Institution: King's College London

Unit of Assessment: 1- Clinical Medicine

A. Overview

King's College London (KCL) is a multi-faculty research led institution ranked in the world's top 20 universities. It has **5 Health Schools**, namely the School of Medicine (SoM), Biomedical Sciences, Dentistry, Nursing & Midwifery, and the Institute of Psychiatry. The SoM and the School of Biomedical Sciences will merge in 2014 to form a Faculty of Life Sciences and Medicine, a change designed to further enhance inter-disciplinary activities and deliver our strategic aim of increasing the impact of basic science discovery. There is a comprehensive research and postgraduate training portfolio across the Health Schools, with these being organised and coordinated through **Research Divisions**. KCL has excellent PhD completion rates (91.6%; HEFCE 2013) and graduate employment rates (94%; HESA 2011/12).

In 2009, KCL along with our partner NHS Foundation Trusts created **King's Health Partners (KHP)**, one of five DH-accredited Academic Health Sciences Centres in England, which has enabled a close strategic and functional alignment between the Health Schools and partner NHS Trusts. The major organisational units within KHP are **Clinical Academic Groups (CAGs)** that integrate individual Research Divisions with related NHS clinical services and form the driving force to enhance synergistic research, education and clinical innovation. These changes are greatly strengthening bench-to-bedside-to-community research programmes and the training environment, as well as imbuing a strong academic ethos into the clinical service. The process is enhanced by the 3 NIHR **Biomedical Research Centres** (BRCs) hosted by KCL and its partner NHS Trusts (awarded/renewed for 5-year terms in 2012). KCL is a partner in the **Francis Crick Institute**, a world-leading research institute being established in central London to focus on the underlying causes of health and disease and on accelerating discoveries from the laboratory into the clinic.

Six SoM Research Divisions are returned in UoA1, i.e. Asthma, Allergy & Lung Biology (**Respiratory**); Cancer Studies (**Cancer**); **Cardiovascular**; Genetics & Molecular Medicine (**Genetics**); Immunology, Infection and Inflammatory Disease (**DIIID**); and Transplantation Immunology & Mucosal Biology (**Transplantation**). They comprise 144 fte category A and C PIs (including 27 early career researchers [ECR]) and 340 PhD students among ~1100 research staff. They host major national Centres (e.g. MRC, BHF and CRUK Centres), international research networks and training schemes, and have attracted substantial research grant income (£274M). Other SoM and Health School Divisions are returned in UoA 2-5, 15 and 26.

B. Research strategy

i. Overall strategy

We aim to optimise **vertical bench-to-bedside integration within individual Research Divisions** and **horizontal integration across Divisions**, so as to achieve maximum inter-disciplinarity, value and outputs in our overall mission to advance human health (**Fig. 1**). Equal priority is therefore given to a foundation of strong basic science, translational research and clinical research, which are underpinned by major investment in basic and clinical research infrastructure.

Each Division in this UoA is a large interdisciplinary grouping that achieves bench-to-bedside integration across conventional discipline and departmental boundaries, has optimal alignment of administrative and research structures, and a critical mass able to pursue internationally competitive research and deliver outstanding research training. The Divisions each form the core academic component of a KHP **CAG** (**Fig. 1**) and are therefore linked to nationally and internationally-leading clinical services. Each CAG was formed with a unified, well-developed and extensively-reviewed vision and strategy for the delivery of excellence in clinical care, research and education. This integration of KCL- and NHS-based research and service work has had significant impact on clinical and translational research, capacity-building and research training, as well as the clinical service, and we expect these positive effects to accelerate over the next few years.

A powerful driver that has supported and synergised with KHP CAGs is the co-development of our **NIHR comprehensive BRC**. This has enhanced translational research within our CAGs, each of which contribute to specific BRC themes (*see ii below*), and facilitated effective integration across CAGs. This integration is achieved through our 4 BRC Clusters, i.e. Experimental Medicine & Therapeutics; Biomarker, Devices, Co-diagnostics & Imaging; Population Science; the School of

Translational Research; and the outstanding core clinical research infrastructure that supports our work (*see section D*). KHP has also integrated health services research expertise across the SoM, Institute of Psychiatry, School of Nursing and the social sciences at KCL, into King's Improvement Sciences. This unit will enhance patient care and outcomes through the forging of new modes of care, innovative treatments and development of service delivery.

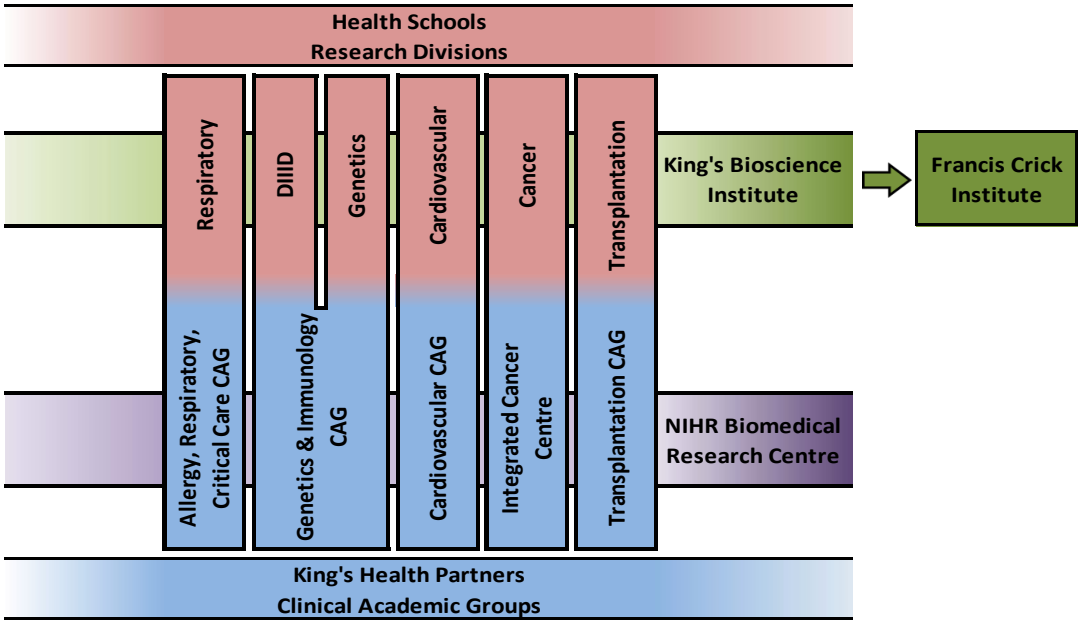

Fig. 1. Schematic diagram depicting the inter-relationship and integration among Research Divisions and CAGs

Basic and fundamental science across the Health Schools, extending into interactions with the natural sciences at KCL, is coordinated through the cross-cutting **King's Biosciences Institute** (Director, M Malim FRS). This is especially important for the strategic organisation of research infrastructure, shared core facilities, cross-Divisional research and training initiatives, and the involvement of KCL in the **Francis Crick Institute** (*see also section E*) - **Fig. 1**. Major recent investments in infrastructure are described in *section D*. The effectiveness of the focus on strong basic science alongside innovative translational research is illustrated by the success in recruiting world-leading scientists to KCL (e.g. F Watt FRS, to lead the King's Centre for Stem Cells and Regenerative Medicine; K Otsu, new BHF Chair; R Noelle, Wellcome Trust Principal Fellow). The Biosciences Institute has also driven the recruitment of numerous outstanding ECRs, e.g. recent investment in KCL Crick Lecturers who bridge research between the Crick Institute and KCL.

Overall strategic integration across the SoM occurs through the School Management Board which includes all Heads of Division while wider integration across the Health Schools and KHP occurs through the KHP Research Forum and the CAG leaders' group.

ii. Research groupings

(a) Respiratory (Asthma, Allergy & Lung Biology Division)

The Division (Head, T Sethi) pursues basic, translational and clinical research in asthma, allergy and respiratory medicine, from identification of novel genes, pathways and biomarkers underlying respiratory disease to the development of new treatments and predictors of response. It comprises 13 PIs among 158 staff and students, forms the academic core of the **Allergy, Respiratory, Critical Care and Anaesthetics CAG**, and contributes to the **BRC** Environment & Respiratory Health theme. The close interaction engendered between non-clinical and clinical scientists provides excellent opportunities for new discoveries to be fully exploited for patient benefit.

Research activity is integrated through complementary themes – i.e. airway inflammation and remodeling (lead, Ward); IgE structure, function and regulation (lead, Corrigan); steroid action and the role of vitamin D in asthma and allergy (lead, Hawrylowicz); adenovirus infection (lead, Sethi); prevention and treatment of allergy in children (lead, Lack); chronic obstructive pulmonary disease and respiratory physiology (lead, Moxham); lung cancer (lead, Sethi); and paediatric/neonatal respiratory physiology (lead, Greenough). New recruits (Azzopardi/ Hagberg/Gressens) are initiating a programme in neonatal ischaemic injury in close collaboration with the Imaging

Sciences Division, while there are also productive interactions with other foci of excellence, e.g. the KCL Randall Division of Molecular Biophysics and the Cancer Division.

The **MRC & Asthma UK Centre in Allergic Mechanisms of Asthma**, established in 2005 as a partnership between the MRC, Asthma UK, Imperial and KCL, is embedded in the Division. The Centre underwent rigorous peer review by MRC and successful renewal for a further 5 years in 2010. The Centre fosters extension of collaborations and novel areas of research through transfer of technology and expertise between laboratories, effectively removing barriers. It has significantly enhanced the Division's training capability and portfolio and generated substantial outputs (e.g. Lancet, JCI, PNAS). The Division works closely with the MRC-Public Health England Centre for Environment and Health on projects related to asthma and lung cancer.

Over the next period, significant effort will be invested in the following key areas: an enhanced use of imaging, genetics and genomics; environmental pollution and its implications for asthma development; and the role of early respiratory infection on respiratory health. Our focus on food allergy (particularly in children) will continue and we are currently conducting two large randomized controlled clinical trials (LEAP and EAT) that will inform public health policies and guidelines. Thoracic oncology research will be developed through enhanced collaboration with the Cancer Division, supported by recent joint grants and the BRC. In respiratory physiology, supported as a Clinical Development Group by the BRC, the integration of KHP clinical services in sleep disorders (Lane Fox Unit), assisted ventilation, critical care and respiratory disease, and the existing research expertise within the Division, will create a unique internationally competitive interdisciplinary group.

(b) Cancer

The Cancer Division (Head, P Parker FRS) is embedded in the KHP **Integrated Cancer Centre CAG** (Lead Purushotham), with research programmes encompassing the entire patient pathway from prevention and policy to treatment. These draw upon capabilities from fundamental cancer biology and single molecule imaging in tumour models to the development and delivery of complex interventional trials, facilitated by our **Experimental Cancer Medicine Centre** (CRUK/DH) and the **BRC** Cancer theme. This continuum provides for all researchers a line of sight to the clinic, wherever along that pipeline their primary expertise sits. The Division comprises 29 PIs among a total of 170 staff and students.

Research activities are organized into 4 sections: Research Oncology (lead, Pinder); Cancer Cell Biology and Imaging (lead, Ng); Haemato-oncology and Haematology (lead, Mufti); and Epidemiology (lead, Møller). Breast cancer research spans prognostic biomarkers, molecular pathology, mouse models, phase 1 clinical trials and tumour/data banking. The **Breakthrough Breast Cancer Research Unit** (Director, Tutt) established in 2007 focuses on basal-like breast cancer. Work in prostate cancer will accelerate with additional senior recruits (Loda [Harvard-based]) joining KCL this year. Lung cancer programmes involve strong collaborations with the Respiratory Division, Imaging Sciences and the Randall Division. They include biomarker development, a high-resolution systems biology model for the ErbB network in lung cancer (Parker leading a UK-wide consortium; BBSRC), imaging studies with new PET tracers (**CRUK/EPSRC Cancer Imaging Centre at KCL;** lead Ng), and the Thoracic Cancer Tissue Bank. A strong foundation in fundamental molecular cell oncology underpins functional genomics studies and tumour model building, with programmes including work on migration, invasion, protein kinases, cell division and epigenetics (outputs include Cancer Cell, Nature SMB, etc). The programmes in haemato-oncology include bone marrow failure, myeloproliferative disorders, cellular gene therapy, myeloma, leukaemia and stem cell biology, and also generate substantial outputs both in fundamental and clinical research (e.g. Cancer Cell, NEJM, etc).

Epidemiology programmes covering prostate, breast, lung and other solid organ cancers involve many national and international interactions and benefit from unique resources, e.g. the Thames Cancer Registry. Work in this area has had major impact, e.g. changing FDA policy by identifying the cardiovascular risks of prostate cancer therapy (Holmberg, Lancet Oncology). Research on oncopolicy (Sullivan/Purushotham) focuses on major policy and public health issues affecting high income and emerging economies (e.g. India, China) and collaborates with the social sciences and health economics through the Institute of Cancer Policy. Outputs from this work have been used to set major policy debates in global cancer, e.g. affordable care (Lancet Oncology commission).

Our future research is committed to enabling and implementing the precision medicine

agenda, through increased molecular profiling, informed interpretation, functional genomics, intervention developments and their trial-based evaluation. We will pursue this drawing upon our extensive experience in immunotherapies (antibodies, cells, vaccines, immunomodulators), unique GMP capabilities and phase I expertise. This will be informed by our work in oncopolicy and the affordability of cancer care, assessed in the context of quantitative measures of improved care and outcomes, and complemented by continued productive collaborations with national and international colleagues in academia and industry.

(c) Cardiovascular

The Division (Head, A Shah FMedSci) focuses on bench-to-bedside programmes that combine fundamental discovery science in cardiovascular pathophysiology with translational science spanning diagnostics, biomarker discovery, experimental medicine and therapeutics. It comprises 34 PIs (incl. 4 BHF Chairs) among a total of 280 staff and students and forms the academic core of the **Cardiovascular CAG**. Divisional PIs lead the CAG (Shah), the **BRC** Cardiovascular theme (Shah & Marber), and the KHP Clinical Research Facilities (Chowienczyk).

The **King's BHF Centre of Research Excellence** (established in 2008 as one of 4 UK centres) is pivotally important to the Division's focus. It has cemented a foundation of strong fundamental science and leading edge methodology that underpins our work, and has greatly enhanced integration across our research themes - i.e. muscle cell biology (lead, Gautel), vascular cell biology (lead, Shanahan), redox signalling (lead, Eaton), vascular risk (lead, Chowienczyk), atherothrombosis (lead, Xu), myocardial ischaemia (leads, Avkiran/Marber), heart failure (lead, Shah) and proteomics/ biomarkers (lead, Mayr). Innovative interdisciplinary research has been catalysed with other KCL foci of excellence, notably the Randall Division and the Division of Imaging Sciences and Bioengineering, in areas such as structural biology, bioengineering, biophysics and *in vivo* molecular imaging. The Centre has leveraged major developments in infrastructure, e.g. advanced proteomics, *in vivo* imaging, high resolution microscopy (*see section D*). The vibrant research and training environment thus created has attracted numerous high calibre scientists, e.g. Otsu (BHF Chair of Cardiology), Pfuhl (CV structural biology), Webb (CV clinical pharmacology), Perera (interventional cardiology); outstanding ECRs, e.g. Eminaga, Modarai, Okonko, Schulz, Warren, Zhang, Zampetaki; and excellent students. Many new recruits bridge Divisions (e.g. Pfuhl with the Randall, Schulz with DIIID) thereby cementing cross-Divisional collaborations. The BHF Centre has also leveraged >15 senior joint appointments with other Divisions, e.g. in PET chemistry, MR physics, computational modelling, bioengineering, developmental biology, cell biology. Outputs include high-impact papers on novel disease mechanisms and targets (e.g. in Nature, Science, Nature Med, PNAS), clinically relevant work on biomarkers, molecular imaging, experimental medicine and new therapies (e.g. in Nature Med, NEJM, JAMA, Lancet, Circulation), and 2 spin-out companies.

The BHF Centre was recently renewed (2014-19) and is one of only 2 Centres to receive a full award of £6M. Our main focus **over the next period** is chronic heart failure (CHF), where there is a major unmet need for novel advances. The Centre environment is very well suited for this effort. For example, major strengths in the basic biology of cardiovascular stress sensing interfaced with expertise in structural biology, advanced optical imaging and kinase targeting offer real prospects of new therapeutic approaches. Expertise in cell death, protein turnover and sterile inflammation will allow a concerted effort to develop new approaches targeting these processes. The recently awarded BHF Regenerative Medicine Centre (KCL lead, Xu) will drive efforts in stem cell therapy. We will invest further in systems biology and modelling to underpin a more integrative approach to target and biomarker discovery and personalised treatment. Clinical translation will be accelerated through enhanced interaction at the interface with our extensive clinical services, supported by the KHP CAG structure and BRC clinical research facilities.

(d) DIIID (Division of Immunology, Infection and Inflammatory Disease)

The focus of DIIID (Head, M Malim FRS) is on the integration of host defence mechanisms into a broad range of pathophysiology. This is consistent with the emerging view that immunology plays not only a primary role in defence against infectious disease but contributes substantially to the maintenance of general homeostasis. Hence, immune dysregulation is genetically associated with maladies ranging from obesity, through cardiovascular disease, to neurodegeneration. Reflective of the grounding of immunological mechanisms in basic biological processes, pioneering work by Martin-Serrano's team has shown that the budding of HIV is critically regulated by a molecular

mechanism central to aurora B-kinase-mediated mitotic cell abscission (Science 2012). The Division comprises 24 PIs among a total of 183 staff and students, and contributes to the **Genetics and Immunology CAG** and the Immunity and Infection theme in the **BRC**.

To investigate the breadth of immunobiology, DIIID combines studies of basic mechanisms of innate and adaptive host defence in the Programme in Infection and Immunity with studies of immune dysregulation in the Centre for Molecular and Cell Biology of Inflammation (CMCBI). Moreover, the strategy of DIIID has been to identify and support researchers who collectively interrogate across a broad spectrum of expertise from the basic molecular biology of viral genome regulation (e.g. Malim, Linden, Neill, Swanson) through the cellular biochemistry of antigen presentation and recognition (e.g. Guermonprez, Peakman) to the complexities of immune cell development and function *in vivo* (e.g. Geissmann, Klavinskis, Spencer, Hayday). New ECRs (Barral, Doores, Cantanese, Calado, Schulz) fit this pattern. In each area, experiments range from animal models (Drosophila, mouse) to humans, with real and rapid translational potential facilitated by the Division's long-standing commitment to key initiatives. Thus, Malim, Cope and Peakman have leading roles in the BRC while Hayday is joint lead of a CAG that contributes substantial clinical R&D activity. DIIID investigator-initiated trials span type I diabetes, anti-HIV, rheumatoid arthritis, anti-bacterials and tumour immunotherapy. There is particular facility for young faculty to rapidly develop clinical settings for their own research findings.

Such broadly reaching activities build on a wide platform of deep-drilled approaches, as reflected in the high standard of outputs (e.g. papers in Science, Nature, Nat Med, Cell). They also offer excellent training opportunities whose structure has been widely adopted elsewhere (*see section C*). The breadth of expertise promotes many collaborations with other Divisions, as evidenced by co-publication. One goal is for King's researchers to trust that cutting-edge research strength in immunobiology, supported by outstanding core facilities, is available to them.

Future strategy focuses on further consolidation of the activities of existing staff and recent recruits, and increased integration with physical scientists as well as clinical academics. In Infectious Diseases, Doores (MRC Career Development Fellow) will examine antibody responses to pathogen-borne carbohydrates, Catanese will address fundamental mechanisms of HCV-induced liver damage, Henckaerts and Linden will use parvovirus vectors to modify iPS cells from diabetic patients, and Edgeworth will lead the NIHR-funded ARREST study investigating rifampicin treatment in S. aureus bacteremia. In Immunobiology, Barral will examine the role of NKT cells and lipid antigens in models of inflammatory bowel disease, Guermonprez will study the role of autophagy in antigen presentation in dendritic cells, Geissmann has initiated a novel programme examining the mechanisms and consequences of high lipid diet on tissue macrophage function and inflammation (collaboration with BHF Centre), and Peakman is leading a pioneering peptide immunotherapy trial in type 1 diabetes. Future recruitment will add expertise in complementary areas ranging from transcriptional control mechanisms to clinical immunology.

(e) Genetics

The Division (Head, G Bates FRS) focuses on work to uncover the genetic variation underlying human disease, its functional consequences, and the impact on diagnostics and therapeutics. The research encompasses complex and rare genetic diseases and cancer genetics, and is underpinned by outstanding infrastructure and expertise in statistical genetics, bioinformatics and genomics. The Division has 28 PIs among 216 staff and students and is part of the **Genetics and Immunology CAG**. Divisional PIs play leading roles in the **BRC**, including the Biomarkers Cluster (Nestle), Bioresource core (Spector), Genetics theme (Mathew) and Dermatology theme (Barker).

Programmes in complex genetics include inflammatory bowel disease, lupus, rheumatoid arthritis and psoriasis (**St John's Institute of Dermatology**), integrating Divisional expertise and leading international consortia (e.g. 36 papers in Nat Genetics in last 2.5 years). Immunogenetics is a strength that was further enhanced by the strategic recruitment of Vyse in 2010. Longitudinal phenotype data on 12,000 twins (**Dept. of Twin Studies**, led by Spector), together with extensive biosamples, provides an unparalleled resource, e.g. to identify gene-environment interactions and study traits such as aging. Epigenetics is an expanding area that is underpinned by recent large awards (e.g. ERC to Spector, the Marie Curie training network Epitrain) and new Crick lecturers.

We have led internationally in identifying mutations underlying rare disorders, e.g. Haju Cheney syndrome (Nat. Genet), primary lymphoedema (Nat. Genet). Our development of preimplantation genetic haplotyping has led to preimplantation genetic diagnosis being offered for virtually any

monogenic condition without the need to develop specific tests for each mutation.

In cancer genetics, discovery programmes include the search for predisposition to oesophageal cancer in South Africa, exome sequencing of head and neck cancers, and functional interpretation of genetic variants in BRCA1. The identification of mutations and dysregulated signalling pathways in primary cutaneous T-cell lymphoma has led to new molecular diagnostics (Whitaker). In acute promyelocytic leukaemia, identification of underlying genetics has progressed to a UK-wide clinical service (Grimwade), and is now expanding to acute myeloid leukemia (AML).

Well-established international functional genomics programmes in diseases such as Huntington's (Bates), psoriasis (Barker), melanoma (Nestle), breast cancer (Solomon) and epidermolysis bullosa (McGrath) bring expertise in disease modelling to better understand disease pathogenesis and validate therapeutic targets. Immunotherapy programmes are being developed for psoriasis and melanoma and cell-based therapy for epidermolysis bullosa is under clinical evaluation.

Over the next period, we will continue with the investment in gene discovery whilst expanding functional genomics capacity. The Twin Research Resource will be invaluable for identifying the consequences of genetic variation at the level of gene expression. The **King's Centre for Stem Cells and Regenerative Medicine**, established in the Division with the recruitment of F Watt FRS in Oct 2012, will provide an iPS cell-based differentiation platform as a first pass phenotypic screen for new mutations. Our next generation sequencing capacity (BRC Genomics Core) will support custom sequencing projects, e.g. RNAseq/ChIPseq of cells/tissues for mechanistic studies. We will enhance recent investment in bioinformatics to develop more expertise in systems biology for the integration of these complex datasets. This strategy is well aligned with the engagement between the Francis Crick Institute and HEI partners. The KCL contributors to the recent Crick Strategy Working Group in Human Biology were Watt (stem cells and tissue engineering) and Bates (reverse translation).

(f) Transplantation (Division of Transplantation Immunology and Mucosal Biology)

The Division (Head, S Sacks FMedSci) sets out to convert its extensive knowledge of inflammation, immunity, and immune tolerance into new treatment, diagnostic and prognostic technologies for patient benefit. The Division comprises 21 PIs among a total of 260 staff and students and forms the academic core of the **Transplantation CAG** (lead, Sacks) and the **BRC** Transplantation theme. Lord is the BRC Director.

The **MRC Centre for Transplantation** was established in 2007 and is central to the Division's strategy. Our priorities are to overcome the initial immune barriers to transplantation and to induce long term graft acceptance with guidance from immune prediction and monitoring, so reducing some of the major limitations of modern transplantation. The Centre has cemented strong collaborative links between fundamental research in transplant immunology and programmes in cell therapy (Lombardi), protein therapy (Smith), imaging sciences, stem cell biology and genetics. Productive interactions have been catalysed among clinical specialities responsible for the treatment of patients with diabetes, liver, kidney and bone marrow diseases. New researchers of international quality have been attracted, e.g. Noelle, Dorling, Sanchez-Fueyo, Dasgupta, Smith, Kemper. The Centre has leveraged the development of outstanding infrastructure (*see section D*), e.g. a Protein Therapeutics lab, biomarker capability, rodent microsurgical lab, and BRC GMP cell therapy facilities. As a result, the first membrane-targeted therapeutic regulators are entering a multicentre efficacy trial; Treg cell therapy strategies are part of investigational protocols designed to induce tolerance in liver and kidney recipients; new tolerance biomarkers are being clinically evaluated; and new imaging ligands that detect activated complement and migratory T cells have emerged. Wellcome Principal Fellow (Noelle)-driven research has identified new negative regulators of T cells, which provide a clinical-ready asset to investigate prevention of transplant rejection. A communications programme involving patients and the wider public ensures that they are aware of the importance of science in transplant medicine and we are responsive to their expectations. This is supported by inclusion within the MRC Centre of a senior academic (G Richardson) in the KCL Centre for Law and Medical Ethics.

The Division also supports strong programmes in mucosal immunology and T cell differentiation (Lord), liver immunology (Sanchez-Fueyo) and organ fibrosis, helping to establish linked expertise on tissue inflammation, immunity and repair. It integrates medical and surgical research, including a programme of surgical innovation and robotics (Dasgupta).

The MRC Centre was renewed for a further 5 year term in 2012. **Future priorities** are to: (1) determine whether cytoprotection against early stress responses improves transplant recovery and long term results; (2) assess whether new pathways for peripheral tolerance induction in organ and tissue transplants will enhance the application of Treg cell therapy; (3) establish the value of biomarkers of graft acceptance or rejection, e.g. in personalising immunosuppressive therapy; (4) develop molecular and cellular imaging as a predictive and investigative tool in transplant rejection and tolerance induction; (5) focus on islet and hepatocyte transplantation to examine the effects of cytoprotective therapy on graft outcomes; (6) translate knowledge of cytoskeletal signalling to the application of new anti-fibrotic therapies.

C. People, including:

i. Career development and resources for staff

Our Divisions aim to attract the best staff and students by being national and global leaders in their disciplines and by a strong focus on mentoring, support and career development. An equal emphasis on horizontal integration across disciplines (e.g. through the King's Bioscience Institute for basic science) and vertical bench-to-bedside integration within CAGs enables our researchers to develop in an environment where fundamental and clinical science are equally supported.

Personal development is promoted through comprehensive KCL-wide as well as Division-specific programmes. The Graduate School-based **Researcher Development Unit** (RDU) provides training, development and career advice for post-doctoral staff, postgraduate students and PhD supervisors. Over 300 workshops per year are available to all KCL researchers to attend free of charge (http://www.kcl.ac.uk/study/pg/school/training/RDPTrainingBrochure.aspx). These include training in leadership, becoming a PI, teaching, equality and diversity, conflict resolution, language and IT skills, mentorship, and 1-to-1 coaching. The RDU leads College strategy on personal, professional and career development for researchers and implementing the Concordat for the Career Development of Research Staff. It also hosts the Vitae London Hub (http://www.vitae.ac.uk), thus providing direct input into national policy on researcher development.

At Divisional level, staff are helped to identify training needs through **annual appraisals** and interim reviews, and encouraged to pursue continuing professional development through relevant KCL or external courses. All staff appointed at Lecturer or Senior Lecturer level enter a formal **mentoring** scheme; female staff are also eligible for the KCL Athena Mentoring Programme (http://www.kcl.ac.uk/hr/od/mentoring.aspx). Personal development is promoted through positions of responsibility and leadership in CAG and BRC activities, research sections, and educational programmes. They are encouraged to develop national and international activities linked to their research interests, e.g. meeting organisation, international consortia, editorial boards, work with funding bodies (*see section E*). Such support has resulted in many recent promotions, e.g. Burchell, Eaton, Martin-Serrano, Mayr, Oakey, Rees, Tutt and Wendon all to Professorships.

An extensive range of **educational programmes** are available for staff and students. The King's Biosciences Institute Rosalind Franklin Lectures involve highly distinguished international scientists from different fields of experimental biology and medicine. The monthly BRC Biomedical Forum is a focus for translational research, and is video-linked to all campuses. The SoM Inaugural Lecture series is placed on YouTube to widen access. Each Division within this unit runs subject-specific monthly seminar series involving high calibre external speakers that are open to all KCL staff and students, as well as regular divisional seminars, workshops, journal clubs and meetings. There are regular programmes to encourage cross-disciplinary interactions, e.g. BRC Cluster seminars and focused workshops run by the MRC Centres and BHF Centre. All staff have access to BRC training courses on clinical and translational research topics, e.g. Good Clinical Practice, ethics, clinical trial design. These educational and training opportunities are supported by excellent **library and IT** facilities, including a comprehensive range of e-journals, on-line software, e-learning resources, and training in information retrieval and data management.

ii. Early career researchers (ECRs)

We have an active policy and very good track record of nurturing ECRs towards research fellowships and subsequent independent academic careers in biomedical and clinical science. All PIs are strongly encouraged to promote the careers of postdoctoral researchers, e.g. through developing independent areas of research, building up collaborations, and involvement in teaching, management and decision-making. The Divisions support **ECR Fora** that facilitate interactions and networking independent of more senior researchers. Investment in 18-24 month **Career**

Development Fellowships has been particularly effective in facilitating the independent development of the brightest postdocs (recruited from outside KCL or internally), who then go on to obtain external fellowships. Such ECRs have been funded through the Wellcome Trust Institutional Strategic Support Fund (£1M pa), a partnership with Nomura, and the major Centres hosted by our Divisions (e.g. the BHF and MRC Centres). Since 2008, the 6 Divisions have hosted over 170 **external fellowships** including 26 MRC (5 Senior, 5 Intermediate), 2 EPSRC (Intermediate), 21 Wellcome (7 Senior, 8 Intermediate), 21 BHF (2 Senior, 4 Intermediate), 5 Arthritis Research UK (3 Senior), 2 CRUK (1 Intermediate), 12 EU (2 Senior, 1 Intermediate) and 42 NIHR (3 Senior) fellowships. As mentioned earlier, KCL has also invested in Crick Lecturer positions to bridge research between the Crick Institute and KCL, and 4 of these are based in this UoA.

Notable achievements by our ECRs include many **national and international awards**, e.g. the British Association of Dermatologists best paper prize 2013, British Society for Cardiovascular Research Bernard and Joan Marshall Research Excellence Prize 2010, Circulation Research Best Manuscript Award 2011, European Society of Cardiology Heart Failure Association Young Investigator Award 2013, Royal Society of Medicine Young Epidemiologist Award 2010, World Allergy Organisation Henning Lowenstein Award 2009.

iii. Equality and Diversity

KCL recognises that **equality of opportunity** and the recognition and promotion of **diversity** are integral to its academic and economic strengths. Key principles followed by all our Divisions are: to promote equality of opportunity in all areas of work; to develop the diversity of skills and talent within our community; to ensure that all KCL members and prospective members are treated solely on the basis of merit, ability and potential without any discrimination related to age, disability, gender, marital status, pregnancy, maternity, race, religion, sexual orientation; to provide and promote a positive working, learning, and social environment free from prejudice, discrimination, harassment, bullying or victimisation; and to promote good relations between individuals from different groups. These principles are followed in all areas of work, e.g. recruitment, grading of posts, promotions, appointments to positions of responsibility. Recruitment and other panels are chosen to reflect diversity in experience and expertise. KCL provides a wide range of strategic programmes and networks to promote equality of opportunity and achievement, e.g. the *B-MEntor* scheme for Black and Minority Ethnic group staff, the *Parenting Leave Fund* for academic staff returning from a career break (e.g. maternity, paternity, adoption leave), the *Women's Network*, and the *Springboard Development Programme* for women research staff.

The career progression and retention of **female scientists and researchers** and the adoption of Athena SWAN principles is a particular priority that our Divisions proactively promote through a range of measures. This starts at the time of recruitment where we ensure that interview panels have appropriate female membership. The Cardiovascular Division initiated a specific mentorship scheme for female scientists at junior postdoctoral level and higher in 2008, which is now being rolled out to all Divisions. Each researcher is assigned an individual mentor who meets regularly with them, provides independent career guidance, is a point of contact for other personal development issues, and encourages them to take responsibility for their own careers. There is a significant emphasis on a family-friendly work environment, e.g. the timing of meetings and seminars, policies on flexi-working, availability of on-campus childcare, etc. We believe that visible female role models are very important in inspiring and guiding younger female scientists and fortunately have a large number of these within the unit; e.g. the Head of School (Greenough), 1 Head of Division, 16 Professors, 2 Fellows of the Royal Society, and 15 talented female ECRs included within this return. The principle of female role models is also implemented in the choice of external speakers at Divisional seminar series.

iv. Integration of clinical academics and NHS-employed active researchers

The development of the **CAG structure** (which integrates individual Research Divisions with related NHS clinical services) and the **BRC** have greatly enhanced the effective integration of KCL- and NHS-based clinical research within the overall research portfolios of each of the 6 Divisions in this UoA. KCL-employed and NHS-employed researchers are now in the same organisational structures and subject to similar reporting lines. Furthermore, NHS consultants and other staff involved in the clinical service are also in the same structure so that there is an increasingly strong research ethos across the organisation, backed up by outstanding clinical research infrastructure (*see section D*) and substantial funding support.

The involvement of NHS staff in research is proactively encouraged through the development of joint CAG research projects, the close involvement in divisional activities of category C staff who are awarded Honorary academic appointments, academic input into the appraisals/promotion of such staff, and the "credit" that these individuals obtain within our partner NHS Trusts. With the formation of KHP, the already strong track record of **NHS funding** to support senior clinical academic appointments has accelerated. 50 of the clinical academic PIs within this return receive at least part salary support from the NHS. The Trusts and the BRC also initiated a scheme through which research-active NHS clinicians embedded within CAGs are supported through dedicated, funded research time in their job-plans and/or research assistant support. £1.6M pa was spent as part of this scheme over the last 3 years. Other ways in which clinical research has been facilitated include the embedding of research within **specialist clinics** (e.g. hypertension, rheumatology, dermatology, etc) and, in turn, the research facilities available for patients seen in such clinics (e.g. specialist imaging, flow cytometry, genomics, vascular phenotyping). The regular Divisional/CAG/ BRC seminar programmes emphasise the clinical relevance of work presented and promote inter-disciplinary interactions. The collaborative research output of the 71 clinical academic category A and category C staff in this return attests to the value of these interactions.

All senior clinical category A staff in this return have Honorary Consultant appointments and are fully integrated into the clinical service in a wide range of medical and surgical specialities, therefore providing strong clinical links. These PIs have significant involvement in clinical **training** through their roles in the relevant regional Training Committees, including control of exit and re-entry of junior academics into clinical rotations. KHP currently holds sole or joint responsibility for the organisation and delivery of clinical training across South London in virtually all specialities relevant to this submission. The combination of the outstanding research training opportunities within our Divisions and the excellent clinical training in related specialities, aspects that are fully joined-up as a result of the CAG structure and the KHP oversight of training rotations, provides unparalleled opportunities for bright young clinicians embarking on an academic career path. There are currently 44 NIHR Integrated Academic Trainees (IATs) within our UoA1 Divisions, and 153 clinicians undertaking PhD training through MRC/Wellcome/BHF/NIHR and other Clinical Training Fellowships.

v. Students

There is an extensive and vibrant postgraduate research (PGR) training portfolio across the 6 Divisions which includes 3-year and 4-year PhD studentships supported through diverse funding streams, and 9 MRes/MSc programmes. Our mission is to recruit and train the brightest students for whom their research project provides an opportunity to pursue basic or clinical science in a translational environment. Basic science and clinical trainees learn side-by-side and gain experience from the integration of skill sets across the spectrum of work. In this way, we aim to develop future leaders who will deliver change, innovation and improvement in biomedicine.

At KCL Health School-level, there are 16-18 four-year PhDs per year funded by MRC, EPSRC and the King's Graduate School, of which about a third are based within this UoA. There are an average of 3 CASE studentships per year within the UoA1 Divisions. The King's Biosciences Institute and the NIHR BRC together fund 20 four-year PhDs per year in Translational Science, of which 75% are based within the UoA1 Divisions. **Dedicated Divisional PhD programmes** include a 4-year MSc/PhD in Immunology and Respiratory Disease (MRC/Asthma UK Centre; 3 students/year); a 4-year BHF MRes/PhD in Cardiovascular Biology (4 students/year); a 4-year MRes/PhD in Transplantation Biology (MRC Centre; 7 students/year); a 3-year interdisciplinary Cardiovascular PhD specifically targeting non-biomedical graduates (BHF Centre; 3-4 students/year); a joint PhD programme in Signalling in Heart Failure between the BHF Centre and the Gottingen Heart Centre in Germany (24 students/4 years); and a Marie Curie Initial Training Network in epigenetics (Genetics Division; 2 students). These purpose-designed training programmes are highly competitive and attract exceptional candidates who obtain distinctive experience in specific discipline-based areas as well as an understanding of how research informs science, technology and clinical medicine, and exposure to regulatory, ethical and societal aspects of the research. The programmes have wider impact by helping us leverage additional support for further studentships (e.g. from the NHS and charities) and other research initiatives, and thereby aid in attracting high-calibre staff and students at all levels. We currently have a total of 340 PhD students in the above programmes.

All PGR students are enrolled in the **KCL Graduate School**, through which an excellent graduate skills development programme is delivered and College-wide support, monitoring and quality control of training/supervision is coordinated. The College Code of Practice specifies the minimum requirements for PhD student recruitment, supervision, training environment, delivery of core transferable skills and satisfactory progress, and is strictly enforced. Indeed, HEFCE figures for 2013 indicate that KCL has one of the highest PhD completion rate at 91.6%. There are robust mechanisms at Divisional level to ensure excellence of training and environment. Appointment to a training programme requires formal interview and Divisional approval. Students are assigned two supervisors, at least one of whom must have an established supervision track record. Significant emphasis is placed on supervisor training for ECRs, regular refresher training, and a multi-disciplinary training environment. A PGR Committee chaired by the Postgraduate Lead and including local coordinators is responsible for monitoring student progress, organising MPhil/PhD upgrade transfers (which involve 2 independent assessors, a written report, oral presentation and *viva voce*), and providing independent advice to students. All PGR students participate in weekly multi-disciplinary laboratory meetings, regular Divisional seminars and journal clubs, and are expected to present research-in-progress to a broad audience and submit abstracts to relevant external meetings. All students present a poster or talk at the **annual KCL PGR symposium**.

Our students have won many **national and international prizes**, e.g. the Association of Cancer Physicians McElwain Prize 2013, British Cardiovascular Society Young Investigator Award 2008, British Society of Haematology Young Investigator Prize 2013, British Society of Immunology Young Investigator Prize 2012, British Transplantation Society Roy Calne Young Investigator Award 2008, Infectious Diseases Society of America Young Investigator Award 2010, International Society for Fibrinolysis and Proteolysis Young International Investigator Award 2011, Royal College of Paediatrics and Child Health Lorber Prize 2012.

D. Income, infrastructure and facilities

i. Research income

The total value of research awards for this submission from 2008-Jul 2013 was £274M, equating to £381K/PI/year, and has steadily increased (**Fig. 2**). This income derived from a wide range of national and international funding bodies, including UK Research Councils (21%), UK charities (41%), the EU (8%), industry (7%) and NIHR (5%). Substantial income was attracted from international networks and consortium grants in multidisciplinary research areas. There were 55 programme grants over this period including 13 MRC, 1 BBSRC, 3 ERC, 1 NIH, 2 EU, 1 Food Standards Agency, 3 NIHR, 8 BHF, 10 Wellcome Trust, 1 MRC/WT strategic award, 3 CRUK, 4 Leukaemia and Lymphoma Research, 1 Arthritis Research UK, 1 Oak Foundation, 1 Breakthrough Breast Cancer, 1 Juvenile Diabetes Research Foundation and 1 Human Frontier Science programme.

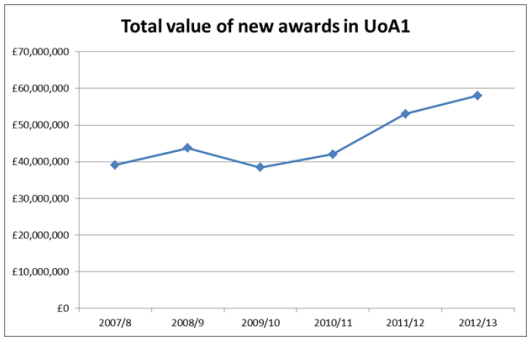

Fig. 2. New research grants.

ii. Major benefits-in-kind

UoA1 NIHR income-in-kind averaged £8.4 M/year (2008-13) and included the NIHR BRC directed by Lord, the NIHR Clinical Research Facility (CRF) led by Chowienczyk, 50% of the NIHR/Wellcome Trust CRF at King's College Hospital campus, the Experimental Cancer Medicine Centre led by Purushotham, and 50% of the NIHR/UKCRC CRF associated with the latter. In addition, our local partner NHS Trusts and their associated charities made strategic and financial contributions of over £200M to the infrastructure supporting R&D activity within the unit (*see also section iii below*).

iii. Research infrastructure and facilities

An extensive range of state-of-the-art facilities and foci of excellence for basic, translational and clinical research support the inter-disciplinary research programmes within this UoA. These comprise KCL/KHP core facilities, each with a dedicated manager, as well as Divisional facilities. In many cases, the individual Divisions in this UoA have an important role in coordinating institution-wide core facilities. Many of the research facilities described below were established or

significantly extended during the current assessment period.

Institutional core facilities

- The ***BRC Experimental Medicine Hub*** (£18M investment) located on the Guy's campus of KCL contains outstanding infrastructure platforms to support clinical research studies ranging from proof-of-concept experimental medicine and early translational work through to clinical trials. It includes (a) an ***Immune Monitoring Core*** with cell sorting facilities; (b) a ***Genomics Core*** with state-of-the-art services for next generation genomic DNA/RNA sequencing, high throughput SNP genotyping and genome-wide gene expression analysis on microarrays; (c) a ***Bioinformatics Core*** comprising a team of data managers, bioinformaticians and statisticians who provide bioinformatic analysis of sequence and array data, interrogation of publicly available datasets, integration into network and pathway analysis, development of databases for integrated analysis of clinical, genomic and other biological data, and provision of computing capacity for secure storage and analysis of data; (d) a ***GMP Pharmacy Manufacturing Unit*** with facilities for formulation of small molecules for first-in-man use; (e) a ***Phase 1 Clinical Trials Unit*** (partnership between Quintiles and KCL); (f) a ***Joint Clinical Trials Office*** which provides advice on study design, ethical/R&D approval, MHRA approval, and consultancy services in clinical trials management and biostatistics. This set of facilities in one location is probably unique in Europe.
- ***Clinical Research Facilities*** *(CRFs; £35M investment).* The Experimental Medicine Hub at Guy's campus has a dedicated CRF, as do the King's College Hospital and St Thomas' Hospital campuses - established with substantial NHS investment in partnership with NIHR, the Wellcome Trust, BHF, local Charities, Tate & Lyle and others. These CRFs provide excellent facilities for translational research and clinical trials as well as dedicated specialized facilities on different campuses, e.g. cardiovascular and metabolic phenotyping, research PET/MRI, and an intensive care facility for acutely ill patients.
- ***GMP-grade Cell Therapy Suites*** are located in the Guy's Experimental Medicine Hub and the King's College Hospital CRF, focusing on immune cell therapy and haematopoietic/solid organ transplantation respectively. The ***TSB Cell Therapy Catapult*** provides clinical, technical, regulatory and business expertise and infrastructure designed to accelerate the transfer of new cell therapy products into the clinic.
- ***In vivo imaging.*** Over £50M has been invested by the SoM in establishing comprehensive infrastructure and facilities for pre-clinical and clinical *in vivo* imaging which are among the best in the world. These include dedicated research MRI (1.5, 3, 7 and 9.4 Tesla; hybrid XMR), multinuclear and hyperpolarized spectroscopy, PET/CT, SPECT/CT, embedded chemistry for design/synthesis of new probes, and physics/maths/computer science for advances in image acquisition, processing and co-registration. Research utilising these facilities forms an important component of work within several of the UoA1 Divisions and is strongly facilitated through the BHF Centre of Excellence, the MRC Transplantation Centre and the Cancer Imaging Centre, e.g. through joint academic and technical support posts.
- The ***Nikon Imaging Centre*** for advanced microscopy was established in 2012 as a £4.5M partnership between KCL and Nikon. It is one of only 8 such Centres worldwide and provides the very latest advanced cell/tissue imaging approaches, e.g. FRET, FLAP, GFP-complementation; spinning disk/laser/multiphoton/STED/STORM super-resolution microscopy; and intravital microscopy.
- The ***Centre for Biomolecular Spectroscopy*** was established in 2010 with Wellcome Trust and KCL funding, and provides outstanding expertise and equipment for the determination of protein structure, protein-protein interaction analysis by NMR spectroscopy, surface plasmon resonance, isothermal titration calorimetry and optical spectroscopy, and related techniques.
- The ***Randall Division of Molecular Biophysics*** provides core expertise in biophysical characterisation and has facilities for single-molecule force-spectroscopy; protein purification and crystallisation; robotic screening; site-directed protein labelling; fluorescence polarisation microscopy; muscle fibre reconstitution; and muscle X-ray diffraction analysis. Three of the Divisions in this Unit have particularly close interactions with the Randall through the BHF Centre of Excellence, the MRC Transplantation Centre and the MRC/Asthma Research Centre respectively, underpinned by joint academic and technical appointments.
- ***Biological services*****.** Each of the 6 Divisions has access to new or recently refurbished animal

research units close to their research laboratories. These provide comprehensive facilities for breeding, genomic manipulation and specialist phenotyping.

- Other core institutional facilities include a ***human ES cell production*** unit associated with the Assisted Conception Unit; comprehensive ***mass spectrometry*** facilities for proteomics, metabolomics and specialist assays; and transmission and scanning ***electron microscopy***.

Divisional research facilities

The 6 Divisions in the unit each have excellent laboratory research facilities for comprehensive modern cell biology, molecular biology and biochemistry. In addition, there are extensive specialist facilities for the subject-specific research themes that are being pursued.

- ***Respiratory***. The MRC/Asthma UK Centre provides core technology platforms such as flow cytometry, protein production and purification, an adult respiratory and muscle physiology lab, a sleep laboratory (the Lane Fox Unit), and a dedicated ***paediatric clinical trials unit*** in the Evelina Children's Hospital with specialised facilities for work on allergy. A respiratory clinical pharmacology research unit at GCP standards supports Phase 1 and 2 trials. Specialist neonatal, infant and paediatric lung function labs allow study of respiratory control during sleep, including bedside testing in the neonatal and paediatric intensive care units.
- ***Cancer***. Specialist facilities include the Cancer Early Phase Trials Unit; GMP facilities for cellular, viral, protein and radionuclide work; optical proteomics (jointly with the Randall Division); cancer imaging (jointly with Imaging Sciences); and resources for cancer policy and public health (jointly with the King's Centre for Global Health). In addition, KCL has been awarded £15m from the UK Research Partnership Investment Fund (UKRPIF) towards a ***Research and Innovation Hub*** within the new Cancer Centre at Guy's campus.
- ***Cardiovascular***. BHF Centre core facilities include a dedicated proteomics and metabolomics lab; a murine microsurgery/*in vivo* phenotyping core (incl. 3D echo, MRI, telemetry, pressure-volume analysis); comprehensive *in vitro* physiology (incl. myocyte function, electrophysiology, myography, intracellular Ca/pH imaging); EPR spectroscopy/redox chemistry. Clinical facilities include a vascular function lab (incl. FMD, forearm plethysmography), cardiac catheterisation labs with dedicated research sessions, intravascular ultrasound, intracoronary pressure and flow measurement, ventricular PV analysis, and 2D and real-time 3D echocardiography.
- ***DIIID***. The BRC Immune Monitoring Core (*see above*) is embedded within and overseen by the Immunology Division. Other specialist facilities include category 3 labs for virus research, a core lab for generation of gene therapy vectors, a Drosophila lab, and an intravital imaging lab (Centre for Molecular and Cellular Biology of Inflammation).
- ***Genetics***. The BRC Genomics Core and Bioinformatics Core (*see above*) are embedded within and overseen by the Division. Genetics diagnostic labs include DNA diagnostics, Cytogenetics and Biochemical Genetics. The King's Centre for Stem Cells and Regenerative Medicine has been funded through a Wellcome Trust Strategic Award to house the Stem Cell Hotel, which will provide state-of-the-art infrastructure for high throughout and other functional assays on iPS cells, ES cells and other stem cells.
- ***Transplantation***. The MRC Centre houses a dedicated Protein Therapeutics lab; a biomarker resource that includes state-of-the-art immune monitoring, statistics, bioinformatics, data manager, research nurses and project coordinator; a microsurgical suite for complex transplant procedures in genetically modified mouse models. Centre PIs oversee outstanding clinical solid organ transplantation facilities (renal, liver, islets, etc) that link closely to BRC cell therapy facilities for clinical trials in recipients.

iv. Research governance policy and practice

KCL has a comprehensive policy regarding the conduct of research, research ethics, integrity and data management (http://www.kcl.ac.uk/innovation/research/support/index.aspx) that follows the UK Research Integrity Office Code of practice for research: Promoting good practice and preventing misconduct (UKRIO, 2009), the Singapore Statement on Research Integrity (2010), and the RCUK code and policy. It recognizes that the proper conduct of research requires the maintenance of high standards of integrity, based upon principles and professional responsibilities that are central to the protection of the research community, participants in research, and the broader community that considers research evidence in the adoption of new policies and practices.

All staff and students are expected to adhere to the principles of honesty and integrity in all

aspects of research; accountability in the conduct of research; excellence when conducting, reporting and disseminating research; co-operation in working with others; and good stewardship of research on behalf of participants and consumers of research. Researchers are required to be aware of regulations and policies related to research (e.g. GCP, data protection and data archiving policy, health & safety, COSSH), keep clear and accurate records, employ appropriate research methods, take responsibility for the trustworthiness of their research, and be aware of the ethical obligation to weigh societal benefits against the risks inherent in their research. They need to follow guidance criteria for authorship and acknowledgement of contributions to their research, be fair in their evaluations of other's work, respect confidentiality, disclose any conflicts of interest, and share data and findings openly and promptly once priority and ownership are established. Any research misconduct, such as fabrication of data, falsification of data, plagiarism, deception, fraud, or collusion in any such activity, is taken very seriously and must be reported to the appropriate authorities as soon as possible. The KCL procedures for investigating and resolving allegations of research misconduct and the policy on information disclosure (whistleblowing) are the overall responsibility of the Head of Administration and College Secretary and are openly publicised (http://www.kcl.ac.uk/innovation/research/support/conduct/cop/misconduct.aspx).

Supervisors and line managers of researchers have particular responsibility to be fully conversant with the above principles and responsibilities and to ensure that students and junior staff receive appropriate training in good research practice. This commences when staff and students first join the College, as part of their compulsory induction process, and is then continuously reinforced at group, Departmental and Divisional level. The importance of good research practice is reinforced for supervisors when they undertake compulsory refresher training. At College level, there are a range of procedures to ensure compliance with the above principles and for dealing with allegations of misconduct and other poor research practices, as well as protecting those who report such incidents. Clear lines of accountability for the organisation and management of research are essential; the KCL Research Divisions are the key organisational units for this purpose, as described in *Section A*. Staff and student training and mentoring, Health, Safety & Environment Protection, and adherence to relevant regulations are coordinated at Divisional level. All Divisions have specific named staff responsible for key functions such as Health & Safety, Radiation Protection and Biological Safety, overseen by the KCL Health, Safety & Environmental Protection office which carries out regular inspections and audits. Research ethics for work involving human participants, material or personal data is overseen by the KCL Research Ethics Committee and/or National Research Ethics Committees as appropriate while for animal-related work, compliance with Home Office Regulations is coordinated through the Biological Services Unit and its committees.

E. Collaboration or contribution to the discipline or research base

i. The Francis Crick Institute

KCL is investing £40M in its partnership with the MRC, CRUK, Wellcome Trust, Imperial and UCL in the Francis Crick Institute (FCI), an £800M initiative to establish Europe's leading biomedical research institute in central London by 2015, with 1500 staff when fully operational. A major **interface with CRUK/FCI already exists** through Parker's position as Principal Scientist at the London Research Institute and the recent appointment of Hayday to a position, providing cell signalling and T cell expertise respectively and links to translational opportunities at KHP. Bates and Watt are playing important roles in the developing **FCI strategy**, with major contributions in the areas of reverse translation and stem cells respectively. KCL will **embed researchers** in the FCI and FCI scientists will be seconded to King's, with a particular focus on clinical translation, e.g. in cancer, immune-mediated disorders, infection, heart disease and stroke. About 100 FCI **PhD students** will have King's co-supervisors. The FCI partnership and resources will be transformative for a wide range of biomedical research at King's, and these effects are already apparent in enhanced collaboration and joint research strategy development between the partners. FCI is already attracting outstanding young researchers to London biomedicine; King's has recently appointed 11 **new lecturer/senior lecturer positions** linked to FCI (e.g. Arnold, Barrall, Schulz, Ciccarelli within this submission) plus 3 new joint appointments with the FCI parent Institutes, the MRC National Institute for Medical Research and CR-UK's London Research Institute. The general FCI philosophy of strengthening links between traditional biomedical research and the physical sciences, engineering and maths/informatics on the one hand, and with experimental medicine on

the other, is perfectly aligned with that of the Divisions in this Unit.

ii. NHS interactions, health policy, practice and guidelines

The transformative effects of the formation of KHP and the consequent closer alignment of research priorities and strategy between KCL and our local partner NHS Foundation Trusts were discussed earlier. The benefits of this integration are expected to further increase over the next few years. Moreover, the development of a **South London Academic Health Sciences Network** with KHP at its core will result in an even greater influence on the local health and research economy, covering the whole of South London and extending further afield into Kent.

KHP has acted as the host organisation for the **Comprehensive Local Research Network** (CLRN) for London (South) since 2007, and the **South East London Cancer Research Network** since inception in 2001. It also co-hosts the **Medicine for Children's Network** via the Evelina Children's Hospital and the **NIHR Research Design Service for London** (collaboration with Imperial College, Queen Mary University of London and UCL).As an AHSC and major recipient of NIHR BRC funding, KHP has significant influence on the UK translational research agenda, e.g. through the **NIHR BRC Directors Group**. There has been significant influence on the national agenda for bioresource collection and storage (where KCL has a unique contribution through our Twin Bioresource); catalysing progress in rare diseases; and in the **National Health Informatics Collaboration** (where KCL leads on Transplantation). Malim leads the cross-BRC "Collaborative HIV Eradication of Viral Reservoirs: a UK BRC initiative (CHERUB)" programme, which will provide a unique experimental medicine approach to HIV eradication. Numerous PIs contribute to NIHR National Specialty Groups, including leading these groups; e.g. Greenough chairs the Paediatrics Group and Smith is vice-chair of the Dermatology Group. Pinder chairs the NHS Breast Screening Programme Pathology Research Group.

Our PIs play active and leading roles in influencing **national and international health guidelines** on a wide range of health-related topics. For example, PIs have contributed to NICE HTA Appraisals and Guidelines in biomarkers, COPD, food allergy, gastroenterology, lung cancer, minimally invasive surgery, perinatal care, psoriasis, renal disease, respiratory disease, smoking cessation, trauma, valve disease and many other areas.

Examples of policy input at the highest national and international levels include Moxham (Chair, **Action on Smoking and Health**); Lechler (Chairman of Expert Advisory Group on novel biological agents for the **Committee for Safety of Medicines**); Watt (**House of Lords** Science and Technology Committee inquiry into Regenerative Medicine); Young (UK Advisory Group on Non-Ionizing Radiation within **Public Health England**, and **United Nations** Environment Programme (UNEP) Environmental Effects Assessment Panel); Purushotham (International panel for designation of French Cancer Centres).

This level of local, national and international involvement is indicative of the wealth of expertise being used to create strong networking and developing research and health policy.

iii. Interactions with industry

There are extensive collaborations with the pharmaceutical industry including GSK (4th largest contract/grant volume in the UK), Pfizer, Genentech, GE Healthcare, Novartis and many others. KHP undertakes more commercially sponsored studies that any other AHSC or comparable UK institution. Income from commercial trials was £2.65M in the year 2012/3. Quintiles, the largest Clinical Research Organisation in the world has a 30-bed state-of-the-art Phase 1 clinical trials facility embedded within the BRC Experimental Medicine Hub**.** Major strategic partners include Beckton Dickson (BD) Biosciences to develop immunology platforms for clinical diagnostics and research application, UCB Celltech in psoriasis, Sanofi in type I diabetes (with JDRF), Pfizer in metabolomics in the UK Twin cohort, ImmuNext in renal transplantation, Serco in pathology, Edwards Life Sciences in our internationally recognized Transcatheter Aortic Valve Implantation programme, and Johnson & Johnson Pharmaceuticals in oncology.

Many of our PIs are experienced consultants and advisors to industry, with excellent working relationships with pharmaceutical and small biotech companies, including representation on scientific advisory boards that keep us informed of the latest developments in pre-clinical translational research and new small molecule agents. PIs have also helped to shape and/or have led major industry-sponsored international clinical trials, e.g. in cardiology, dermatology, diabetes, infectious diseases, oncology, rheumatology, transplantation. Since January 2008, PIs in the submission have filed 34 priority patents and set up one spin-out company.

iv. National and international collaborations

We work collaboratively with other institutions in the UK and abroad to maximise the impact of our research. Examples at **institutional/divisional level** include the following: the MRC Centre in Asthma is a formal partnership with Imperial; the MRC Centre for Transplantation partners with Harvard; the BHF Centre has partnerships with the MRC Protein Phosphorylation Unit (Dundee) and the Göttingen Heart Center (Germany); a joint UCL-KCL facility for gene therapy vectors is led by Linden and has been selected to be the future manufacturing partner of Lysogene; a BHF Centre for Cardiovascular Regenerative Medicine award is a partnership with Edinburgh, Glasgow and Bristol; the Department of Twin studies is involved in numerous international collaborations; an institution-level strategic partnership with the University of California San Francisco covers experimental medicine, genetics and immunology.

Major **international networks** led by PIs in this unit include EU FP7 programmes on the genetics of thrombosis and strokes, and on osteoarthritis (both Spector), an EU FP7 programme on personal ultraviolet radiation exposure (Young), an NIH-funded International Consortium on Genetics of SLE (Vyse), and Fondation Leducq Transatlantic Networks of Cardiovascular Excellence in redox signalling (Shah) and proteotoxicity (Gautel). In addition, PIs participate in over 20 EU networks, numerous international genetics consortia, and several NIH programmes.

At **individual PI level**, notable KCL-led collaborations include: a multicentre Wellcome Trust Strategic Grant to immunophenotype hundreds of gene knockout strains (Hayday); a Wellcome Trust/MRC strategic award on behalf of the UK human iPS consortium (Watt, co-lead); and a Wellcome Trust Experimental Medicine initiative to develop peptide immunotherapy (Peakman).

v. Contributions to peer review and work with funding bodies

These include serving as editors and editorial board members of leading journals and contributing to the work of major national and international funding bodies. Examples include:

Editors-in-chief: Biochemical J (Parker), Clin Experimental Immunol (Peakman), Exp Physiol (Ward), J Cell Science (Watt), J Muscle Res Cell Motility (Gautel), PLoS Currents: Huntington's disease (Bates).

Deputy/Section Editors: BMC Immunol (Hawrylowicz), Clin Experimental Allergy (Corrigan), eLife (Watt), Exp Biol Med (Farzaneh). J Dermatol Sci (Young), J Investig Dermatol (McGrath), J Mol Cell Cardiol (Mayr), J Perinatal Medicine (Greenough), PLoS Pathogens (Malim).

Associate Editors: AJP Heart Circ (Shah), Am J Transplant (Dorling), Arterioscler Thrombosis Vasc Biol (Xu), BMC Immunol (Woszczek), Cardiovasc Res (Shah), Clin Experimental Allergy (Hawrylowicz), Dermatology (Nestle), Diabetologia (Peakman), Free Rad Biol Med (Mann), Histopathol (Pinder), J Investig Dermatol (Flohr), J Mol Cell Cardiol (Avkiran), Mucosal Immunol (Spencer), PLoS Pathogens (Linden), Thorax (Sethi), Virology (Malim).

Editorial Board memberships encompass virtually all leading subject-specific journals relevant to this unit as well as leading generalist journals such as EMBO Molecular Medicine, Cell Stem Cell, PLOS Medicine, Science and Nature Scientific Reports.

Work for **national funding bodies** includes service on the HEFCE Board (Greenough); MRC Boards and Panels (Bates, Lewis, Malim, Sacks, Sethi, Watt); NIHR (Nestle); Wellcome Trust Boards and Panels (Bates, Geissman, Grimwade, Hayday, Lewis, Malim, Peakman, Watt, Gautel, Shattock); Arthritis UK (Cope, Vyse); Asthma UK (Sethi); BHF Council (Lechler); BHF committees (Shah, Marber, Avkiran, Mayr, Shanahan); British Skin Foundation (McGrath, Nestle); CRUK (Jackson, Mathew, Ng, Hayday); Heart Research UK (Mann); Psoriasis Association UK (Barker).

Work for **international funding bodies** includes Agence Nationale de la Recherche, France (Geissmann, Chair); European Haematology Association (Grimwade); European Research Council (Spencer); European Society of Cardiology (Shah); Fanconi Anemia Research Fund USA (Mathew); JDRF (Tree); MATWIN France (Parker); National Cancer Institute, NIH (Nestle, Noelle).

vi. Contributions to national and international specialist societies

International leadership roles include the European Society for Dermatological Research (Barker, McGrath), European Society for Microcirculation (Mann), European Society of Cardiology Heart Failure Association (Shah), Federation of Clinical Immunology Societies (Nestle), International Psoriasis Council (Barker), International Society for Heart Research (Avkiran), International Society for Stem Cell Research (Watt), Society for Free Radical Research International (Mann), International Society of Twin Studies (Spector).

National leadership roles include British Cardiovascular Intervention Society (Redwood),

British Pharmacological Society (Brain), British Society for Gene and Cell Therapy (Antoniou), British Society for Haematology (Grimwade), British Society for Investigative Dermatology (Nestle), British Society of Immunology (Hayday), Genetics Society (Oakey), Physiological Society (Ward), Royal Society of Medicine (Marber).

In addition, PIs have contributed to **council/committee memberships** of many societies during the current period, e.g. Academy of Medical Sciences council, American Society for Cell Biology council, American Heart Association, American Society of Hematology, American Thoracic Society, British Cardiovascular Society council, British Thoracic Society council, European Academy of Allergy and Clinical Immunology, European Haematology Association, International Society for Heart Research, Royal College of Physicians, Royal Society Council.

vii. Public communication

Public engagement is a key priority for King's, and we have raised £7m to create a Science Gallery at our Guy's Campus, to open in 2016. This will be a founding member of an international network of Science Galleries that includes Dublin and New York, and will provide an excellent environment for our PE activities locally, nationally and internationally.

All our Divisions place great emphasis on the dissemination and communication of our work to the public and other users. The Divisional websites provide a readily accessible window into our educational and research activities and their impact. This work is frequently featured in lay and scientific national and international news media (paper, radio, TV, internet), covering not only research advances but also a range of ethical and policy issues (e.g. organ donation, smoking, HIV prevention). Regular events are hosted for donors and other lay public (e.g. by the MRC and BHF Centres) at which they are able to interact with a wide spectrum of staff and students and learn first-hand about the interdisciplinary research and training being undertaken. Structured shadowing experience is offered to A-level students from across London, thereby promoting an interest in biomedical research from an early stage.

PIs participate in a wide range of external public awareness events, e.g. the British Science Festival, the Cheltenham Science Festival and MRC Centenary events. We are involved in many external educational events, e.g. working with national charities (BHF, Wellcome Trust, etc) or local schools. Examples of innovative material produced for the public include: The Body is a Big Place. Science Gallery Dublin: Exhibition and video. http://www.youtube.com/watch?v=CDt_ebModRo and The Story of a Single Heart Beat: Guardian Online Video http://www.guardian.co.uk/science/video/2011/nov/11/affairs-heart-heartbeat-video.

viii. Other markers of esteem

PIs in this submission include 4 Fellows of the Royal Society (Bates, Malim, Parker, Watt), 18 Fellows of the Academy of Medical Sciences (Bates, Gautel, Hayday, Jackson, Lechler, Malim, Mathew, McGrath, Nestle, Ng, Noelle, Parker, Sacks, Shah, Solomon, Thein, Vyse, Watt), 3 EMBO Fellows (Bates, Parker, Solomon), 1 European Academy of Cancer Sciences Fellow (Parker), 1 Fellow of the Royal College of Pathologists (Farzaneh), 1 Fellow of the Society of Biologists (Farzaneh) and 4 NIHR Senior Investigators (Lord, Nestle, Greenough, Sacks). Lechler was awarded KBE for services to medicine. Significant personal awards include a Wellcome Trust Principal Research Fellowship (Noelle) and 4 BHF Personal Chairs (Gautel, Otsu, Shah, Xu).

Selected international and national prizes awarded to PIs included the Aaron Lerner Discovery Award in Dermatology 2012 (Hayday), American Society for Cell Biology - Women in Cell Biology Senior Award 2008 (Watt), American Society for Pediatric Dermatology Hurwitz Lectureship 2010 (McGrath), AstraZeneca Women in Pharmacology Prize 2010 (Brain), European Federation of Immunology Societies Lectureship Medal 2010 (Hayday), European Respiratory Society Congress Chair award 2012 (Moxham), European Society for Photobiology Medal 2011 (Young), ISHR Janice Pfeffer Distinguished Lecturer Award 2013 (Marber), ISHR Keith Reimer Distinguished Lecturer Award 2012 (Avkiran), ISHR Outstanding Investigator Award 2009 (Gautel), International Society for Stem Cell Research Anne McLaren Lectureship 2012 (Watt); Jeang Retrovirology Prize 2010 (Malim), Leslie Brenner Gehry Prize for Innovation in Science 2011 (Bates), Lister Institute Research Prize 2008 (Martin Serrano), Paula and Richard von Hertwig-Award for Interdisciplinary Cooperation 2010 (Spector), World Congress of Perinatology Erich Saling Prize 2009 (Greenough).