**Institution: University of Nottingham**

**Unit of Assessment: 1 Clinical Medicine** **REDACTED FOR PUBLICATION**

**a. Overview**

The **School of Medicine** comprises 11 large Research Divisions of genuine critical mass underpinned by cross-cutting Technology Platforms. We also manage Teaching Centres in Nottingham and Derby. Six of our Divisions are returned in UoA1 and are described here; others are returned in UoA 2 and 4. Researchers in our Division of Medical Sciences and Graduate Entry Medicine based in Derby are attached to various Research Divisions and are returned here with those. Medicine is the largest School in the University, giving critical mass for strategic decision-making. Of our 122 senior academic staff (Clinical Associate Professor/ Non-clinical Lecturer or above) in the UoA1 area, 80% are returned in REF. Most of the others are primarily teachers, 11 of whom are within our Division of Medical Sciences and Graduate Entry Medicine, which focuses on Education. We also have 79 Honorary academic appointees, mostly within our partner NHS Trusts, 40 of whom are at Associate Professor level or above. In the REF period, 5,470 original research articles in Scopus were attributed to Medicine in Nottingham. Researchers in UoA1 attracted £131M in research awards into the University (24% RC, 22% charity, 22% NIHR, 9% other government, 22% industry), another £49M into Nottingham University Hospitals NHS Trust and £11M into Derby Hospitals NHS Trust. Within UoA1, we recruited 366 new PhD students to study in Nottingham within the REF period. Our Divisions returned in UoA1 are:

**1. Cancer and Stem Cells**: This new Division includes research groups in Clinical and Pre-Clinical Oncology, Haematology, Histopathology, Breast Surgery and Child's Brain Tumours. There is close collaboration with other Divisions, particularly Digestive Diseases. Stem Cell Biology has many research interests outside oncology, but is managed here.

**2. Nottingham Digestive Diseases Centre**: This includes Gastroenterology, Hepatology and GI Surgery. The NIHR Biomedical Research Unit (BRU) in GI and liver disease is within this Division.

**3. Respiratory Medicine**: This Division also won an NIHR BRU in 2008, and is priority-funded to maintain its critical mass in translational research and clinical trials

**4. Rheumatology, Orthopaedics and Dermatology**: Rheumatology and Orthopaedics work closely together and share centre-level funding equivalent to the BRUs. The Dermatology group shares a commonality of approach in clinical trials, meta-analyses and guideline synthesis.

**5. Child Health, Obstetrics and Gynaecology**: The Obstetrics and Gynaecology group and the Child Health group both perform translational research on conception and early life development and both have a major emphasis on clinical trials.

**6. Clinical Neuroscience (including Vascular Research)**: This Division includes Stroke Medicine (which oversees all vascular research), Clinical Neurology, Radiology and Imaging, Anaesthetics (although some anaesthetists have a research focus with other groups), Ophthalmology and Hearing. The NIHR Biomedical Research Unit in Hearing is within this Division, but although some of its work is returned in UoA1, most concentrates on neural processing which is a major theme of our UoA4 return, and so is returned there.

**b. Research strategy**

**i) Significant changes to the research environment in the assessment period**

NIHR investment in translational and clinical research under-pinned our strategy. In 2008, in response to national priority calls, the Faculty of Medicine and Health Sciences attracted >£30M National Institute of Health Research (NIHR) investment into the University and partner NHS Trusts. For the School of Medicine, most influential was the award of three NIHR Biomedical Research Units (BRUs) for patient-based translational research in Digestive Diseases, Respiratory

Medicine, and Hearing. With this money and >£6M matched funding from the University and the Nottingham University Hospitals NHS Trust, we built and staffed bespoke translational research units next to patient-care areas and invested in new young Principal Investigators to work alongside established senior researchers. This new patient-based translational research complemented parallel growth in large clinical trials, a traditional strength in Nottingham. Here considerable new NIHR and other funding boosted research in Digestive Diseases, Respiratory Medicine, Stroke, Rheumatology, Dermatology, Obstetrics, Child Health and Oncology. The clinical trials agenda was further enhanced by the roll-out and maturation of LCRNs and Specialty Networks and by NIHR and University investment in our Clinical Trials Unit. Finally, in 2008 we won and recently renewed an NIHR CLAHRC (returned mostly in UoA2) in partnership with the Nottinghamshire Healthcare NHS Trust.

An external review of Faculty research strategy influenced our plans. To build on our funding successes, in 2009 we asked Sir John Savill to chair an intellectually powerful (Jeremy Tavare, Richard Trembath, Michael Wakelam) review of research, and our 5 year strategy was greatly influenced by their recommendations. We list below the 5 guiding principles they suggested and how we have incorporated them into our strategy, followed by our other key areas of strategic investment.

**1. Build strategy around the 3 NIHR Biomedical Research Units (BRUs) and partner with research funders to build other strategic areas, such as Magnetic Resonance Imaging.**
We invested heavily in the BRU areas, fully matching NIHR investment with funds from the University and the NUH NHS Trust. Two BRUs were successfully renewed in 2012, both with increased NIHR funding. Digestive Diseases is the only BRU in the UK focussing on luminal GI disease; it is embedded in our flagship Nottingham Digestive Diseases Centre. Hearing is a nationally unique 3-way partnership between University, NHS Trust and MRC Institute for Hearing Research, and is the biggest integrated hearing research initiative in the UK. The Respiratory BRU was not renewed amongst stiff national competition, despite outperforming the other BRUs in income and patient recruitment. However, it is now a well-funded high-quality translational research unit with real critical mass and will be competitive in any further NIHR funding round.
- We have invested heavily in MRI with strategic support from the MRC, EPSRC and industry. Specifically: we have built infrastructure and collaboration within the Sir Peter Mansfield MRI Centre in Physics which houses one of only two 7T systems in the UK; we have built and staffed an academic Imaging Unit in the Medical School and invested in new research-dedicated 3T and 1.5T magnets and a hyperpolarised gas facility; and we have set up a new animal imaging facility.
- We have built the Musculoskeletal area into a cross-School (with Physiology) translational initiative of similar size to the BRUs. In response to national calls we won the multi-disciplinary Arthritis Research UK National Osteoarthritis Pain Centre and, with other academic partners, the MRC/ARUK Musculoskeletal Ageing Research Centre; the ARUK Centre for Sports Injury and Osteoarthritis Prevention; and a DoH National Sports and Exercise Medicine Centre.

**2. Build "Discovery Engines" (strong scientific pipelines to clinical research) to drive the BRUs. Examples could be; Bacteriology; Pharmacy/Molecular Therapeutics; and Imaging.**
- BRU's (and other initiatives) are now truly multidisciplinary and work seamlessly with these and other strong areas of basic science in Nottingham. We have invested heavily from NIHR and University funding in posts and projects in these areas. For example, the GI BRU, which focuses on GI infection and post-infectious diseases, is partly embedded in bacteriology, and several senior bacteriology researchers are now BRU Principal Investigators (PI's). The BRU also focuses on MR imaging with an embedded physicist in the BRU and PI's in the Sir Peter Mansfield MRI Centre. There are joint projects with Pharmacy, one of whose PI's sits on the BRU Management Board.

**3. Invest to stimulate inter-School and inter-Faculty research in Nottingham.**
- As well as investing to site leading groups in stem cell and GI research within our flagship £23M multi-disciplinary Centre for Biomolecular Science (CBS), we built and funded collaborations with other strong basic science groups to drive translational research, particularly bacteriology, tissue engineering, molecular therapeutics and human physiology. We also sponsored collaborations and now have joint initiatives with Pharmacy, Psychology, Physics, Chemistry, Engineering, and Maths.

**4. Invest in equipment and support facilities, and ensure their sustainability**.

- We have funded, set up and now administer "Research Platforms" to service our research groups, with ring-fenced finance, dedicated leadership, and access for all researchers. The platforms are: Human MRI Facilities; Clinical Trials Unit; Clinical Research Facility; Biomedical Service Unit; Animal Imaging Facilities (SPECT, PET and Optical Imaging); Deep Sequencing (next generation sequencing); Fluorescence-Activated Cell Sorting; and Advanced Microscopy.

**5. Re-energise research training programmes and encourage cross-University working.**

- We set up the innovative Nottingham Translational Research PhD Training Programme (*N-trans*) and funded its studentships in our areas of strength. We instituted a compulsory two supervisor model to encourage supervision across School and Faculty boundaries.
- In response to the national initiative in clinical academic training, we set up systems to integrate Academic F1 posts, Clinical Fellows and Lecturers (ACF1/F/Ls) with University-matched posts and provided bespoke training in the *N-trans* programme. We targeted posts into strong areas, for example establishing more ACF posts in Gastroenterology than anywhere else in the UK. Our intermediate researchers won 4 NIHR Senior Fellowships to establish their independence.
- We directly funded 27 Clinical Research Fellows in areas of real Nottingham strength.

<u>We took several other key strategic actions to shape our research environment.</u>

**6. Set up infrastructure to further strengthen research with NHS partners**

- In 2013, in response to a national call, we were awarded an East Midlands Academic Health Science Network for Nottinghamshire, Derbyshire, Lincolnshire, Leicestershire and Northamptonshire, with University Hospitals Nottingham as the lead Trust. This Network also includes the Universities of Leicester and Loughborough.
- We have co-located our University and Nottingham University Hospital NHS Trust patient-based research administration and named ourselves Nottingham Academic Health Science Partners. NAHSPs house the University Clinical Trials Unit, the NIHR Research Design Service, and the Trust R&D and Governance Units. It has been used as a national exemplar by the NIHR.
- In response to a national initiative to increase Clinical Trial Unit infrastructure and with dedicated NIHR (£1.3M) and University funding, we made external appointments of a Professorial Director and a Professor of Trials Statistics (both University funded) and expanded the unit to 44 centrally-based trial managers and support staff with many further staff embedded in Divisions.
- We have built, commissioned and staffed a dedicated Clinical Research Facility for Phase 2+ studies, including those requiring access to our two research-dedicated MRI scanners.
- We have overhauled Honorary University appointments for NHS researchers to make these more valued and effective (see later).

**7. Set up joint working with the University of Birmingham.**

In 2011, The Universities of Nottingham and Birmingham signed a concordat on joint working including joint research and education initiatives in the UK and abroad. Two examples in UoA1 are: joint working between the Nottingham Digestive Diseases Centre BRU and the Liver BRU in Birmingham, with shared governance, shared patient recruitment, joint ownership of 6 studies and joint meetings; and a successful joint bid for an MRC/ARUK Centre in Musculoskeletal Ageing.

**8. Increased our focus on commercialisation and industry partnership.**

- We have invested in and supported several exciting new spin-out companies: i) Oncimmune develops autoantibody-based diagnostic tests for cancers before they are otherwise detectable. In the US it markets a serum test for lung cancer, which is now being trialled by the NHS in Scotland; ii) Pre-Clinical Oncology Services perform stratified testing of new anti-cancer agents; iii) Scancell develops and tests new therapeutic anti-cancer antibodies; iv) Platelet Solutions develops and markets platelet stabilisation and testing systems already used in large clinical trials; v) Nurture delivers an *in vitro* fertilisation service with one of the best pregnancy rates in the UK; vi) Gamma Technologies performs high resolution nuclear medicine imaging to study drug distribution in man.
- We have increased industry partnerships: UoN has set up a Business Engagement and Innovation Services Directorate and attracted industry funding totalling ~£70M to Nottingham, including a £5.2M partnership investment in the Division of Oncology from a single company for

developing clinically relevant models for the selection and testing of new anti-cancer drugs.

**9. Set up mechanisms to improve impact by active promotion and dissemination of research.** We publicise research on our web pages and disseminate it through blogs, Twitter, Facebook and other social media platforms. We use videos and podcasts to profile our new advances. Our reach for University research news is benchmarked at 125M people/month internationally and medical research is our most popular item. We showcase research at public lectures, NHS open events, and MayFest, a University Open Day attended by thousands, including many Nottingham residents. For specific stakeholders, we circulate a news bulletin featuring major research successes and a bespoke magazine called Research Exchange.

**ii) Forward Research Plans**

To help us build further on our successes, in 2011, we commissioned a top internal and external panel (Sir Peter Rubin, Patrick Sissons, Robert Lechler, Debra Humphris, Saul Tendler) to review and simplify Faculty structures. A key recommendation was the creation of a new large School of Medicine to allow more strategic use of budget, support areas of true research excellence and further reduce barriers to multi-disciplinary research. The new School was launched in August 2013, and in this facilitated environment, **our forward plans** are based on performing big-project high-impact research in focussed areas of critical mass where we have internationally-competitive research programmes. We place particular emphasis on multi-disciplinary research (within and outside the University), research training, collaboration with industry, and commercialisation.

**Five Year Plans:**

1. **To sustain existing and build new critical mass in specific areas, including building new facilities and making targeted new senior academic appointments.**
a) We will invest even further in our successful translational research in Gastroenterology/ Hepatology; Respiratory Medicine; Musculoskeletal research and Hearing. We will also look to combine these strengths and have already opened negotiations with Birmingham about applying jointly for NIHR BRC status, and with Leicester about applying for Academic Health Science Research Centre status. We are lobbying for changes in the current rules to allow UK regions to build these partnerships to give real competition to Oxbridge/London.
b) We have now (August 2013) brought together Oncology research into a single Division to give critical mass. We will re-focus around the themes of Prevention and Early Diagnosis, Drug Discovery and Stratified Management. We have recently appointed a new non-clinical Professor in Oncology focussed around translational oncology and drug discovery, and re-located his research group of 20 from Bristol. We have advanced plans for a new “Nottingham Translational Cancer Research Centre” which will function as a “hub” and co-house our laboratory-based oncology research groups allowing close interaction with the internationally renowned Oncology Drug Discovery groups in our School of Pharmacy (UoA2). Clinical research and trials will be co-ordinated from the hub and managed in “spoke” sites, close to patients, embedded in our partner NHS Trusts and in particular at our regional cancer centre in the Nottingham University Hospitals NHS Trust. As part of this University initiative we aim to make three new senior appointments in Clinical Trials, Respiratory Oncology and in vitro and in vivo Cancer Modelling.
c) We have just (August 2013) brought together Clinical Neurosciences into a single research Division to join with our Division of Psychiatry and School of Psychology to create real critical mass. A task and finish group is studying co-location and strategic appointment options in areas where we can lead the UK, for example hearing, stroke, neuro-imaging and child’s brain tumours.

**2. To further invest in and expand our key research support platforms and units**
a) We will invest further in our world-leading strength of MR imaging, within both the Sir Peter Mansfield Centre and the Medical School. We will now purchase: the first low strength MRI in the UK for intra-operative scanning for brain tumour surgery; a new research-dedicated scanner for dynamic brain imaging using our expertise in hyperpolarisation; and a facility for scanning anaesthetised children and adults. We also have active investment plans for moving beyond 7T.
b) We will expand our Clinical Trials Unit into dedicated space within our shared University/NHS facility and establish satellites in all partner Trusts. We will use our excellent Division of Primary

Care (UoA2) to deliver more and better large pragmatic community-based trials. With our infrastructure established, we plan to attract three new senior clinical trialists to provide a pipeline from our successful translational areas, using a recently-established Strategic Development Fund.
c) We will invest in our Clinical Research Facility with specific development of the Phase I/II capabilities needed by our Biomedical Research Units and other translational research centres
d) We have recently invested heavily in our Stem Cell Biology unit with the development of the first human pluripotent stem cell automated screening platform in Europe. We will invest further in staff and equipment and continue active sponsorship of the unit's close working with our UK-leading Tissue Engineering Group in the School of Pharmacy.

**3. To promote, fund and facilitate large-scale multidisciplinary research across Schools and Faculties.** This includes: generous internal funding of one and two year pump-priming research programmes by a Faculty Inter-Disciplinary Research Committee; further support of the Centre for Biomolecular Science as a focus for active cross-disciplinary collaboration; active funding of researchers and research students based in other Schools and Faculties co-supervised by School of Medicine researchers; continued specific support of the Research Engines of Bacteriology, Pharmacy/Molecular Therapeutics and MRI; and creation of special links with (including giving financial support to) new Research Engines including Stem Cell Biology, Tissue Engineering, Virology, Human Physiology, Human Genetics and Engineering.

**4. To build even better collaboration with our NHS partners.** We will better align joint objectives and streamline patient-based research processes by assigning more senior academics to our University/NHS Trusts partnerships to support Trusts' R+D Directors, who in each case are University-employed clinical academics. Through our East Midlands Academic Health Science Network, we aim to improve regional University and NHS collaboration, expand access to patient populations and improve impact dissemination across the whole of the East Midlands.

**5. To improve research training and career opportunities for young researchers.**
**a)** We will innovate our PhD training by adding to our bespoke translational programme (*N-trans*) to create focussed training in clinical trials (*N-trials*), epidemiology/Health Services Research (*N-epi*) and basic biomedical research (*N-base*). We will work on attracting more Doctoral Training Centre funding from Research Councils, NIHR, charities and industry, offering 50% matched funding.
**b)** To build capacity at the early Principal Investigator level, we will guarantee University appointments to all young Investigators winning our highly competitive internally-funded Intermediate or Senior Research Fellowships in Nottingham, as we already do for external Fellowships. We will aggressively continue to expand our internal Fellowship programmes.

**6. To promote major industry collaborations and commercialisation**. Our new Business Engagement and Innovation Services Unit is creating a new model of industry partnerships with joint finances and joint governance to attract further multi-million industry investment, based in part on our recent successes in Medicine. Through the Hermes programme, we are sponsoring 5 further possible spinouts from the areas of the School within UoA1.

**7. To make our research truly international.** The University has campuses in China and Malaysia and we have current plans to set up facilities and projects in China in oncology, stem cell biology, reproduction and evidence-based medicine. We have recently established research collaborations through our offices in South America, India and west Africa, and plan to attract and train high quality research students in a mobility partnership model which recognises local drivers.

**iii) Research Groupings: activities, multi- and inter-disciplinarity, and achievements**

**1. Cancer and Stem Cells.** The Division is truly multi-disciplinary, with joint projects throughout the University and particularly with molecular therapeutic "drug discovery" groups in Pharmacy and Life Sciences. Our strong laboratory research focuses on early detection, stratification and targeted therapy, and in part through an active commercialisation programme has fed through to real clinical translation. For example, our Centre of Excellence for Autoimmunity in Cancer (CEAC) and its spinout Oncimmune have invented, standardised and launched the first serum autoantibody test for early detection of lung cancer (EarlyCDT-Lung) and a large prospective RCT assessing this is

now underway in the NHS in Scotland. CEAC is developing similar early detection tests for colon and hepatocellular cancer (£0.5M MRC/NIHR). Our Breast Cancer Research Group has used the national Breast Cancer Campaign Tissue Bank (which it houses) to describe the major molecular alteration patterns found in breast cancers (Nature) and honed its widely-used Nottingham Prognostic Index to better guide treatment decisions (£2.5M charity/industry). The group won the Breast Cancer Campaign Research Team of the Year award. Our Children's Brain Tumour Research Centre (£5.3M charity) recently developed the only transgenic model of childhood ependymoma following their high resolution genetic analysis of a tumour cohort (Nature) and led similar analyses of high grade glioma and primitive neuro-ectodermal tumours (Lancet Oncology/ JCO), work now influencing treatment decisions. A targeted anti-cancer antibody developed in our CRUK- and University-sponsored Therapeutic Antibody Centre is in phase I clinical trials in GI cancer. Our Ex Vivo Pharmacology Centre has developed stratified therapy of lung cancer (£5.2M industry) and their spinout tests new therapeutics. They have recently expanded their models to include tumour vascularity and angiogenesis (new appointment from Bristol) and identified new drug targets including FBXW7 (JExpMed). Finally, a novel anti-cancer DNA vaccine invented in Nottingham and developed though spinout is in a University-led first-in-man trial in melanoma.

In the Clinical Research arena, our cancer clinical trials teams (>£1M/y NIHR/Industry) concentrate on novel targeted cancer therapies, for example leading to the licensing of fulvestrant, the only new endocrine therapy licensed worldwide in the last 10 years. Current trials include a new AKT inhibitor for breast cancer (£0.8M industry) and a novel therapy for brain tumours in children (£1.3M CRUK). The Child's Brain Tumour Group are developing translational imaging (£2.5M CRUK/EPSRC) and run a national public awareness campaign, HeadSmart, reaching >14M people and leading to reduced time to diagnosis (NHS Innovation Award).

Stem Cell Biology are managed within the Division but housed in purpose-designed laboratories in our Centre for Biomolecular Sciences with Tissue Engineering (School of Pharmacy) to form the Wolfson Centre for Stem Cells, Tissue Engineering and Modelling (STEM). Success has been underpinned by £10M collaborative funding for basic science (MRC, NC3Rs, EPSRC; BHF) and industrial translational funding (BBSRC Industrial Partnership Award £1.3M; Stem Cells for Safer Medicine private-public partnership; two BBSRC Bioprocess Research Industry awards £1.5M). Building on this interdisciplinary research base, we attracted major investment (MRC/BBSRC/ EPSRC £5.1M to Nottingham) for embryonic stem cell characterisation and development of the first human pluripotent stem cell automated screening platform in Europe (Nature Biotech, Nature Methods, Nature Protocols). With MRC, BHF and NC3Rs funding (£1.3M) and in close collaboration with Imperial College (BHF Regenerative Medicine Centre and Programme Grant £3M) we have established novel disease models for patients with long QT and Duchenne muscular dystrophy by reprogramming cells from their skin biopsies to a stem cell state then differentiating to cardiomyocytes (Eur Heart J x2). Our stem cell research is also embedded in the Divisions of Clinical Neuroscience, Child Health / O+G, and the Nottingham Digestive Diseases Centre.

**2. Nottingham Digestive Diseases Centre and its Biomedical Research Unit (BRU).**

During the REF period, we co-located Gastroenterology, Hepatology and GI Surgery and attracted a £6M NIHR BRU (2009) allowing us to build a dedicated patient-based translational research facility, and win a £7M renewal (2012). The BRU, directed by one of 2 NIHR Senior Investigators in the NDDC, is one of the highest recruiting in the UK, attracting >2,500 patients/ year into clinical studies. It has a major focus on academic training and has the biggest GI ACF programme nationally. Together with dedicated GI and liver researchers in its inter-disciplinary "Research Engines", particularly bacteriology, virology, MR Imaging and Pharmacy (returned in other UoAs), we believe the NDDC to be the largest Digestive Diseases Research grouping in the UK with >£33M grant income and ~120 PhD students across clinical and pre-clinical areas.

Translational and laboratory research includes a major focus on GI and liver infections and their long-term consequences, particularly *Helicobacter pylori*-induced disease, functional GI diseases and hepatitis C. Translational highlights include: discovering new *H. pylori* virulence markers which underlie and predict ulcer and gastric cancer risk (Gastroenterology); identifying serotonin uptake as a tractable therapeutic target in irritable bowel syndrome (Gastroenterology); describing single genetic determinants of drug-induced liver injury, leading to genetic pre-testing (Nat Genetics); and showing that serum markers of liver fibrosis are better than invasive biopsy for many purposes

(Hepatology). Work is underpinned by MRC, NIHR, EU, CRUK and >£12M industry funding, including a recent FP7 grant (€4.9M) to develop anti-HCV human monoclonal antibodies and an MRC Regenerative Medicine Platform (£4M) for therapy delivery. A cross-cutting BRU focus is MR imaging as a diagnostic and prognostic tool. Highlights include demonstrating pathological small bowel water handling in IBS (Gastroenterology) and that the structure of the gastro-oesophageal junction predisposes to acid reflux (Radiology). We lead internationally in real-time manometry and novel endoscopic imaging, for example developing novel imaging for Barrett's oesophagus, which is now in widespread clinical use (Gastroenterology). Clinical research flows from our translational work, and includes both small complex trials (ASTIC: stem cell treatment of Crohn's disease) and very large community-based trials (HEAT: Helicobacter Eradication Aspirin Trial, £1.7M HTA; STOP-HCV: Prevention of HCV, £4M MRC). Long term follow-up of our faecal occult blood screening studies (£3M MRC) has shown lives are saved, underpinning the UK national bowel cancer screening programme and others worldwide. Our epidemiological research has quantified dangers of drug use and infection in diverticular disease (Gastroenterology) and the efficacy of non-operative treatment for simple appendicitis (BMJ). Nottingham recently won the multi-disciplinary UK CRC Centre for Tobacco and Alcohol Control (£5M) and our researchers lead major projects in alcoholic and fatty liver disease.

**3. Respiratory Medicine.** The Division attracted a £6M NIHR BRU in 2008 and built patient-based translational research and imaging facilities. We have since recruited 1 in 9 of all UK patients entering respiratory studies and now house 130 staff. Research focuses on Asthma, COPD, cystic fibrosis (CF), idiopathic pulmonary fibrosis (IPF) and the rare condition lymphangioleiomyomatosis (LAM), for which we are national co-ordinators and international leaders. We co-ordinate genome-wide association studies, particularly in asthma, COPD and pulmonary fibrosis and have identified key genes determining lung function (Nat Genetics x3). We are conducting follow-on functional studies (MRC £1.3M, £3.4M) including the first very large study using the National Biobank. We have recently identified novel epigenetic abnormalities in asthma and IPF (J Immunol, MCB), and a role for integrin-mediated TGFβ activation in lung fibrosis (Am J Pathology) (Wellcome programme /MRC /Industry). We attracted EPSRC (£1.5M) and industry investment for MRI functional assessment of diseased lungs using hyperpolarised gases and used this to attract two leading physicists from the US (one a Professor) to establish a dedicated MRI research facility. Our anaesthetic-led research on modelling pulmonary pathophysiology (£1.2M EPSRC, MRC, industry) has led to changes in crisis management adopted in critical care/anaesthetic guidelines (JRoySoc). Our extensive clinical trial work includes demonstrating the utility of quadrupling inhaled steroids in asthma exacerbations (AmJRespCritCare; £2M HTA). The Division collaborates in two EU FP7 consortia (€40M), the NIHR Translational Research Partnership in inflammatory lung disease, the £2M Erica TSB COPD consortium and the £6M MRC-ABPI COPD initiative. Respiratory Epidemiology in Nottingham (mostly UoA2) is a major partner and complementary strength; they host and co-ordinate the multidisciplinary UK CRC Centre for Tobacco Control Studies (£5M + £5M renewal).

**4. Rheumatology, Orthopaedics and Dermatology.** Rheumatology and Orthopaedics have attracted a tranche of Centre level funding focused on joint pain, osteoarthritis (OA) and sports injury, giving a secure funding platform equivalent in size to our BRUs. Our multi-disciplinary Centres are led from the Division and run jointly with Human Physiology, MR Imaging and Clinical Psychology. They include: the £2.5M Arthritis Research UK (ARUK) Pain Centre, focusing on osteoarthritis and including ultra-high field MR imaging; the MRC/ARUK Centre for Musculoskeletal Ageing run jointly with Birmingham; the Olympic Legacy National Sports and Exercise Medicine Centre with Loughborough and Leicester; and the ARUK Centre for Sports Injury and Osteoarthritis (OA) Prevention with Oxford and others. Our laboratory research is truly translational, for example identifying genetic factors encoding tractable targets in osteoarthritis, osteoporosis and pain (AmJHumGen, PNAS, Lancet) and inventing coating polymers for rendering implantable devices resistant to bacterial attachment and launching them in man (Nat Biotechnol). Our clinical research on OA and gout (MRC, NIHR, ARUK) has changed practice, for example showing the beneficial effect of exercise on OA pain (BMJ). Importantly, we have led European guideline publication, inventing novel methodology for this (AnnRhDis). Our work with anaesthetics to stratify hip fracture patients (NIHR) has led to a national scoring system for prioritisation for surgery (BrJAnaes).

The Evidence-Based Dermatology Group, led by an NIHR Senior Investigator, comprises three interlinking cogs: the international Cochrane Skin Group (summarising evidence, informing guidelines and identifying research priorities); the UK Dermatology Clinical Trials Network (>700 members, >£10M funding including NIHR programme and 13 large multi-centre NIHR or charity-funded trials); and the Evidence Dissemination and Implementation group. Recent clinically important findings have included demonstrating the benefits of antibiotics in preventing leg cellulitis (NEJM); showing that softening water is ineffective for eczema (PLOS Med); and clarifying the roles of salicylic acid and cryotherapy for plantar warts (BMJ).

**5. Child Health, Obstetrics and Gynaecology.** The Division translates research on conception and early-life influences on disease into practice through our University-owned *in vitro* fertilisation facility, runs large clinical trials (including co-ordination of the Medicines for Children Research Network for East England) and won and co-ordinates Cascade-Fellows a €15M EU FP7 Post-doctoral Fellowship Training programme which will recruit up to 96 fellows, many to Nottingham. Our translational research on control of ovulation rate (BBSRC) and fertility preservation following oocyte freezing (MRC) has led to the breakthrough of live births from fertilised whole frozen sheep ovaries (£1.3M MRC; Human Reproduction). We have investigated environmental influences on obesity and hypertension from conception to childhood (FASEB J), translating laboratory work to sheep models and human studies, in which we have shown the importance of variation in brown fat using MR imaging (J Pediatrics, Diabetes, Hypertension; NIHR Senior Fellowship). We lead large multicentre trials such as the Growth Restriction Intervention Trial (£1M MRC and EU) and a trial on improving care for very pre-term births (£1.8M HTA). We have shown that: ursodeoxycholic acid reduces itching in cholestasis of pregnancy (BMJ); nicotine patches are ineffective for quitting smoking in pregnancy (NEJM); and oral steroids are ineffective for viral-induced wheeze in young children (NEJM). Our large cohort studies have described determinants of survival in very pre-term babies (BMJ) and of poor outcome in cystic fibrosis (BMJ). Our flagship Child's Brain Tumour Research Centre is described under Oncology as its research is focused there.

**6. Clinical Neuroscience and Vascular Research:** Our research has critical mass in large clinical trials, the development of imaging (particularly MRI) to guide future therapy, and underpinning translational research, particularly in Ophthalmology. The Stroke Trials Unit led by the UK Stroke Association Professor (a NIHR Senior Investigator) co-ordinates and delivers international treatment trials such as: ENOS Efficacy of Nitric Oxide in Stroke (MRC £4.5M); TARDIS Triple Antiplatelets for Reducing Dependency after Ischaemic Stroke (BHF/HTA £3.5M); and TICH-2 Tranexamic acid for IntraCerebral Haemorrhage-2 (HTA £2.5M). We have published recently in JAMA, NEJM and The Lancet. Laboratory research includes developing practical (and now patented) platelet function tests, which are being tested in TARDIS. The Neurology Trials Unit studies new treatments for multiple sclerosis (Lancet Neurology x2) and has recently analysed the effect of smoking in a large MS cohort (Brain). Imaging underpins our Neuroscience and Vascular research. For example, we have used ultra-high field MRI (MRC/EPSRC £2M) to develop novel diagnostic and prognostic markers in Parkinson's Disease (Neurology) and multiple sclerosis (NIHR Senior Fellowship; Brain). We lead the largest multi-centre MRI biomarker project in Parkinson's Disease internationally (Charity >£0.5M) and have developed MRI to show that carotid plaque haemorrhage is the strongest known predictor of stroke risk (Ann Neurology). Our Ophthalmology group works on amnion patching of eye injuries (MoD + 2 patents) and corneal transplantation and regeneration (EPSRC; Ophthalmol). They recently discovered a novel layer in the human cornea (Dua's layer) with big implications in lamellar corneal surgery (Ophthalmol). Other work in the Division, including by the Hearing BRU, is returned largely in UoA4.

**c. People, including:**

**i) Staffing strategy and staff development**

Staffing strategy. This directly supports our research strategy and avoids direct replacement of vacated posts. With BRU and other funding and with University and NHS Trust matching we have been through a period of growth in UoA1 areas with 29 new senior academic appointments made or approved versus 16 retirements/leavers, 6 now with Emeritus appointments. Of the new appointments, only 11 were replacements; instead, we have targeted new posts to strong areas.

For example, within the BRUs we have made 13 new senior appointments over and above direct replacements besides funding cadres of junior academic staff, research nurses and others (23 in Digestive Diseases and 22 in Hearing). We have also supported new growth areas, for example bringing in a new cancer professor and large group as the first step in our Cancer Research Plan. We have invested strongly in Research Platforms and Facilities, for example: MR Imaging, 4 new senior appointments including 2 physicists; Clinical Trials Unit, 2 Professors and expansion to 44 central support staff; Stem Cell Biology, 2 new senior academics. We have used BRU and other funds to invest in posts outside the School, for example in Bacteriology, Virology and Physics.

Integration of NHS-employed researchers. In 2011 we reviewed this area and launched a new NHS Partnership Initiative. This included making more Honorary University appointments of NHS researchers in a prestigious and rigorous new process and increasing their benefits by; enabling them to hold grants within the University and jointly supervise PhD students (including as lead where adequately qualified); liasing with the NHS Trusts to ensure they had appropriate numbers of Trust-funded research SPAs; involving them fully in the life of their Research Division and the University; and giving them access to our eJournals, research courses and events. We made 11 Honorary appointments from 2008-11 (before the change) and 48 from 2011-13 (after) and our Honoraries now include 17 Professors, 23 Associate Professors and 39 Consultant Lecturers.

Career development and support of the research work of staff. We revised our arrangements in 2009 to take advantage of our research success and further in 2011 to comply with the national Concordat to Support the Career Development of Researchers. In brief, researchers had an intensive individual research appraisal in 2009/10, then enhanced annual formative appraisals (jointly with NHS appraisers for clinical academics) under the University's Personal Development and Performance Review procedure. In these meetings, feedback on performance is given with internal and external benchmarking, and Personal Development Plans are developed. Our emphasis is on collegiate striving for excellence, with individuals given encouragement, skills and tools to improve. Initiatives for all researchers have included: ensured access via Professional Development to a wide array of courses, many on-line, with dedicated funding to support development needs; a rolling series of workshops on topics including grant writing, paper writing, adding impact to research, PGR student supervision, patents and commercialisation; a formative but compulsory internal peer review system for grant applications over £100K and Fellowships to disseminate best practice and increase success; a motivational financial reward system of returning a proportion of grant overheads and PGR student income directly to individual researchers and groups; a series of cross-disciplinary workshops and "sandpits" with pump-priming funding opportunities, held jointly with other Schools and Faculties; careers workshops with independent advice; and a mentorship programme for all staff outside their Divisional line management. As well, and with lower profile, we set up an intensive structured improvement programme for less successful researchers led by the Head of School: one third have left the University and two-thirds have improved their performance.

Promotions: We have a transparent formative promotions procedure including self-nomination, and many staff progress their careers with us. Since 2008 we have made 12 internal appointments to Professor and 10 to Reader, with a balance between clinical and non-clinical. Clinical academics are appointed to Associate Professor through external competition, but we recognise national issues with non-clinical academic career progression and have a policy of promoting talented staff internally, making 10 non-clinical promotions from Lecturer to Associate Professor since 2011.

Specific initiatives for early career researchers. We have two competitive internal Fellowship programmes for our best early independent researchers, the Nottingham Advanced Research and Anne McLaren programmes, and we guarantee Faculty positions after these. We run a mentorship programme matching promising non-clinical and clinical early career researchers with successful senior researchers from another Division. For clinical early career researchers we start integrated training through Academic F1 posts, and then offer Academic Clinical Fellow positions targeted at our areas of international strength with considerable success. For example from our large ACF programme in Gastroenterology >90% obtain externally-funded Research Fellowships, for which they move out of clinical training to complete a PhD. To encourage all specialties and capture brilliant young clinicians moving late to research, we have supplemented our externally-funded Clinical Research Fellowships with 27 Nottingham Fellowships, some from BRU funding. Our best

young clinical researchers move into either NIHR Academic Clinical Lectureships (ACLs) or matched University Lectureships. Of these, 60% have gained substantive senior research posts.

Initiatives to support equality and diversity. We have created an environment in which our staff are free from discrimination and recognise the value of diversity. Induction training is compulsory. We provide time and resource for staff to attend equality and diversity networks including our Carer's Network, our Black and Minority Ethnic Network and our Disability Network, and for female staff to attend the University's award-winning positive action programmes APPLE (Academics' and Administrators' Professional, Personal and Leadership Experience) and WAND (Women's Advancement Networking and Development). We provide support at School and University level for carer's leave, flexible working, career breaks and parental support and leave. In spring 2013, the University was awarded a Silver Athena Swan award (the third University in the UK to achieve this) and the School is developing a Silver Departmental Award application for spring 2014.

**ii) Postgraduate Research Students** Following the Nottingham Savill Review we have committed much resource and effort into PGR, increasing recruitment from 55 in 2008/9 to 81 in 2012/13. We now plan to attract further Doctoral Training Accounts from the NIHR, Research Councils, charities and industry, and offer 50% matched funding for this, as is our current model with our MRC DTA.

Effective and sustainable doctoral research training. Our PGR training involves supervision to a carefully monitored standard, a taught course modular element and moderated student meetings and research presentations. To encourage supervision across School and Faculty boundaries, every student has two formal supervisors and we encourage supervisors from different Schools by personal allocation of a generous proportion of fees. Stimulated by our BRUs, increased industry partnership studentships and MRC/BBSRC industry development studentships, we set up the Nottingham Translational Research PhD Training Programme (*N-trans*) and pump-primed it with BRU and internally funded non-clinical and clinical PhD studentships, including 27 newly-funded Clinical Research Fellows. This innovative PhD training programme covers laboratory and patient-based translational research and their interface. It combines a modular taught course, student-led supervisor-moderated sandpit events and research in a translational subject area. The taught modules cover generic, transferable laboratory and patient-based research skills, cross-disciplinary familiarisation, and pragmatic training in running translational research projects (clinical and non-clinical) as well as a broad range of generic and specialised training modules which can be studied online, in lectures or in residential placements. It features specific training in commercialisation (including patents) and working in and with industry. Students interested in further University research take part in a prestigious Researcher Development Programme. We now plan to add to our *N-trans* programme by creating similarly innovative focussed training in clinical trials (*N-trial*), epidemiology/Health Services Research (*N-epi*) and basic biomedical research (*N-base*).

Evidence of a strong and integrated research student culture. We regard PGR students as integral to our research, and their success as a good measure of vibrancy of research groups. Thus PGR student number, progress and satisfaction are overt criteria in senior academic appraisal and promotion. Students are active participants in all research meetings and their contributions are highly valued. They have ring-fenced funding for presentation at national/international research meetings, participate in a poster prize session (year 1), and a prestigious oral prize session (year 2) both widely attended by senior academics. Student representation in wider research matters is strong, through staff-student consultation and formal student representation. Our collegiate culture is evidenced by a high recruitment rate to our post-doctoral researchers from current students, a very high satisfaction rating in University surveys, and a strong 4 year PhD completion rate of 78%.

**d. Income, infrastructure and facilities**

We believe in physical co-location of groups to create critical mass, rather than creation of "virtual" structures. We have actively relocated research groups and built new facilities to fit this strategy. For example, we moved Gastroenterology and Hepatology and built their BRU to co-locate these groups with GI Surgery close to relevant wards and patients and to central GI-related laboratories. We moved Hearing Research and built the Hearing BRU to co-locate both these with Audiology Services. We built the Respiratory BRU to co-locate patient research facilities with clinical services,

close to the Respiratory laboratories. We moved our Clinical Trials Unit, NIHR Trent Research Design Services Unit and other research support into re-fitted joint space with the NUH NHS Trust R+D and research support services to create Nottingham Academic Health Science Partners.

Central laboratory facilities. Our flagship multi-disciplinary £23M Centre for Biomolecular Science with its Research Engines including Microbiology, Pharmacy/Molecular Therapeutics, Tissue engineering, Structural Biology and Chemical Biology, is built next to the Medical School to facilitate collaboration. Within the School, most laboratory work is housed in large bespoke laboratory areas and we have a yearly process of review, investment and refurbishment. For example we invested >£1M in oncology laboratories and equipment in 2013, in part to house a large group move from Bristol. At the City Hospital campus, all laboratory work except Oncology (for whom we have active plans for a central Hub) is co-located in our Clinical Sciences Building, which we have nearly doubled in size by building a large extension. Purpose-built laboratories at our Derby site are co-located in our new Medical School Building adjoining Royal Derby Hospital.

Technology Platforms and Specialised Equipment. Research Platforms in the Faculty of Medicine and Health Sciences are managed by Schools with unfettered access to all Faculty researchers. Laboratory Platforms include: Deep Sequencing (next generation sequencing); Flow Cytometry; and Advanced Microscopy, including single-cell imaging. The School manages Stem Cell facilities including the Tecan Robot, a bespoke robotic platform to culture human stem cells in a pharmaceutically-relevant format, and the first of its kind in the world. The School contributes to an inventory of specialist equipment “the kit catalogue” to allow easy access to it and its efficient use.

*[text removed from publication]*

Patient translational research facilities. We have built, staffed, and run our 2 BRUs, our Respiratory Translational Research Unit (£12M NIHR/NHS Trust/University) and our new Clinical Research Facility, a 6 bedded unit suitable for phase IIa research. This is co-located with and services our new Human MR Imaging Platform (MRC/Industry) with research-dedicated 1.5T and 3T magnets, and dynamic lung imaging facilities using hyperpolarised xenon. We make extensive use (particularly Gastroenterology and Neurosciences) of the high specification MRI facilities in the Sir Peter Mansfield Research Centre, in particular one of only two 7T systems in the UK.

Clinical trials facilities. We have expanded our Clinical Trials Unit (now 44 central staff) and re-located it in bespoke space in “Nottingham Healthcare Partners”. Trials are run from this hub and from spoke units embedded in the BRUs, Oncology, Stroke, Dermatology and Rheumatology.

Facilities for research students. We have dedicated PGR Centres with computing facilities, social space and private offices in our main campuses in the Medical School, City Hospital (refurbished 2013) and Derby. We have also (2013) greatly expanded and modernised our central study/library area in the Medical School and built a large modern student space for group study and facilities.

Cross-HEI shared use of research infrastructure. In 2011, Nottingham and Birmingham Universities signed a concordat to agree access to unique equipment items. For example, the Nottingham Digestive Diseases BRU and the Birmingham Liver BRU grant reciprocal access to immunotherapy facilities in Birmingham and MRI facilities in Nottingham. We have a tripartite concordat with Birmingham and Loughborough on access to high level imaging facilities. We have established an Olympic legacy National Centre for Sports and Exercise Medicine with Loughborough, Leicester and 3 partner NHS Trusts including a physical Centre on the Loughborough campus. Our ARUK Sports Injury and Osteoarthritis Prevention Centre with Loughborough and others accesses junior sports academies and elite athlete facilities. We have agreed joint registration of “kit catalogues” with Warwick, Birmingham, Loughborough and Leicester to optimise use and avoid duplication.

**e. Collaboration or contribution to the discipline or research base**

**Indicators of wider influence or contributions to the discipline or research base:** The School encourages its academics to take up national and international positions directly and indirectly related to research, as this helps embed research and its values at the highest level. For example

Sir Peter Rubin is seconded from Nottingham as Chair of the GMC. Nationally, Presidents/Chairs of Royal Colleges and Learned Societies include: Royal College of Ophthalmology (Dua), Pathological Society of GB and Ireland (Ellis); British Society of Gastroenterology (Hawkey); and British Nuclear Medicine Society (Perkins). We have 6 Chairs of Scientific or Research Committees of Royal Colleges/Learned Societies and many Committee Chairs, members, officers and examiners. Internationally, lead positions include: President, International Society for Research in Hydocephalus and Spina Bifida (Bayston); President, International Dermato-Epidemiology Association (Williams); President, European Association for Vision and Eye Research (Dua); President, European Society for Corneal and Ocular Surface Specialists (Dua); and Secretary-General of United European Gastroenterology (Atherton). School members sit on many international committees, boards and working parties, including for the WHO and the OECD High Level Group for security of medical isotopes (Perkins). They have organised many international research meetings, including a Gordon conference and major world conferences in Gastroenterology, Nephrology and Dermatology. We believe that academics should help drive clinical excellence and we contribute as: Chair, National Bowel Cancer Screening Advisory Board (Scholefield); Chair, National Co-ordinating Committee for Breast Cancer (Ellis); Chair, National Dermatology Specialist Interest Group (Williams), and Chair, National Trainee Selection Board in Surgery (Lund). School academics also serve on NIHCE Committees (9); Department of Health Advisory Groups, the Human Fertilisation and Embryology Authority (Young), the East Midlands LETB (Hall) and two NHS Trust Boards (Donnelly and Hall). We contributed to the quinquennial panel review of INSERM (Bordeaux) and the renewal of the Oxford BHF Centre of Excellence.

**Participation in the peer-review process:** Lead roles include: MRC Clinical Training Panel (Chair Hall); HTA Commissioning Board (Chair Williams), HTA Programme (Deputy Director Williams), RfPB Board East Midlands (Chair Williams, then Fortnum), National Dermatology Specialist Interest Group (Chair Williams). Three other School members sit on MRC boards/panels, 4 on HTA panels and 6 on NIHR panels. For charities, we contribute to panels for the Wellcome Trust (2), Cancer Research UK (5); Arthritis Research UK (Chair Doherty + 3), NC3Rs (3), British Heart Foundation, Crohn's and Colitis UK, Leukaemia and Lymphoma Research Fund, Asthma UK, British Society for Audiology, Action on Hearing Loss, Parkinson's UK, Multiple Sclerosis Society and Wellbeing of Women. We contribute to international funding boards and Research Councils in Norway, Finland, Hong Kong, Singapore and Kuwait. We serve on boards of the EU FP7, National Science Foundation (US), LAM Foundation (US) and various European charities. Most of us review for UK and international funding bodies and charities.

**Fellowships / Prestigious Awards** include: Stroke Association Professorship (the only one in the UK - Bath); Moynihan Fellowship, Association of Surgeons GB and Ireland (Lobo); McIntosh Professorship of Royal College of Anaesthetists (Hardman); 3 NIHR Senior Fellowships (Spiller, Hawkey, Bath); 3 HEFCE Senior Fellowships (Harrison, Evangelou, Sharkey). Pre/postdoctoral awards include: 13 MRC and Wellcome Training Fellowships at various levels (£2.4M); 5 NIHR Fellowships; and 17 other Fellowships (charities, RC's, FP7, Marie-Curie).

**Journal Editorships:** Within the REF period, our academics have been Editor in Chief of: Gut; Diabetes, Obesity, Metabolism; British J Anaesthesia; British J Ophthalmology; Nuclear Medicine Communications; Frontiers in Epigenomics; Platelets; European J Obstetrics, Gynaecology and Reproductive Biology; Nephron Clinical Practice; and several Cochrane Groups. Collectively, they serve as Associate Editors or on Editorial Boards of 46 titles.

**Collaboration, including both mechanisms and response to priorities and initiatives.**

**NHS and government agencies:** As described in Section b, in collaboration with our partner NHS Trusts, in 2009 we won 3 NIHR BRU's with £30M investment from NIHR, NUH NHS Trust and the University, an NIHR CLAHRC (mostly outside UoA1) and a tranche of large clinical trials. We also hosted the NIHR Trent Research Development and Support Unit. These joint University/Trust successes led us to form Nottingham Academic Health Partners to oversee governance of clinical research, to house our NIHR-supported CTU (£1.3M), and to interact with our newly-established Clinical Research Facility and our Human MRI Functional Imaging Facility. Outside the NHS, we have established a relationship with the MoD who currently fund our research into battlefield eye

injuries. We also house the MRC Institute for Hearing Research which partners us and the NUH NHS Trust in sponsoring and running our NIHR Hearing BRU.

**Public and patients:** Our public and patient initiatives have been transformed by our BRUs. On set-up, we organised Patient Advisory Groups co-ordinated by a Uni/Trust partnership-employed PPI facilitator and overseen by a Patient Advisory Panel. Patient Advisory Group members receive dedicated training, advise on BRU strategic direction, and help with induction of research staff, web page design, lay funding reviews and volunteer education/recruitment. 137 patients and members of the public have been actively involved since 2008. Good practice stretches beyond our BRUs, and includes: our LAM (pulmonary fibrosis) action groups, our Cystic Fibrosis research and our Evidence-based Dermatology, which co-ordinates national James Lind alliance agenda setting.

**Industry:** The University is regarded nationally as a leader in industry partnership. With our new Business Engagement and Innovation Services Directorate and Business Development Executives embedded in Schools, we have capitalised on opportunities created from our investments. For example, our Digestive Diseases BRU has attracted £12M industry funding and Respiratory Medicine have a major role in the £6M MRC/ABPI COPD consortium, the £2M ERICA TSB COPD Consortium and lead the NIHR Office for Clinical Research Infrastructure (NOCRI) Translational Research Partnership in Respiratory Inflammatory Diseases (HTA £1.8M). We won £1.3M MRC + matching industry money to set up our new Human MRI Imaging Facility in the Medical School and established hyperpolarised lung imaging within it through an EPSRC/industry collaboration. We won a BBSRC Industrial Partnership with Industry (£1.3M) for Stem Cell Biology to create cellular models for drug testing. Our current Cancer Initiative was started by a £5.2M industry partnership in stratified treatment and many of our most influential clinical trials are industry-funded; for example our trials leading to the registration of Fulvestrant and our current cancer trials on DNA vaccines, anti-cancer antibodies, and anti-IGFR therapy. Industry collaboration has helped drive our *N-trans* PhD training programme, which includes modules on commercialisation and industry partnership, and following our success with industry-partnered clinical trials we now plan a similar *N-trials* PhD training programme. Our major industry partners include Roche, AstraZeneca, Novartis, GSK, Pfizer, Fresenius AG, Gambro, AMGEN and Janssen, but we also work closely with SMEs, many housed in “Biocity”, a sponsored incubator based in Nottingham which has been seen as a national exemplar. In particular, we sponsor new product partnerships with SMEs, for example: a uterine manipulator for laparoscopic surgery (Pennine Healthcare); novel gut transit MRI markers (ViVOSmart Medical Devices and NHS R&I); BioCornea for corneal regeneration (Aeon Astron Europe); GMP grade media for stem cell banking (CellnTech) and a novel skin peel biologic (X-BioCell Ltd). We also have a successful policy of spinout for investment, often retaining partnership on exit for continuing development and profit, and our nationally-acknowledged profile in this area attracts industry partners. Our academics are encouraged to interact with industry by taking up board membership/consultancies and we provide protected time for such activities within job plans if it is registered with us. This enables a co-ordinated overview of our industrial opportunities to allow strategic planning and rapid response to priority HEI/Industry calls.

**International:** We have built a reputation as a global University through our campuses in China (Ningbo) and Malaysia and active offices in Brazil (with Birmingham), India and west Africa. We lead many multi-national clinical trials, for example in Stroke (MRC ENOS, HTA TICH-2, HTA TARDIS; across 5 continents, 23 countries, 173 sites), Oncology (including FALCON- endocrine therapy for breast cancer; 150 centres) and Dermatology, where we co-ordinate the International Federation of Dermatology Clinical Trials Network**. Collaborations with European HEIs** (>50) are particularly strong. Notable examples of successful EU-funded partnerships include: the FP7 Ubiopred Consortium in chronic asthma (20 EU partners, €23M); Euro-HYP-1 to test hypothermia (€11M); FP7 for anti-HCV Mab development (€4.9M); the TINN/TINN-2 neonatal trials (€0.3M); AIDPATH Digital Pathology €3.1M), long-term effects of early nutrition in later health (€13.6) an FP7 COST Award on corneal regeneration (€5m across Europe); Cacade-Fellows, an FP7 Marie-Curie EU post-doctoral training programme including Asian and US HEIs, co-ordinated by us (€15M). European industrial funding includes for trialling a medical device for diabetic foot ulcers n with European partners funded by a Danish company (£2M). **Collaborations beyond Europe** include ~56 HEI partners, many in North America including Harvard, Yale, Cornell, Michigan,

Bethesda and Montreal. Examples of US-UoN collaborative projects include (among many others): VEGF expression and regulation (>£1M from MRC, BHF, BBSRC); evaluating models of influenza transmission (EMIT) study (~$11M from US CDC); neural stem cells in MS (4 joint publications with Thomas Jefferson University since 2010). We collaborate on access to tissue banks, offering ours and accessing others including two for NIH-supported RCTs for early cancer detection. Recent new ventures in China, Brazil and India, include studies on the link between psychosocial stress and digestive health, on 3D obstetric ultrasound imaging, and on 4D GI tract imaging.

**National:** We work in partnership with other Universities as lead and co-applicant to combine our areas of international excellence and thus increase our competitiveness. We actively seek out the most suitable partners for specific initiatives, but look early to Birmingham (formalised link between Universities), and to Leicester and Loughborough (East Midlands regional partners). The musculoskeletal area has been particularly successful: MRC/ARUK Musculoskeletal Ageing Centre with Birmingham; ARUK Centre for Sports Injury and Prevention (6 HEIs); and the National Sports and Exercise Medicine Centre (East Midlands). We have had many other high level partnerships, for example: with Imperial College London (lead) and our School of Pharmacy (UK Regenerative Medicine Platform MRC/BBSRC/EPSRC, £4.6M to Nottingham; BHF initiative on stem cell therapy in cardiac disease "Mending Broken Hearts", £7.5M); with Exeter Control Engineering Department (MRC/EPSRC £1.5M for respiratory modelling); with Birmingham liver BRU (joint governance and working with our Digestive Diseases BRU); with Birmingham CTU (several RCTs including FoxTRot - Fluoropyrimidine, Oxaliplatin and Targeted-Receptor pre-Operative Therapy for patients with high-risk, operable colon cancer); with Leicester (UK BiLEVE study, MRC and SpiroMeta consortium for large-scale GWAS studies of lung function); with Loughborough and Keele (EPSRC Doctoral Training Centre for Regenerative Medicine, for training engineers and physical scientists to research regenerative medicine). We have responded to national biobank initiatives, being one of 4 core centres comprising the National Breast Cancer Biobank and we are the first large scale user of the UK National Biobank (for asthma genetics, MRC £3.4M).

**Within the University of Nottingham but outwith the School of Medicine:** As described in section b, collaboration with the best researchers throughout the University has been a cornerstone of our research strategy. As well as our close partners in Life Sciences, we have established interdisciplinary collaborations with Chemistry, Mathematics, Engineering and Physics, particularly the Sir Peter Mansfield Magnetic Resonance Centre. Specific initiatives have included: our 2 supervisor PhD model (encouraging one from outside the School); embedding ourselves in our £23M Centre for Biomedical Sciences, next to the Medical School and where many of our Research Engines are based; and a series of cross-disciplinary workshops and "sandpits" with attached pump-priming funding opportunities, held in partnership with other Schools and Faculties. This strategy has allowed us to build on our success. For example, the Digestive Diseases BRU has partnered with Physics to win MRC funding for non-invasive imaging of gastric function to identify the causes/diagnose functional dyspepsia (call from the British Society of Gastroenterology and the International Rome Foundation); and with virology, to win funding for a community-based study to detect early liver disease (priority call from the Chief Medical Officer). Outside the BRUs, collaboration with Physiology, human MRI imaging and Clinical Psychology helped us win the ARUK National OA Pain Centre (£2.5M) which kick-started our other successes in this area.