mis-folded protein signalling, by targeting translational repression and by induction of neuroprotective signalling pathways; ii) To integrate existing strengths in genomics, imaging, electrophysiology and behaviour, with the objective of understanding the relationship between genetic susceptibility and decline in neuronal and network function.

2. Cognition & Behaviour (17 staff; 251 papers published): This grouping covers two main fields: **vision sciences** (including clinical ophthalmology and spatial cognition) and **behaviour**.

The **vision sciences** group uses eye movement tracking, optical coherence tomography (OCT), electrophysiology, psychophysics and modelling to investigate human vision from structural, functional, genetic and clinical perspectives. The **clinical** section (**Gottlob, Proudlock**) has an international reputation in the treatment and investigation of nystagmus, which negatively impacts quality of life (see Impact Case Study) including daily tasks such as reading. High-resolution OCT is providing new insights into foveal development, and the group is pioneering its application in treatment of retinal disorders, including achromatopsia and albinism. **Spatial cognition** research is focussed on models of motion and depth perception (**Carlisle, Duke, Hutchinson, Shimozaki, Souto**), with links to visual attention and search, as well as spatial memory (**Carlisle, Fuggetta, Prados**). Much of this work involves analysis of eye-movements that are key to research in normal reading and its disruption in reading disorders (**Paterson, White**). The influence of aging on all of these visual functions is also an increasing area of interest.

Key achievements. *i) Demonstration that Infantile Nystagmus is associated with FRMD7 gene mutations that interfere with development and neurite growth,* ***Gottlob***[4]*; ii) Demonstration that cortical oscillation by high-frequency transcranial magnetic stimulation (TMS) reflects the capacity of electromagnetic pulses to alter synaptic transmission in vivo,* ***Fuggetta***[1]*; iii) Direct observation of the shift from visual working memory to long-term memory controlling attention as learning occurs,* ***Carlisle***[1]*; and iv) Evidence against the split-fovea hypothesis of word recognition from work on Latinate (English) and non-Latinate (Arabic) language,* ***Paterson***[2]*.*

Plans: i) To investigate genetic variants and nystagmus susceptibility in families with *FRMD7* mutations via whole genome sequencing and to test the diagnostic potential of OCT in brain disease and neurodegeneration; ii) To use a more mechanistic approach to extend existing studies in human visual cognition, e.g. through further development of EEG and TMS facilities.

The **behaviour** group explores how environmental and/or genetic factors can constrain or drive the evolution and expression of behaviour. Animal models are being used to investigate social conflict in reproduction (**Hammond**), how parasitic infestations interact with host behaviour and personality, and how early life experiences alter expression of heritable behaviours (**Barber**) to provide insights into how such factors might shape human health. For example, in locusts the switch from solitary to gregarious phenotypes shows how environmental clues induce profound changes in brain structure and long-term behaviour (mediated by induction of serotonin neurotransmission; **Matheson & Ott**). Like human anxiety or depression, this affects behaviour and disturbs social interaction. Fly and zebrafish provide further models of genetic susceptibility in attention-deficit/hyperactivity disorder (ADHD) and in aggression (**Norton, McDearmid, Kyriacou**). Work on circadian biology has reassessed fly rhythmic behaviour in terms of the natural "zeitgebers", and contributed to a comparative study that views clock evolution as arising from a redox oscillation that emerged during the "great oxygenation event" (**Kyriacou**).

Key achievements. Demonstration that: *i) Predators affect evolution not only as agents of selection, but influence heritable variation in the prey species,* ***Barber***[2]*; ii) Circadian behaviour of fruit-flies in the wild challenges the dogma from artificial conditions; and protein-redox clocks evolved before transcription-translation clocks,* ***Kyriacou***[3,4]*; iii) ADHD susceptibility is linked to latrophillin-3 orthologue and to dopaminergic development,* ***Norton***[1]*; iv) The signalling underlying phenotypic change and swarm formation in desert locusts involves serotonin and PKA,* ***Ott***[1]*.*

Plans: i) Further exploration of clock-related phenotypes - diapause, tidal rhythms, orientation, and sexual behaviour; ii) Exploitation of fly clock neurogenetics to study agricultural pests, such as D. Suzuki, using the parasitic wasp Nasonia for biological control; iii) Identification of 'arousal' genes with circadian, sleep, ADHD and aggression implications, using transgenic zebrafish and mammal electrophysiology; iv) Investigation of individual differences using animal models.

3. Social & Applied Psychology (7 staff, 171 papers published): This group focuses on questions ranging from understanding variation in individual human functioning, to understanding wide-scale group processes, with a core emphasis on the application of research to practice and policy. For example, researchers study human behaviour in terms of Judgment and Decision-Making and the application of Game Theory to cooperative behaviour (**Colman**). Others (**Vostanis, Holliday, Brugha**) examine the interplay between environmental risk (e.g. children in war zones), social process (e.g. family support) and developmental outcomes across the lifespan, with important implications for NHS and Social Care policy (**Vostanis** - see Impact Case Study). Social issues are also examined with application to population health and vulnerable groups in legal settings (**Maltby, Flowe**). Important epidemiological studies have informed Government policy and public understanding of Autism Spectrum Disorders (ASD) in adults (**Brugha,** see impact case study).

Key achievements: i) *Identification of how similarity discrimination (when a gene causes carriers to display a variable phenotypic trait and a predisposition to cooperate with similar carriers) can evolve across a wide range of strategic interactions,* ***Colman***[1]*; ii) Development of the first direct test of theoretical models that view authenticity as integral to well-being and application to relevant social and group-based contexts,* ***Maltby***[4]*; iii) Examination of patterns of parenting in the context of Asian (Indian) families and social networks, underlying variation in mental health symptoms and well-being,* ***Vostanis***[4]*; iv) Demonstration that the emotional hallmark of crimes increases false memory and reduces reporting accuracy, findings crucial for legal applications of child memory,* ***Holliday***[2]***;*** *v) First epidemiological-based demonstration of ASD prevalence rates in adults, showing no association with age,* ***Brugha***[1]***.***

Plans: i) To develop stronger research links with the College's Population Sciences Research Theme in relation to 'Mental Health and Well-Being'; ii) to identify risk and protective factors for child and adult mental health and develop "stratified medicine" solutions.

Interdisciplinary activities

Although the N&B theme covers the core of this submission, cross-Theme cooperation is also important, in particular with the College's Molecular & Cellular Sciences Theme (most of which is submitted under UoA5). This cooperation includes researchers specialising in the basic science of ligand- and voltage-gated ion channels and G-protein receptor pharmacology (**Evans**, **Challiss & Tobin, UoA5**). Links to the College of Science and Engineering are facilitated by a 'Life-Science

Interface' and collaboration on specific projects (**Hamann, Gottlob**), computer modelling (**Matheson, Forsythe**) and shared PhD students with the Centre for Systems Neuroscience (**Qian Quiroga, UoA15**). (See section 'e.' for external collaborators).

Mechanisms for research development, promotion and dissemination

The N&B Theme provides a framework for fostering interdisciplinary research, and a natural forum for communication, collaboration and research development.

• **Regular research days** bring colleagues together for general exchanges of information and ideas, typically including short talks from investigators, post-docs and PhD students, and presentations on facilities, enterprise and career development.

• **Subject-focused research events** include internal and external speakers; examples from the last two years were with Nottingham MRC Institute of Hearing Research on tinnitus, with the NHS Ophthalmology department on eye-movements, and with the MRC Toxicology Unit on neuro-degeneration. There are also special "Research Days" aimed at early-stage researchers, again topic focussed, with poster and short oral communications from post-docs and PhD students.

• **Seminar series***.* Two seminar series are run in UoA4 with internal speakers and high-quality external international speakers, the latter including over the last 2 years: Walter J. Freeman (Berkley), Karen Steel (KCL), John Aggleton (Cardiff), Jonathan Ashmore (UCL), Horatio de la Iglesia (Univ. Washington), Kevin Fone (Nottingham), James Fawcett (Cambridge) Marcelo Rivolta (Sheffield), Geraint Rees (UCL) and James Kaltenbach (Cleveland, USA).

• Public engagement. The University press office supports the public dissemination of key research findings. Examples achieving world-wide exposure include: 'Breakthrough in neurodegenerative disease treatment', **Giorgini (**11/04/13**);** Deafness & tinnitus, **Hamann (**30/08/12); 'More than a feeling – emotions affect memory accuracy', **Holliday (**21/12/10**); '**A compound that arrests neurodegeneration in mice', **Mallucci** (10/10/13**);** and 'Evolutionary links to teamwork', **Colman (**09/07/09). The College (N&B Theme) runs numerous outreach events (see section e); for example, in May 2012 PGRs ran a very successful Café Scientifiqué style event attracting 150 people.

Responsiveness to national and international priorities and initiatives

Our thematic structure provides natural links into the research strategies of major funders. UoA4 relates specifically to, and has benefitted from, the following strategic initiatives: i) **Wellcome Trust:** 'Maximising the health benefits of genetics and genomics'; ii) **MRC:** 'Genetics and disease', 'Neurodegeneration', 'Stratified Medicine' and 'Autism epidemiology'; iii) **BBSRC:** 'Basic bioscience underpinning health' and 'Food Security'; iv) **NERC**: 'Biodiversity & Ecosystem Sustainability'; and **v) ESRC**: 'Health Systems Research Initiative' and 'Alcohol Misuse'. Specific funding calls which are current funders or future targets include: 'Data Driven Biology', 'Replacement, Refinement & Reduction', Action on Hearing Loss and the BBSRC's 'Life-course of the Auditory System'. Applications are planned for European funding through **Horizon2020** and the **European Research Council**. Funding for large-scale facilities is being targeted to Wellcome Trust's 'Biomedical resource and technology development' and the Technology Strategy Board.

c. People

i. Staffing strategy and Staff development

Our overall strategy is to achieve excellence: i) by **recruiting** academic staff who not only meet the highest standards of research performance, but also fit strategically with our priority areas; and ii) by **developing** new and existing staff to realise their maximum potential, through individual mentoring and team-working. The N&B Research Theme is key to both approaches i) by advising the College Board on priorities for new investment/replacement posts, and ii) by providing the framework for staff development in research. Following these principles, there has been major investment in recent years in UoA4, with three new chairs (**Forsythe**, **Luthi-Carter** & **Mallucci**), a Readership (**Martins**) and seven new Lecturers (**Carlisle**, **Norton, Ott, Marra, McCutcheon, Souto** & **Terunuma**), the last specifically targeted at strengthening key fields, for example the development of *in vivo* optogenetics expertise (**McCutcheon**) and synaptic signalling (**Terunuma**). A new Chair in Behavioural Neuroscience and an associated lecturer are in the process of being established. Personal Fellowships include a Royal Society University Fellow

(**Ott**), a BBSRC Research Development Fellow (**Matheson**), a British Academy Mid-Career Fellow (**Paterson**) and two RCUK fellows, who are now full Lecturers (**Hamann, Straub**).

Research career development: The University's Academic Practice Unit provides professional development training including induction of research staff, mentoring, and workshops on research leadership and management, research ethics and governance, pathways to impact, public engagement, PhD supervision and *viva* examination skills. The 'Intrepid Researcher' series offers methodology taster sessions in which experts provide overviews of particular research methods.

Early career researchers (ECRs): The University's annual Research Staff Forum helps ECRs realise their career potential, while CMBSP has a dedicated academic (**Luthi-Carter)** responsible for leading on Early Career Development, including mentorship and training. A Research Staff Day aims to help researchers build local networks, discuss issues and explore career progression. Theme Research days, sub-theme workshops and research seminars provide many opportunities for post-docs to present their work. Advice on funding applications is provided generically through University-run courses in grant writing skills, and more specifically through Grant Development Meetings run by the N&B Theme. These extend from initial mentoring, through presentation of preliminary data, to full internal peer review of grant and fellowship applications by senior colleagues before submission. The Wellcome Trust ISSF has (via College grants) financially supported promising ECRs in fellowship applications (e.g. Nicoletta Moisoi to Parkinson's Disease, and Aman Asif-Malik to Daphne-Jackson Trust).

Equality & Diversity: The University has an Action Plan to implement the Concordat to Support the Career Development of Researchers, and in 2011 was awarded the European Commission 'HR Excellence in Research' award. We have an Equal Opportunities (EO) Policy, an Equalities Unit (with EO and an Athena SWAN coordinator) and an EO Committee at which gender equality and EO issues are under continual review. The University and involved Departments have each submitted, or already hold, Bronze Athena SWAN Awards and applications for Silver are being developed.

ii. Research Students

The current postgraduate research (PGR) population in UoA4 is 84 (with 34 in Neuroscience, 20 in Cognition & Behaviour, and 30 in Social & Applied Psychology). 35 PGR students graduated in 2011/12 and PGRs are authors in 38% of the submitted UoA4 outputs.

Funding: Sources of funding for current PGR scholarships are predominantly from the UK (62%) with 24% coming from overseas governments (e.g. Kurdistan, Mexico, Saudi Arabia, Iraq and Libya) and 14% being self-funded. The University (College) funds 29% of current Scholarships, with additional major funding coming from the NHS (15 DSc students in Clinical Psychology), BBSRC (4), MRC (4), NERC (3), and charities (5 students). Three specific PhD schemes from which we benefit are: i) the **BBSRC Midlands Integrated Biosciences Training Partnership (MIBTP)** which was awarded to the Universities of Warwick, Birmingham & Leicester in 2012 and currently funds 8 PhDs in UoA4; ii) the **Integrative Toxicology Training Partnership** (ITTP) which is run through the MRC Toxicology Unit and has funded 2 students; and iii) the **Marie Curie International Training Network (ITN)** in Insect Timing: INsecTIME (coordinator **Kyriacou**) which has just agreed funding for 4 students from 2013. Future plans include development towards a 4 year PhD Scholarship scheme in Neuroscience (aimed at Wellcome Trust funding), which will build from our Neuroscience BSc programme due to start in 2014.

Training: In the first year, CMBSP provides a 28-week training programme including RCUK-required topics such as presentation skills, teaching, bibliographic IT, career management, plus generic (e.g. safety, design & statistics, ethics, IPR & commercialisation) and specialist (e.g. bioinformatics, structural biology) research skills. Subject-specific skills are taught in the supervisor's lab and include specialist external courses (e.g. Plymouth Electrophysiology Workshop). PGRs participate in delivering tutorials and demonstrating to undergraduates. Students present at departmental and thematic seminar programmes and journal clubs (including one run specifically for PGRs and ECRs, **Straub**). An annual Festival of Postgraduate Research provides an opportunity to present work to academics, potential employers and the public; for example Adam Tozer (**Forsythe**) won the 2009 Press Release writing prize. Residential Graduate School Programmes and outreach experience are provided and an annual Postgraduate Careers

Symposium showcases career pathways from past students.

Progression & Recognition: An online system manages and records PhD training (PROSE). Progression beyond year one is contingent on a project report, a Departmental seminar and a Thesis Committee viva. Progress is also assessed at the end of year 2, and a final thesis plan is required as the student enters writing up. All full-time students must submit the thesis before the end of year 4. High achievement is recognised by a Doctoral Inaugural Lecture award (which in 2012 was won by Dr Mervyn Thomas (**Gottlob & Proudlock**) for work on infantile nystagmus). Overall satisfaction with the PGR experience was indicated by 82% of CMBSP students in the 2013 PRES survey, in line with Russell group universities. PhD graduates have gained excellent positions: e.g. Adam Tozer and Jamie Johnston have become CDFs at LMB, Cambridge, Nadia Pilati leads a lab at Autifony Therapeutics Ltd, Verona, Italy and Melanie White is a Marie Curie Postdoc Fellow in Edinburgh.

d. Income, infrastructure and facilities

i) Research Income

Research grant awards over the REF period to UoA4 staff totalled £25M. **Neuroscience** received **£11M**. **Plasticity:** Three projects on neuronal nitric oxide signalling were funded by the MRC & BBSRC, **£1.6M** (Straub, McDearmid, Forsythe); seven projects on synaptic transmission and calcium imaging by the Wellcome Trust, Leverhulme, and BBSRC, **£2.4M**, (Forsythe, Hartell, Gerdjikov). **Sensory Processing**: the BBSRC funded **£1M** for studies of the somatosensory system (Matheson); projects on acoustic trauma, bilirubin toxicity and tinnitus were funded by Action on Hearing Loss, Wellcome Trust, MRC, EPSRC and Autifony Therapeutics Ltd, **£1.4M** (Hamann, Forsythe). **Neurodegeneration** studies were awarded **£4M** (Giorgini, Luthi-Carter, Gibson) from the MRC, PD and HD Associations, and Research into Aging. In addition, **FP7 EU** grants were recently funded on neurodegeneration (NeuroAct, **£806k**, Luthi-Carter).

Cognition and Behaviour has been awarded £11M. The vision group has successfully bid for over **£2M** for exploration of retinal abnormalities, clinical assessment and nystagmus therapy trials, funded by the MRC, Nystagmus Network, Ulverscroft Foundation, University Hospitals of Leicester, Eye Research Foundation and Merz (Gottlob, Proudlock, Hutchinson, Paterson). Awards to support study of environmental and genetic influences on behaviour are continuing from the BBSRC, Royal Society, Wellcome Trust, NERC and Nuffield Foundation, **£1.7M (**Barber, Hammond, Ott, Matheson). The extensive research programme of the circadian group (Kyriacou) has received over **£6M,** principally from BBSRC and including NERC, NC3Rs and MRC. Recent **FP7 EU** grants on circadian genetics (INsecTIME, **£891k**, Kyriacou) and aggression (AgressoType, **£332k**, Norton) have also been funded recently.

Social & Applied Psychology has received awards of nearly **£3M**. The Leicestershire Partnership NHS and Child and Adolescent Mental Health Services (CAMHS) fund the Greenwood Institute for Child Health, £**0.7M** (Vostanis). Judgment and decision-making are funded principally by an endowment and the AHRC £**300k** (Colman, Pulford). Research awards for studies of 'eyewitness testimony', 'women and sexual assault' and disability studies, were supported by ESRC and Nuffield, **£300k** (Holliday, Flowe, Maltby). Funding the National Autism Strategy and psychiatric morbidity research was from the National Institutes of Health Research through the CLR network and NHS Trust, **£1.5M** (Brugha).

ii) Research infrastructure

Research support: Centrally, we are supported by the University Research and Enterprise Offices, under the direction of a Pro-Vice Chancellor. At College level, we have a dedicated Research Office, led by an Assistant Registrar, with 3.7FTE of staff, which provides support to each Theme for organising meetings, workshops, speaker organisation and website management. Administrators act in concert with the Theme Lead to implement the Theme plan, manage applications for our internal grant peer review, and organise our key research committees. An annual budget of ~£2M is available for theme support, mostly distributed on the basis of competitive bidding, though the College Research Implementation Group.

Facilities: Significant developments since 2008 included the following:-
Core Biotechnology Services (CBS): This brings together under one management structure a range of key College facilities. The **Imaging** facility provides advanced light, fluorescence,

multiphoton and electron microscopy, as well as *in vivo* imaging (small animal MRI, MicroCT, Luminescence, & Fluorescence, Ultrasound). **Proteomics** includes Mass Spec. facilities (LTQ-Orbitrap and high-sensitivity diagnostic validation via 4000Q-Trap Mass Spec.), the PROTEX protein expression lab; and the MRC Protein Profiling Group (**Cain, UoA5, MRC Toxicology Unit**). The **Genomics** facility provides Sanger sequencing and more recently Roche GSFLX next-generation sequencing, SNP typing and transcriptomics, an Illumina bead station and C-Scanner, Q-PCR, robotics and DNA clean rooms. **Geneta** is an in-house transgenics facility offering a complete 'DNA to mouse' service. **BBASH**, established in 2010 provides dedicated bioinformatics support, employing a bioinformatician, biostatistician, and training officer to support experimental design and data analysis. **Biomedical Workshop**: we are one of the few institutions to have maintained their Mechanical and Electronic workshop expertise - this facility builds optics, robotics and bespoke experimental apparatus. These facilities are supported by 15 full-time Grade 7/8 and 13 technical posts, from University funds. CBS operates a flexible charging scheme that aims to recoup costs, yet allows PGR students ready access.

Central Research Facility (CRF): This £17M building, opened in 2012 (part-funded by a £3.9M Welcome Trust Capital Award), centralises our animal holding space and provides specialised facilities for transgenic, behavioural studies, *in vivo* imaging (including MRI and an IVIS Spectrum Quantitative 2D and 3D system), electrophysiology, auditory testing, and level 3 containment.

The **Centre for Translational Therapeutics** (led by **Tobin**, **UoA5**), provides a coordinated platform to promote the development of novel therapeutic agents, based on in-house target discovery. It employs experienced scientific support staff, whom are allocated to work with investigators, and is well equipped, including a microfluidic enzyme assay platform (£130K).

Future Development of research facilities will include: i) **Imaging -** super-resolution fluorescence light microscopy (e.g. STED), live multiphoton imaging and serial block-face electron microscopy; ii) Genetic manipulation – by development of **optogenetics**, along with viral transfection, increased use of conditional transgenic mice expressing fluorescent indicators, and knockouts (for example, founders for a *CRE* conditional Kv2.1 knockout mouse were generated this year by **Geneta**); iii) T**ranscranial magnetic stimulation** (TMS) will be developed as a core facility for human cognitive neuroscience, following recent recruitment in this area (**Carlisle**).

iii) Research Governance & Ethics

The University's Research Code of Conduct lays out expected standards in publication, authorship, data storage and use, peer-review, supervision, management and intellectual property. All projects involving human subjects undergo ethical review through the appropriate NHS research or University ethics committee. Use of animals in research is regulated by the Animals (Scientific Procedures) Act 1986, as revised by European Directive 2010/63/EU and overseen by the University's Animal Welfare & Ethical Review Body, which reviews Project License applications, training and all aspects of animal husbandry and research. We are committed to principles of openness in animal research, as exemplified by the widely praised opening of the CRF to which the "media" were invited and which received a Gold Award in the Higher Education (HEIST) Advocacy Campaign. The GM Sub-Committee of the University Biological Safety Office monitors production and use of genetically modified organisms.

e. Collaboration and contribution to the discipline or research base

Our research has received numerous "Perspectives" and "News and Views" highlights in Nature and similar formats; also of note are **11 Faculty-1000 recommendations** on papers from **Brugha, Forsythe, Gottlob, Kyriacou, Luthi-Carter**, **Ott, Mallucci, Marra, McCutcheon, McDearmid** and **Terunuma**.

Collaborators: 51% of submitted outputs involved collaborations with international colleagues, and 34% with colleagues elsewhere in the UK. Major collaborators include: with **Brugha**: R. Kessler (Harvard); with **Colman**: T. Tazdat (CNRS, France); with **Forsythe**: B. Tempel (Seattle), B. Graham (Sterling), L. Katzmarek (Yale); with **Gerdjikov**: U. Rudolph (Harvard); with **Giorgini**: N Scrutton (Manchester); with **Gottlob**: L. Raymond, P. Keller (Cambridge), M. Araki (Nara, Japan); with **Kyriacou**: A. Reddy (Cambridge), C. Johnson (Vanderbilt), M. Merrow (Munich), M. Hastings (LMB); with **Luthi-Carter**: A. Kazantsev (Harvard), R. Faull (Auckland); with **McDearmid**: G. Rouleau (Montreal); with **Norton**: M. Harris (Harvard); with **Ott**: M. Burrows

(Cambridge); with **Vostanis**: M. Wolpert (UCL).

Prizes: Recipients of local and international prizes include: **Gottlob:** the Norman Galloway Lecture (Nottingham Eye Symposium, 2012); the Edridge Green lecture (Royal College of Ophthalmology 2009); the 50th Anniversary Year Special Frank May Lecture (Leicester 2008); **Barber**: the FSBI Medal by the *Fisheries Society of the British Isles* for exceptional advances in the study of fish biology; **Mallucci** (2012) and **Luthi-Carter** (2013) the Frank May Prize and Lecture (Leicester).

Fellowships: **Matheso**n: BBSRC Research Development (2011-2013); **Frosch**: NERC; **Paterson**: NERC Mid-Career (2010-12); **Hamann, Straub:** RCUK; **Marra:** Fondation Recherche Medicale (2012); **Ott:** Renewal of Royal Society University Research Fellowship (2010).

Grant Panels. All staff participate in peer review of grants and papers. In addition the following have been members of **Grant review panels**: **Mallucci:** MRC Neuroscience & Mental Health Board; **Kyriacou**, **Ott**: Royal Society Fellowships; **Hartell**: BBSRC Committee A as Member, and then Chair, **Mallon, Hammond, Barber**: NERC; **Rosato, Kyriacou:** NC3Rs; **Luthi-Carter, Giorgini** European Huntington's Disease Network; **Colman:** ESRC Network for Integrated Behaviour Science and Agence Nationale de la Recherche; **Colman**, **Forsythe:** Deutsche Forschungsgemeinschaft – DFG Excellence Initiative panels; **Brugha:** Ministerial Board for Autism Strategy; CDC, Atlanta, and National Institutes of Mental Health, Washington DC, USA.

Journal Editorial Board: **Kyriacou:** Faculty-1000 member; **Forsythe**: J. Physiology – Senior Editor & Reviews Editor; Hearing Research - Senior Editor. Associate Editors of journals: **Kyriacou**: Behaviour Genetics; **Gottlob**: BMC Ophthalmology; **Brugha**: Psychological Medicine. The following are/have been Academic Editors: **Mallucci & Paterson:** PLoS One. **Luthi-Carter:** Frontiers in Genomics; **Ott**: Physiology; **Tauber**: Invertebrate Physiol. **Giorgini**: Journal of Molecular Medicine, PLoS Huntington's Disease; **Gottlob**: British Journal of Ophthalmology, Strabismus, Neuro-ophthalmology, Biomedical Journal; **Kyriacou:** J. Biological Rhythms, PNAS Guest Editor; **Hamann:** Scientifica (Physiology); **Mallucci**: Expt Neurology, Brain Plasticity.

Roles in professional bodies: Barber: Vice President of the Fisheries Society of the British Isles, member of Education and Public Affairs Committee Soc Exp Biol. **Forsythe**: Physiological Society - Publications & Meetings Committees; **Grubb**: Physiological Society - member of Council, Chair of Education & Outreach Committee; **Mallucci:** Honorary Consultant Neurologist, Addenbrooke's Hospital, Cambridge, member of Clinical Neuroscience Council, Royal Society of Medicine, Fellow Royal College of Physicians; **Kyriacou:** Fellow, Academy of Medical Sciences.

Conference Organisation: Barber: Organising committee for Fisheries Society of the British Isles International Symposium (2008, 2009, 2012); **Brugha:** WPA and IFPE International Congresses and Committees, Experimental Psychology Society (2009); **Forsythe**: WCBR (2009, 2011); International Union of Physiological Sciences "Ion channel plasticity" (Kyoto 2009), Physiological Society (Dublin 2009, Edinburgh, 2012); Society for Neuroscience Satellite Meeting, (New Orleans 2012); Okinawa Institute Science & Technology, 2011; **Gibson**: British Neuroscience Association (2009); **Gottlob**: World Ophthalmology Congress (Abu Dhabi, 2012), Nystagmus Network (Abingdon, 2009, 2013); International Society for Eye Research Biennial Meeting (Berlin 2012); **Prados**: Spanish Society for Comparative Psychology (2011).

International Conference speakers: Staff are frequently invited to give research seminars in the UK; invited plenary lectures at international conferences during the period include: **Forsythe**: 12 lectures; **Giorgini:** 5; **Gottlob**: 12; **Kyriacou:** 13; **Luthi-Carter**: 7; and **Mallucci**: 15.

Outreach: Most staff participate in outreach programs, including: Leicester Education Business company (LEBC), DANA Alliance for the Brain, STEM Ambassadors, BSA Assn. Science Week, University of Third Age, Leicester Secular Society, Centre for Excellence in Teaching and Learning in Genetics and chatiries such as Parkinson's UK. Of particular note were: **Giorgini**: an address to Archbishop Desmond Tutu entitled 'Targeting genes for therapy in neurodegenerative disease' (March 2013) and the Gretschen Amphlet Memorial Lecture, Parkinson's UK, Cambridge; **Colman:** invited appearance by on Radio 4's In Our Time discussing "Game Theory" (May 2012); **Mallucci**: Science Journalist conference at the Royal Society (2012), and Royal Geographic Society public debate on "Barriers to Creativity" between writers and scientists.