Institution: University of Manchester

Unit of Assessment: 1 Clinical Medicine
(Returned staff members are shown in bold, those in other UoA, honorary or former staff in italics)

a. Overview

This Unit of Assessment reports on 150 staff (136.9 FTE) working in major disease areas of Cancer, Cardiovascular Medicine, Human Development, and Inflammation and Tissue Repair, at the University of Manchester (UoM). The mission of staff returned in this UoA is to carry out world-class research spanning from discovery science to translational research in clinical settings to maximise impact in clinical application. Clinical Medicine research in Manchester gains added value from a strong environment of interdisciplinary and cross-Faculty collaboration, supported by a series of initiatives to enhance this.

Highlights of achievements since 2008

Key targeted recruitments to enhance research focus

32 of the 150 staff returned have been recruited since RAE 2008. Key appointments include:
Crow (2008) Chair in Clinical Genetics; **Woolf** (2009) Chair in Paediatric Science; **Cooper** (2010) Director, Centre for Advanced Discovery and Experimental Therapeutics (CADET); **Farrow** (2010) Chair in Molecular Pharmacology; **Jacobs** (2011) Dean of Faculty of Medical and Human Sciences (FMHS); **Hussell** (2012) Director, Manchester Collaborative Centre for Inflammation Research (MCCIR); **Lisanti** (2012) Director, Breakthrough Breast Cancer Research Unit; **Marais** (2012) Director of CRUK Manchester Institute (CMI); **Townsend** (2013) Associate Dean for Business Engagement; **Keavney** (2013) Director, Institute of Cardiovascular Sciences; **Moncada** (2013) Chair of Translational Medicine; **Cossu** (2013) Director-designate for Centre of Regenerative Medicine; **O'Byrne** (2013) Chair in Respiratory Medicine; **Allen** (2013) Chair in Allergy; **Papadopoulos** (2013) Chair in Paediatric Allergy; **Edmondson** (2013) Chair in Gynaecological Oncology.

Outputs

Over 3,000 peer-reviewed papers were published in the REF period of which more than 80 were in elite journals (*NEJM* (16); *Lancet pubs* (14); *Cell pubs* (12); *BMJ* (3); *Nature* (9); *Science* (3); *Nature pubs* (24). Grant income totalled £194m during 2008-2013, compared to £108m during the period 2001-2007, with an increase in new awards of 64% in 2012-13 compared to previous year. Programme-level funding includes 50 grants of over £1m, and 81 5-year grants (CRUK, NIHR, Wellcome, FP7, MRC, NIH, Breakthrough), and a total of £75m industrial funding.

Cross-sector interdisciplinary collaborations (2008-date)

Manchester Academic Health Science Centre (MAHSC), established 2008 and currently short-listed for redesignation, is central to our integration of translational research in UoA1 with NHS healthcare priorities. Further details are given below.
Manchester Collaborative Centre for Inflammation Research (MCCIR, established 2013): a unique £15m collaboration between UoM (involving Faculty of Life Sciences (FLS) and Faculty of Medical & Human Sciences (FMHS)), and AstraZeneca and GSK, for pipeline molecular targets.
NIHR Greater Manchester Collaboration for Leadership in Applied Health Research and Care (GM CLAHRC, 2008**,** renewed 2013): a £10m contract from NIHR, with matched funding of £10m from NHS partners, involving UoM with 20 Greater Manchester NHS Trusts, with a focus on cardiovascular disease management in primary and community care.
NIHR Biomedical Research Unit in musculoskeletal disease established between UoM and Central Manchester University Hospitals NHS Foundation Trust (CMFT) in 2012.

Research management improvements

The *Faculty Research Deanery* was established in 2011 to provide a flexible support service for academic research staff, especially to support larger scale grant applications. The Research Deanery works closely alongside the Faculty Research Support Service, with a designated research strategy coordinator working with each of the Research Institutes returned in UoA1.

Research business support is provided by an integrated operational structure of 20 Research Support Managers and Research Finance Managers. The *Fellowship Academy* was initiated in 2012 to develop training and fellowship support to increase the attractiveness and success of fellowship career paths. *Core facilities* such as imaging and genomic technologies have been strengthened and integrated with FLS (UoA5) for added value. The impact of each of these developments is described in more detail below (sections c and d).

Infrastructure

- UoM has invested £750m in capital since 2004, including state of the art laboratories embedded within the £600m new hospital build for Central Manchester University Hospitals NHS Foundation Trust (CMFT).
- Other major building programmes during the REF period include the AV Hill Building (£40m), Biological Services (animal) Facility (£30m) and Michael Smith Building (£35m), providing directly linked world-class facilities on the CMFT/Central University Site, and which are shared by the staff of FMHS and FLS to maximise inter-disciplinary research.
- Three Clinical Research Facilities for experimental medicine and early phase clinical studies were awarded NIHR funding (£12.5m) in 2012 after co-ordinated submissions through MAHSC.

b. Research strategy

Our Strategy

Our aim is to translate basic biomedical discoveries into effective diagnostics and therapies, and examples of this work are provided in this document and in our impact case studies. To do this, along with our partners, we have created an environment where clinicians, scientists and industry work together in a large-scale multidisciplinary research environment, with research facilities closely linked with the clinical setting.

- We aim to carry out research extending from identification of fundamental mechanisms of disease to the development of new diagnostic tests, investigation of therapies and diagnostic approaches, and evidence-based innovation in medical care. The strategy of UoA1 is based on major themes identified as priority areas, which are outlined below and have targeted recent and continuing recruitment of outstanding individuals, and which focus future investment.

- Cross-disciplinary integration of research activities has been a priority during the REF period, and collaborative environments have allowed researchers from FMHS to interact extensively with those in FLS, with staff from both Faculties sharing laboratory space and core facilities. A regular fortnightly research forum was initiated in 2013 to develop new strategic initiatives between FLS and FMHS staff. Pump-priming of new cross-discipline and cross-Faculty research consortia has been supported through the Faculty Research Deanery and Faculty Research Office, with funding from the Wellcome Trust Institutional Strategic Support Fund (ISSF, £1m pa), the MRC Confidence in Concept scheme (£0.5m in 2013), and a £1.5m Research Innovation Fund was established that supported 3 new cross-Faculty research programmes in 2013.

- Cross-sector organisations have facilitated clinical translation of research, including CLAHRC and MCCIR, above. Manchester Cancer Research Centre (MCRC, established 2006) is an integrated research and education partnership of the CRUK Manchester Institute (CMI, previously Paterson Institute for Cancer Research), the Institute of Cancer Sciences, NHS, CRUK and AstraZeneca. MCRC incorporates the CRUK Lung Cancer Centre of Excellence (jointly with UCL), the CRUK Translational Cancer Medicine Centre and the CRUK Cancer Imaging Centre. Manchester: Integrating Medicine and Innovative Technologies (MIMIT) is an international affiliate of CIMIT®, Boston USA, and collaborates with hospitals and GP practices to develop and apply latest technology to clinical problems. Achievements include: 7 Manchester/Boston collaborations; £1.4m direct and £4.4m follow-on investment; £11.3m venture capital investment.

Our Structure

- Important organisational and structural changes have been completed during the REF period to facilitate our mission of developing first-class research in Clinical Medicine from discovery

science through to effective clinical translation. Six key themes have been identified as areas of research strength and clinical relevance where we have focussed investment and recruitment of outstanding new academic staff. These themes are Cancer, Cardiovascular Sciences, Human Development, Inflammation and Repair, Mental Health, and Population Health. These themes now structure the research organisation of FMHS and align with the clinical domains of MAHSC and organisation of research in our partner Trusts; the first four of these are represented in UoA1.

The **University of Manchester** (UoM) *Manchester 2020* strategic plan, published in 2011, permeates all levels of the organisation to drive strategic investment at Faculty and Research Group level. UoM comprises 4 Faculties: FMHS; Life Sciences (FLS); Engineering and Physical Sciences; and Humanities. Staff returned in UoA1 are part of FMHS.

The Dean of FMHS, **Jacobs**, has led a major reorganisation to align FMHS with MAHSC (below) and maximise inter-sector collaborations. The new Faculty structure now comprises a matrix of five professional Schools (Medicine; Dentistry; Nursing, Midwifery & Social Work; Pharmacy; Psychological Sciences) and six Faculty Research Institutes, four of which are returned in UoA1 (see next section). In addition to this strategic structuring of research strengths, five cross-cutting themes have been established to address some of the 'grand challenges' for health and medicine in the 21st century. These are: Ageing and the Life Course, Health and Social Inequalities, Prevention and Screening, Stratified and Personalised Health, and Global Health. Academic staff in UoA1 are involved in each of these to develop future impact of their research.

Manchester Academic Health Science Centre (MAHSC) is central to our integration of translational research and NHS healthcare delivery. It is one of five DoH-designated AHSCs, the only such AHSC outside the south of England. The University is a key MAHSC partner along with Central Manchester University Hospitals NHS Foundation Trust (CMFT) (>1m patients pa, hosting specialist regional and national centres, for example pancreas transplantation, lysosomal storage disease treatment), Salford Royal NHS Foundation Trust (SRFT) (major e-health resource with 1^{o} and 2^{o} records for >500k patients, hosts Greater Manchester Academic Health Science Network), Christie NHS Foundation Trust (largest cancer centre in Europe, leading in early-phase clinical trial capability), University Hospital of South Manchester NHS Foundation Trust (>570k patients pa; hosts regional heart-lung transplant centre). Each hospital site has undergone major development and new building since 2008, with embedded University accommodation for groups undertaking translational research. MAHSC comprises six domains, namely cancer, cardiovascular, human development, inflammation and repair, mental health and population health. These map directly onto the Institute structure and strengths of the Faculty and reflect priority areas for investment and development. The first four of these six domains provide the clinical and interdisciplinary context for the research groupings described in UoA1.

Research groupings

INSTITUTE OF CANCER SCIENCES (Lead **Kitchener**) 46 staff returned

Infrastructure

- The world-class (CRUK peer-review assessment, 2010) CRUK-funded CMI (£12m pa) supports basic and translational research and drug development (one of two national CRUK Drug Discovery Centres). The new MCRC building (£28m new build, funded by UoM, Christie, CRUK, Wolfson, UKRPIF) opens in 2014 and will house clinical and laboratory research staff (150 staff with a £30m commitment to recruit 23 new investigators). The Wolfson Molecular Imaging Centre (WMIC), a part of the Centre for Imaging Science (UoA5), is located here and houses the outstanding (Leukaemia & Lymphoma Research peer review 2013) cancer proteomics facility.
- The Christie Hospital is one of the largest cancer centres in Europe, treating over 40k patients per year. It is the first UK centre to be accredited as a comprehensive cancer centre and delivers over 100k radiotherapy treatments annually. Known internationally for its pioneering radiotherapy facilities the Christie has been selected as one of two national centres to deliver Proton Beam Therapy for patients across the UK.
- The MCRC (est 2006) is a partnership between the Christie and MAHSC partner trusts along with

the CMI and University research institutes (FMHS and FLS). MCRC delivers a cross-disciplinary approach by nurturing/embedding the interdisciplinary environment required to bridge the translational gap between research and clinical delivery. The MCRC partnership successfully bid for £12m from the UK Research Partnership Investment call, £8.4m of which is for state-of-the-art equipment. The CRUK Lung Cancer Centre of Excellence jointly with University College London and the CRUK Imaging Centre of Excellence jointly with Cambridge (£9m) exemplify the MCRC's ability to deliver national priorities. The MCRC paradigm influenced the development of the national CRUK Cancer Centre Scheme, and it became an accredited CRUK centre in 2010.

Translational Impact

The integration of laboratory science with clinical research facilities has created a state of the art early phase cancer unit providing patients with access to experimental therapy within carefully conducted trials. As a result there has been a 60% increase in availability of new drugs to cancer patients since 2008. 4,000 volunteer patients are currently engaged in 70 phase I (20% of patients recruited nationally) and 130 phase II cancer trials (32% of patients recruited nationally) over the last three years. 200 clinical studies are currently open on the site. This has led to:

- annual commercial trial income of £4m (doubled within the last four years), with on-going clinical trial programmes with AstraZeneca, Novartis, Roche, Abbott Laboratories, and GSK;
- 71,000 samples from 5,280 patients treated in early phase trials and 2,600 patient tissue samples collected through an extensive biobanking infrastructure involving four large teaching hospitals in Greater Manchester (1,000 new samples added per annum);
- the biobank (housed in the CMI) provides a rich reservoir of tumour samples for research essential for the molecular characterisation of tumours and for drug discovery programmes;
- biomarker analysis has been completed on 110 clinical trials. 75 different assays have been validated to Good Clinical Practice for Laboratories, providing an 'off the shelf' menu for appropriate deployment in trial protocols;
- potential drug applications in development including the embedded Drug Discovery Unit currently working on 6 new drug compounds.

People

28 of the investigators in this group are clinician scientists. Grant income was £63.7m in the REF period ((£1.2m/FTE returned), including CRUK Programme grants held by Birch, Illidge, Jones, Marais and Saha, and a CRUK Centre grant by Marais.

Key achievements include: Women's Cancer: **Kitchener:** decreasing morbidity in endometrial cancer, HPV testing for cervical cancer screening (*Lancet 2009; Lancet Oncol 2011*); **Howell:** endocrine therapy using tamoxifen, fulvestrant and anastrozole for patients with breast cancer (*Lancet Oncol 2010*); **Bundred:** decreasing morbidity in breast cancer patients receiving aromatase inhibitors (*Lancet Oncol 2009*); **Lisanti:** the Reverse Warburg Effect (*Cell Cycle 2009*); Haematological Malignancies: **Saha**: Improving outcome of childhood acute lymphoblastic leukaemia (*Lancet 2010*); **Lacaud** and **Whetton**: insights into haematopoiesis (*Nature 2009, Nature 2009*); **Somervaille**: Identification of new targets for therapy in AML (*Cancer Cell 2012*); Stem Cell Biology: **Lemischka**: genetics of LEOPARD syndrome (*Nature 2010*); Personalised Therapy: **Marais**: mechanisms of secondary skin cancers in melanoma (*NEJM 2012*). Several international collaborations have had impact in this period, eg. **Blackhall** (*NEJM 2013*); **Saha** (*NEJM 2012*); **Hawkins** (*NEJM 2013*); **Radford** (*NEJM 2013*); **Lorigan** (*NEJM 2010, 2011*); **McCabe** (*Nature 2012; Cell 2013*); **Byers** (*Nat Med 2012*).

Examples of cross-disciplinary work in this period include: **Renehan** with **Clayton** (Human Development) (*Am J Epidemiol 2012*); **Jayson** with *Waterton* (Centre for Imaging, UoA5) (*JMRI 2013*); **Dive** with *Williams* (Pharmacy, UoA3) (*Mol Can Ther 2013*). The (CRUK) Translational Cancer Medicine Centre (CRUK Prize for Translational Research 2011 award, **Dive**, **Ranson**, **Blackhall** and *Hughes*) is an exemplar of effective integration of clinicians, scientists and industry to deliver research directly to the bedside. This MCRC development incorporates the early chemotherapy centre (£35m from CRUK, Christie Charity, DoH, AstraZeneca) and new laboratories meeting Good Clinical Laboratory Practice standards at the CMI. The Manchester

Experimental Cancer Medicine Centre (CRUK funded and renewed in 2011, £2.5m) has been the first to demonstrate prognostic biomarkers in small cell lung cancer (*JCO 2011*); and identify circulating biomarkers in SCLC (*JCO 2012*).

INSTITUTE OF CARDIOVASCULAR SCIENCES (Lead **Keavney**) 13 staff returned

Infrastructure

- This Institute is smaller than others in UoA1 but is planned to grow; it has major strengths in cardiovascular physiology, cellular heart failure research, genetics and stroke. UoM has committed to develop the Institute with the recruitment of **Keavney** in 2013 as Institute Director and five planned Chair appointments to develop capacity and strength in cardiovascular science and translational medicine**.** This recruitment is being supported with new laboratory space at a cost of £3.5m (completion January 2014);
- MAHSC partners (CMFT and UHSM) host tertiary cardiothoracic services for a catchment of 3.5m people, and UHSM hosts one of the 6 national cardiothoracic transplantation centres. Together these represent the largest clinical cardiovascular resource affiliated with a single University in the UK;
- The Primary Angioplasty service is provided collaboratively between CMFT and UHSM sites, and is the largest in the UK conducting ~1,200 acute MI cases/year. This has facilitated recruitment to many interventional cardiology multicentre trials, with largest recruitments in the UK (eSelect; PROTECT) or in the world (INFUSE-AMI) for some studies (*El-Omar, Chowdhary, JAMA 2012*);
- Greater Manchester Comprehensive Stroke Centre (GMCSC, the first comprehensive stroke centre in the UK) provides hyperacute stroke care, with the largest patient catchment in the UK. The Stroke Group has clinical research space co-located with the NIHR Hyperacute Stroke Unit at SRFT;
- Five year, £10m contract from the NIHR for GM CLAHRC with matched funding of £10m from NHS partners, 2008-13 (renewed 2013-18) focuses on cardiovascular diseases.

Translational Impact

- PMCA4 as a key molecule in cardiac remodelling and heart failure in experimental models (**Cartwright**, **Oceandy,** *JBC 2011*);
- Identification of effect of PMCA4 deficiency on male mouse fertility. PMCA4 is now undergoing Manchester-led trials as a potential male contraceptive pill;
- The ACT-NoW study (*Bowen, UoA4*, **Tyrrell**, *BMJ 2013*) of speech therapy following stroke incorporated in the 2012 national clinical guideline for stroke (*Lambon-Ralph,* UoA4);
- CLAHRC Stroke theme (**Tyrrell**, *Boaden,* UoA19) post stroke assessment tool adopted across the NHS with services commissioned specifically for delivery;
- Role of interleukin-1-mediated inflammation in tissue damage following stroke (*Rothwell*, *Allan,* UoA5), with IL-1Ra now in ongoing phase II trials in subarachnoid haemorrhage (MRC) and ischaemic stroke (Stroke Association) (**Tyrrell,** *Allan, Rothwell,* UoA5).

People

Grant income in the REF period was £23.1m (£0.8m/FTE returned), external personal awards total >£5m, including: BHF Chairs in Cardiac Physiology (**Eisner**), and Cardiovascular Medicine (**Keavney**); BHF Senior Basic Science Fellowship (**Trafford**); BHF Intermediate Basic Science Fellowships (**Dibb**, **Oceandy**); and BHF Intermediate Clinical Fellowships (*Venetucci*, *Greenstein*). Programme Grants: 4 BHF (**Kitmitto**/**Trafford**, **Boyett/Dobrzynski**, **Eisner**, **Keavney**), and MRC (*Neyses*/**Cartwright**/**Oceandy**). Institute staff published over 600 papers in the REF period more than 60% were in top ranked general or specialty journals. The Institute has a long-term focus on basic research with translational focus in heart failure and arrhythmia, cardiovascular genetics, translational vascular biology, and stroke.

Key achievements: Heart Failure and Arrhythmia Research (MRC, Gates, BHF) **Cartwright:** Pak1 as a novel therapeutic target for the prevention of left ventricular hypertrophy (*Circulation 2011*); **Oceandy**: identification of role of Rassf1 in left ventricular hypertrophy (*Circulation 2009*); **Cartwright:** discovery of PMCA1 and PMCA4 in heart failure (see above); **Eisner**

catecholaminergic polymorphic ventricular tachycardia (*Circ Res 2010*); **Trafford** remodelling of atrial t-tubules (*J Mol Cell Cardiol 2013*). *Neyses*: use of a first-in-class myosin ATPase activator with clinical benefit (*Lancet 2011*); Cardiovascular Genetics: **Keavney:** first GWAS study of congenital heart disease (*Nat Genet 2013*); **Keavney**: first definition of genome-wide copy number variants in congenital heart disease risk (*Am J Hum Genet 2012*); Translational Vascular Biology: **Heagerty** and *Greenstein*: role of perivascular adipose tissue in small artery function (*Circulation 2009; JACC 2013*); Stroke Research*:* Stroke and vascular research in Manchester is cross-disciplinary, from experimental work through to early clinical, rehabilitation and implementation studies. Experimental studies in stroke led by *Rothwell* and *Allan* (UoA5), translational work based at the GMCSC, led by **Tyrrell** with *Tyson* (Nursing, UoA3), *Bowen* (Psychology, UoA4) and *Boaden* (Manchester Business School, UoA19); Cardiovascular outcomes research: **Mamas** demonstrated the importance of access site selection in determining mortality in primary PCI (*Heart 2012*), and that early PCI after thrombolysis in STEMI improves mortality (*Eur Heart J 2010*, incorporated in European guidelines); *Bridgewater* (MAHSC Chair, Consultant Cardiac Surgeon at UHSM) has a national leadership role in promoting transparency in healthcare outcomes.

Examples of cross-disciplinary work include: **Boyett** with *Zhang* (Physics & Astronomy, UoA9) on computer modelling of atrial tissue (*J Mol Cell Cardiol 2012; J Physiol, 2013*); **Cartwright** with *Wang* (FLS, UoA5) on role of Pak1 in cardiac hypertrophy (*Circulation, 2011*); **Tyrrell** with *Rothwell* (UoA5) on translational work in stroke (as above, eg *Int J Stroke, 2011*).

INSTITUTE OF HUMAN DEVELOPMENT (Lead **Black**) 38 staff returned

Infrastructure

- New hospital buildings (£600m) on the CMFT site, with embedded translational research laboratories, including St Mary's Hospital, Royal Manchester Children's Hospital (one of the largest children's hospitals in Europe), Manchester Royal Infirmary, and Manchester Royal Eye Hospital, opened together in 2008. Houses Manchester Centre for Genomic Medicine, MCGM, and proteomics/metabolomics (CADET, Centre for Advanced Discovery and Experimental Therapeutics);
- AV Hill Building (£40m), opened 2008 next to CMFT campus, houses joint FMHS/FLS laboratory work, including the cross-faculty Centre for Nuclear Hormone Receptor Research;
- Nowgen, a centre of excellence in patient and public involvement (detailed below);
- National centres and commissioned services: close interaction with the National Centre for Screening and Prevention of Familial Cancer Syndromes, the National Centre for Cleft Research (Healing Foundation), Tommy's Maternal and Fetal Health Research Centre (one of 3 Tommy's Centres, ~£2m in period), and the Willink Biochemical Unit, for care of children with inherited metabolic disease, including lysosomal storage diseases; research programmes within the Institute have led to nationally commissioned services for neurofibromatosis (*Clin Canc Res 2009*) and congenital hyperinsulinism.

Translational Impact

- High throughput translational platforms in genomic medicine have enhanced diagnostics for rare diseases though gene discovery (**Evans**, **Newman**, *Nat Genet 2013;* **Crow**, *Nat Genet 2012*); breast cancer prediction has developed with population based approaches (**Evans**, PROCAS trial), leading to NICE guidelines; in diabetes, corneal confocal microscopy has been developed to assess diabetic neuropathic complications (**Malik**, *Diabetes Care 2010*);
- The congenital cataract service will be supported from late 2013 by analysis of 113 genes in each patient; 200 exome-sequencing reports for retinal disease (105 genes each, ie 30,000 gene reports) are now being issued per year (**Black**, *J Med Genet 2012*);
- CMFT is second largest recruiter to NIHR CRN trials in 2012-13 (16,000 patients recruited, 277 studies), facilitating and informing the clinical translation of research findings (eg **Evans**, *J Med Genet 2009*; and see impact case studies);
- New research-based clinics allow targeted assessment and intervention for high risk pregnancies and fetal growth restriction (**Heazell**, *PLoS One 2012*), and link nationally commissioned services (lysosomal storage disorders, NF1, NF2; see impact case studies, **Bigger**, **Evans**). CMFT is main site for the trial of Aldurazyme as a therapy for mucopolysaccharidosis type I, leading to

FDA and EMEA approval. More than 10 of these rare diseases are now treatable, improving longevity and quality of life (**Bigger**, *J Pediatr 2009*);
- CADET was established in 2011 as a metabolomics resource with the recruitment of its Director (**Cooper**) to support novel diagnostics in diseases such as pregnancy complications (eg **Myers**, *Mol Cell Proteomics 2013*).

People

Grant income was £39.7m in the current REF period (£0.9m/FTE returned). Programme grant funding includes awards to **Wu** (EU FP7), **Sibley** (MRC), **Davis** (Wellcome), **Hanley** (Wellcome Senior Clinical Fellowship), **Ray** (Wellcome Seeding Drug Discovery), **Black** (Fight for Sight), **Boulton** (NIH), and **Malik** (JDRF International Scholarship). Of the Principal Investigators returned in this group, 22 are clinically active. Staff in Human Development published a total of over 850 papers in the REF period.

Key achievements from the group are: Genomic Medicine: **Crow**, gene discovery implicating genetic factors in complex autoimmune disease (*Nature 2011, Nat Genet, 2009-12*); **Black**, gene discovery in ophthalmic disease (*Nat Genet, 2012*); **Newman**, **Evans**, gene discovery underlying tumour predisposition (*Nat Genet*, 2013); Endocrinology & Diabetes: **Wu**, definition of male ageing and reproductive health (*NEJM 2010*); **Ray**, role of nuclear receptor Rev-Erbalpha in inflammatory response and clock biology (*PNAS, 2012*); **Davis**, discovery and analysis of dynamic cycles of pituitary gene expression (*PLoS Biol, 2011*); Child Health: **Clayton**, definition of new genetic causes of short stature (*Am J Hum Genet, 2009-11*); Women's Health*:* **Sibley**, placental adaptations to fetal growth demands (*PNAS, 2010*); Ophthalmology: **Bishop**, role of complement factor H in macular degeneration (*J Immunol, 2013*).

Examples of new integrative cross-disciplinary or cross-faculty work include: **Davis** with *M White* (UoA5) and *Rand* (Warwick: stochastic modelling of gene expression, *PLoS Biol*, *2011*); **Hanley** with *Ferrer* (Imperial, transcriptomic analysis of human pancreas, *Cell Metab, 2012*); **Ray** with *Loudon* (UoA5, role of Rev-erb in circadian gating of inflammation, *PNAS, 2012*); **Sibley** with *Constancia* (Cambridge, placental-specific knockout physiology, *PNAS, 2010*); **Westwood** / **Aplin** with *Case* (Bristol, nanoparticle signalling across placental barrier, *Nat Nanotech, 2011*). Industrial collaboration with GSK has led to assessment of novel nuclear receptor ligands in physiological response to inflammation (**Farrow**, *Blood, 2011*, *PNAS 2012*).

INSTITUTE OF INFLAMMATION AND REPAIR (Lead **Woodcock**) 53 staff returned

Infrastructure
- Based on three teaching hospital Trust sites across Greater Manchester (UHSM, CMFT, and SRFT), allowing integrated research, teaching and learning within NHS settings;
- Key UoM partner in the £15m Manchester Collaborative Centre for Inflammation Research (MCCIR), directed by **Hussell** and jointly funded by GSK, AstraZeneca and UoM, with academic staff returned in UoA1 and UoA5 (FLS);
- NIHR Biomedical Research Unit in Musculoskeletal Research (2012, £6.3m, below).

Translational Impact
- NIHR BRU in musculoskeletal disease established between UoM and CMFT in 2012, one of 3 musculoskeletal BRUs in the UK. The BRU leads in 7 research areas, with the theme of 'Treating arthritis right: first time': Prevention of disease, complications of treatment (**Worthington,** *Nat Genet 2012, 2013*); Prevention of co-morbidity (**Symmons**, *Ann Rheum Dis 2013*); Inflammatory arthritis in adults (**Barton,** *Nat Genet 2013*); Inflammatory arthritis in children (**Thomson,** *Nat Gen 2008*); Risk assessment in patients with rheumatoid arthritis and SLE (**Bruce,** *Ann Rheum Dis 2012*); Evaluating new therapies and interventions (**Felson,** *JAMA 2013*); Non-genetic biomarkers (**Freemont,** *BMJ 2009*).
- Salford Lung Study (2012) built around the informatics linkage between primary care, pharmacy and hospital care in Salford. Informatics system developed by NWeHealth. GSK funded (£30m) planned to guide new drug development in chronic lung disease (**Singh,** *Lancet 2012*).
- MRC Stratified Medicine Initiative in Rheumatoid Arthritis £5.9m, 2013 (**Barton**)

- MRC STELAR consortium (UK Asthma cohorts) in allergy in asthma; £1.5m, 2013 (**Custovic**).
- MRC Clinical Pharmacology & Therapeutics Clinical Training Programme (with Liverpool) £3m, 2011 (**Griffiths**).
- EU Integrated approaches to Food Allergy and Allergy risk Management (iFAAM); €9m, 2013 (*Mills*).
- NIHR Investigation and Management of Psoriasis Associated Co-morbidiTies (IMPACT); £2.1m, 2012 (**Griffiths,** *Br J Dermatol 2013*).

People

Research grant income was £67.7m in the current REF period (£1.0m/FTE returned), including Programme grants to **Custovic** (MRC), **Smith** (MRC) **Griffiths** (NIHR/MRC), **Thompson** (NIHR, BBSRC), **Hamdy** (Wellcome Trust), **Barton** (MRC).

Key achievements from the group include: Musculoskeletal Medicine: **Worthington**, identification of new genetic loci involved in rheumatoid arthritis (*Nat Genet 2010*); Respiratory and Allergy: **Woodcock**, new therapy in asthma care (*Thorax 2011*); **Custovic**, definition of peanut allergy and tolerance in children (*J Allergy Clin Immunol 2010*), **Smith**, predictors of cough in airway disease (*Am J Resp Crit Care Med 2013*); **Denning**, management of fungal sensitization in severe asthma (*Am J Resp Crit Care Med 2009*); Gastrointestinal Sciences: **Hamdy**, novel treatments for dysphagia in stroke (*Gastroenterology 2008-12)*; **Thompson**, brain-gut axis response to food (*Gastroenterology 2012*); **Whorwell**, insights into functional gastrointestinal disorders (*Gut 2012*), **McLaughlin**, gut cell signalling in response to inflammation (*PLoS Pathogens 2013*); Dermatological Sciences: **Griffiths**, treatment of severe psoriasis (*NEJM, 2010*); **Rhodes**, role of vitamin D in sun damage (*BMJ 2009*); Regenerative Medicine: **Hoyland**, use of mesenchymal stem cells with novel hydrogels for regeneration of intervertebral disc (*Biomaterials, 2008*); **Freemont**, definition of the role of skeletal maturity in sports injury (*BMJ 2009*); Immune Mechanisms: **Hussell**, understanding macrophage phenotype in inflammatory response (*Nature Immunol, 2011*).

Examples of integrative cross-disciplinary or cross-faculty work include: **McLaughlin** with *Grencis* (UoA5) in gut immunology (*PLoS Pathogens, 2013*); **Griffiths** with *Kielty* (UoA5) impact case study on basis of skin-care treatments (submitted in REF3); **Hamdy/Thompson** with *Williams* (UoA4) on brain-gut axis (*Gastroenterology, 2009*).

c. People, including:

i. Staffing strategy and staff development

Recruitments

Since 2008, 20 professorial appointments aligned with major areas of strength in the new Faculty structure have been made and along with those previously described, include: Cancer: **Lemischka** (from Mount Sinai); Cardiovascular Sciences: new positions being established, with 5 professorial appointments planned in the coming year; **Trafford** (BHF Senior Fellow) promoted to Chair, developing work on remodelling of cardiac extracellular matrix; Human Development: professorial appointments included **Hanley** (from Southampton) to develop a new programme on human developmental biology, subsequently awarded a Wellcome Senior Clinical Fellowship; **Crow** (from Leeds) to develop clinical genetics, identifying genetic links with autoimmune disease such as lupus; Inflammation and Repair: **Raychaudhuri** (from Harvard) in Musculoskeletal Disease group, to bring further expertise in the genetics of rheumatoid arthritis; **Cossu** (from UCL) to lead MRC-funded Regenerative Medicine initiatives; **Farrow** (from GSK) to integrate the Manchester Centre for Nuclear Hormone Research; **Bignell** (from Imperial) to bring expertise in drug resistance in fungal disease; **O'Byrne** (from McMaster) to further work on novel mechanisms of inflammatory triggers in airways disease; and **Allen** (from Melbourne) to develop further research in food allergy.

NHS partnership

Partnership with the NHS is essential and integral to our vision. Over 75 academic staff in UoA1 hold clinical contracts, and all major research themes are embedded within the key teaching hospital sites of Greater Manchester, as described above. NHS staff hold honorary appointments

reflecting engagement with UoM research development as well as UG and PG teaching, and have been actively promoted to Honorary Reader or Chair positions. Over 540 honorary clinical staff are currently affiliated to research work in UoA1, including 41 Honorary Professorships (4 in Cancer Sciences, 10 in Cardiovascular Sciences, 12 in Human Development, and 15 in Inflammation and Repair). Since 2011 we have created MAHSC Professorships, to recognise and reward excellence and leadership among NHS clinical colleagues, and 20 such promotions were awarded to NHS consultants affiliated to UoA1 during 2012 and 2013. **Sibley** is Research Director of MAHSC.

Staff development

Retaining and supporting staff is core to our central philosophy of nurturing, developing and promoting excellence. In the 2013 UoM staff survey, 97% of academic staff in FMHS reported that UoM was a good place to work. Over 93% of academic staff across UoA1 have undergone annual appraisal in the last academic year, and since 2012 all academic staff are offered a more detailed annual performance enhancement interview, offering a positive focus on how to develop grant income and publication outputs. Mentoring is supported through the Manchester Gold programme available to all UoM staff. Staff on this programme are matched to an experienced colleague, who acts as their career mentor. Evidence of our emerging mentoring culture can be seen in the involvement of UoA 1 staff in this scheme 2008-2011 there were 33 partnerships with 11 involving staff in UoA1; in 2012 there were 17 partnerships with 10 involving UoA 1 staff; in 2013 15 out of the current 30 partnerships involve UoA 1 staff.

Early career researchers

All junior staff in FMHS choose both a supervisor and a mentor from among the senior faculty in consultation with their Head of Institute. Supervisors have a more active role in the appointees' research activities, while the mentor assumes a pastoral role. All junior academics are required to enrol into the **New Academics Programme.** This 18-month programme includes a series of workshops taken by senior academics and experts in the field from other universities. The focus is on research excellence, inspirational teaching and personal development particularly in leadership and management. 37 academics from UoA1 are either taking part in, or have completed, this programme. There are opportunities to tailor the programme according to previous experience. A further **Research Team Leaders Programme** is now being run in FMHS from 2012-13, to facilitate academics who are starting new and ambitious programmes of activity. Of the 30 academics currently enrolled on the programme, 40% are from UoA1. From Cohort 1 (started Nov 2007), UoA1 staff on the programme subsequently won grants of >£17m.

Fixed Term Researchers

UoM recognises the vital supportive role played by fixed term researchers and their vulnerability with regards to career progression. Research staff on fixed term contracts/fellowships receive advice and support to sustain and develop their academic careers through performance and development reviews and mentoring schemes. The University runs an annual Research Staff Conference under the leadership of *Lambon-Ralph* (UoA4), designed to teach skills in presentation and research impact. It provides the opportunity for staff to interact with early career researchers who have recently achieved a career milestone.

UoM Careers Service, was voted best in the UK for three years running by the Association of Graduate Recruiters and Barker's Graduate National Media Audit. It provides up-to-date information and networking opportunities to research staff from across the University; and has developed a *Concordat Implementation Plan* to support career progression of research staff (recognised by the European Commission with a Human Resource Excellence in Research Award). The annual "Pathways" event supports delegates in career choices, exploring future plans and discovering the breadth of opportunities available to them through discussion with PhD graduates from a wide range of job sectors. The "An Academic Career" website, a comprehensive guide to working in higher education, was the winner of the **THE 2011 Award for Outstanding Support** for Early Career Researchers. *Vitae*, funded by RCUK, champions the personal, professional and career development of doctoral researchers and research staff in HEIs and research institutes. The University participates in the Careers Research Online Survey to find out the views of research staff and, as part of the *Concordat Implementation Plan*, has improved research staff representation on UoM committees. A Faculty Research Staff Handbook is

distributed to ensure that all staff are aware of the support available.

Training and Intermediate Fellowships
During the REF period externally funded *Training Fellowships* have been awarded from MRC (6) and Wellcome Trust (4). Six *Clinician Scientist* awards have been received from MRC (**Dixon**, **Smith**) and NIHR (*Crosbie*, **Horsley**, *Kirwan*, **Myers**). *Intermediate Fellowships* have been awarded from Wellcome Trust (**Lennon**), BBSRC (**Harris**) and BHF (**Dibb,** now a Lecturer, *Greenstein*, *Venetucci)*, Action Medical Research (**Mills,** now Lecturer in Nursing, UoA3), with MRC Career Development Awards to *Clark* and **Dilworth** and a MRC NIRG to **Piper-Hanley**. NIHR SLs include **Chinoy**, **Warren**, *Young*. Stepping Stones Fellowships (£4.6m) were instituted in 2006 to pump prime young researchers. 16/24 Stepping Stones fellowships have been in UoA1 from 2006 to date, 5 currently in scheme and 8 now externally funded (NIHR, BHF, ARUK and MRC). Our Faculty *Fellowship Academy* programme is supported by the Wellcome Trust Institutional Strategic Support Fund (ISSF, £1m pa). Recent successes following Academy mentoring and interview preparation include MRC Career Development Awards to *Clark*, and training fellowships from MRC, Wellcome Trust, Asthma UK, Fulbright Fight for Sight. UoM has provided £3m support for a range of schemes including a one-year bridging funding for clinicians who wish to undertake a PhD and an International Scholars Programme to fund researchers wishing to acquire new skills in an overseas facility. The Faculty also conducts clinics and provides guidance over applications. Junior fellows have been supported for laboratory visits to NIH, Stanford, Mt Sinai, Baylor, and others, and these have led to successful external funding applications as stated above. UoM received the **2011 Scopus Fostering Young Researchers Institutional Award** from the US-UK Fulbright Commission and Elsevier, based on UoM's number of highly-cited Early Career Researchers.

The specific linking of the Research Institutes within UoM and the Domains of MAHSC, and close collaboration with the North West Deanery, provides an ideal environment for the development and growth of Integrated Clinical Academic Training). 13-17 Academic Clinical Fellow posts and 10 Clinical Lecturer posts (5 NIHR funded and 5 matched) posts are offered annually. 70% of ACFs progress onto PG research degrees and CLs to research fellowships or senior academic positions. Of the first 28 ACFs who have completed the programme there are 19 PhDs, 2 MDs, 5 MPhils (BRC, WT, MRC, NIHR, CRUK BHF). 23 CLs completed the programme: 8 Clinical Senior Lectureships, 13 Fellowships (BHF; NIHR; WT; MRC; CRUK; Canadian Fellowships) and 2 have returned to clinical practice.

Equality & Diversity
The University is committed to advancement of equality in employment and career development for its staff. This is a key element of our annual performance review and equality data monitoring and action planning is embedded into annual performance reviews. This includes monitoring and identifying actions in relation to recruitment, current staff profile and promotion. At present across FMHS, 50% of female and 33% of male applicants for Chair promotions were successful (63% for both male and female promotion applications at all levels). Of the current FMHS Senior Leadership Team, 4 of the 11 Institute and School Directors are female. 95 staff have completed Equality and Diversity training, which is an essential requirement for sitting on interview committees. UoM holds the **Disabled Two Ticks Symbol**, showing that the employer is committed to employing disabled people and has a guaranteed interview scheme for disabled job applicants who meet the essential job criteria. UoM is one of a small group of institutions that is part of the Equality Challenge Unit's Black and Minority Ethnic Systemic Change Pilot and is undertaking career development initiatives in relation to recruitment and mentoring. UoM is actively involved in the Athena SWAN charter that promotes the advancement of women in Science and Engineering. All four Institutes in UoA1 were awarded Bronze status (Sep 2013, leads *Hampson L*, **Kitmitto**, **Symmons**, **Westwood**), part of the strategy for the University as a whole to attain a Silver award by 2015.

ii. Research students
FMHS Graduate School coordinates graduate training, and supports 42 Taught Masters courses and 13 Research Masters. In UoA1, Research Masters courses offered include topic specific courses in Cardiovascular, Tissue Engineering, Maternal and Fetal Health, Genetic, Cancer and

Clinical Research (DoH Funded Fellowships for Nurses, Midwives and Allied Health Personnel) and the MRC-funded interdisciplinary Translational Medicine MRes. The Faculty invests >£330k annually in PhD studentships, with UoM holding a greater proportion of industry-academic doctoral training partnerships than any UK HEI (2012 ABPI survey, 'Enriching Research, Training Scientists'). The **President's Doctoral Scholar** awards provide further institutional investment of £2.5m, securing outstanding PhD students (9 currently in UoA1). We are one of 3 UK Universities to offer a multidisciplinary PhD in Systems Biology. In UoA1, c100 postgraduate students complete their degrees each academic year, with 295 current PhD students, including 14 current CASE studentships. Examples of technology development from recent industrial CASE students include identification of new non-steroidal glucocorticoid receptor ligands (*Trebble*, *J Cell Sci, 2013*, with **Ray** and **Farrow**, through collaboration with GSK), and development of novel peptide enrichment methods using iTRAQ (*Potier*, *Anal Chem, 2012*, with **Whetton**, through collaboration with Philips). PhD completion rates within 5 years are >80%. Over 50% of students recruited to our RCUK studentships are drawn from complementary disciplines (chemistry, physics, computer science, materials.

Support has been received from several national Doctoral Training schemes including:

- RCUK studentships, in conjunction with FLS; UoA1 intake of 69 students since 2008, £4.2m;
- MRC Clinical Pharmacology and Therapeutics training programme, with University of Liverpool;
- BBSRC-funded Centre for Integrative Mammalian Biology, operated between UoM (FMHS, FLS) and University of Liverpool;
- BHF 4-year PhD studentship scheme, renewed 2012.

The Manchester Doctoral College provides governance of PhD training at University level. Within FMHS, the **Graduate Society**, launched in 2012, hosts public engagement activities and external speakers, enhancing networking opportunities. **Centres for Doctoral Training (CDTs)** have been established in a number of areas relevant to UoA1 including nanoscience and musculoskeletal research. CDTs aim to develop capacity in research skills shortages in which the Faculty has international repute ('systems approaches', 'health informatics', 'pharmacogenomics'). Each PhD student has a supervisor, co-supervisor and advisor who meet with the student at fixed points each year throughout their programme. Progression and support for postgraduate researchers is provided through **eProg**, an online system that maps each student's training programme, flags key assessment milestones and allows continual supervisory feedback. The system has been commercialised and since contracted to three further UK HEIs. A 'New Supervisor' course introduces supervisory policy and good practice in recruitment, managing student-supervisor relationships and supporting career development. All new supervisors act as co-supervisor alongside an experienced academic prior to holding primary supervisory responsibility. *Supervisor Awareness Training* workshops are held in each Institute covering new developments and essential topics such as recruitment, supervisor student relationships and dealing with failing students. Through scheduled meetings, all researchers have the opportunity to discuss and plan their career. For PhD students this is through formal progression monitoring (see eProg below); for research staff it is through the performance and development review process. Where a need for additional training or support is identified, this is organised by line-managers/supervisors and success reviewed at subsequent review meetings.

d. Income, infrastructure and facilities

Income

Over the period 2008-2013, staff in UoA1 generated £194m in income from new research awards, compared to £108m during the period 2000-07. Specific major funding awards are detailed above in the context of the four Institutes. Income during 2008-2013 averaged £0.8m-1.2m per FTE academic staff returned in the four groupings described here. In the past year there has been over 60% increase in new research grant awards, which is not yet reflected in research spend.

Infrastructure and facilities

UoM has invested £750m in capital since 2004 to provide a 21st century research environment. A second phase of major investment of £1bn over the next ten years, part funded by a £300m public

bond, includes relocating all of the University on to the main campus and creating a new Biomedical Campus with complete refurbishment of the existing Stopford Building (Medical School), and a new health centre for staff and students. UoM is a partner in the N8 Research Partnership, involving the 8 most research intensive universities in the North of England, with the aim of maximising the inter-institutional collaboration across the region. Examples of N8's assets and activity relevant to UoA1 include the asset database, with MR and PET imaging facilities in Manchester (see below), the collaborative translational work in Regenerative Medicine (Regener8 consortium, with funding from TSB, BBSRC, EPSRC), and integration of major NMR facilities (RESON8). The Dean of FMHS, **Jacobs**, also led the recent creation of the Northern Health Science Alliance, bringing together the 8 largest research active universities and NHS Trusts in the north of England, to foster increasing inter-institutional collaboration in biomedicine.

With the goal of delivering high quality translational research in clinical medicine, we have concentrated on developing integrated health, teaching, research and innovation campuses linked to the NHS. This strategy has been developed throughout Manchester with a strong emphasis on economic regeneration, science and enterprise. We have worked to the strengths of the individual hospital Trusts to create research-active hubs that are dynamically linked as outlined below.

University campus

Research staff in UoA1 who are based on the University campus work in 4 new or refurbished buildings interconnected by bridge links: the **Core Technology Facility**, the **Stopford Building,** the **AV Hill Building** and the **Michael Smith Building**. A £3.5m refurbishment is currently being completed to open an additional floor in the AV Hill Building with facilities for MCCIR and the Institute of Cardiovascular Sciences.

CMFT campus

FMHS is directly adjacent to the CMFT hospitals site. A major building programme completed in 2009 resulted in a one-site campus for the CMFT hospitals complex, which includes **Royal Manchester Children's Hospital** (RMCH), **Manchester Royal Infirmary, St Mary's Hospital,** and **Manchester Royal Eye Hospital**. Embedded research space houses major University centres, for example Genomic Medicine, Women's Health (including Gynaecological malignancies) and Paediatrics and Child Health. The site hosts the 2012 NIHR Wellcome Trust Clinical Research Facility (£5.5m), including the Children's Clinical Research Facility (winner of Pharma Times Clinical Research Site of the year in 2013. The campus hosts the **Nowgen Centre**, a centre of excellence in public engagement and education (detailed below).

Christie Hospital campus

The **Christie Hospital** has a new £38m clinical treatment centre, housing the largest early clinical trials unit in the world and the biggest chemotherapy facility in the UK opened in 2011. This centre forms the core of the recently accredited MAHSC Clinical Trials Unit, available to all researchers across the region. The new £28m translational research facility (Manchester Cancer Research Centre, MCRC) will open on the Christie site in summer 2014. This facility, funded by CRUK, Christie Hospital, Wolfson Foundation, UKRPIF and UoM, is focused on developing teams of clinical, basic and translational researchers to develop and deliver new personalised cancer therapies. This is complemented by the 2012 NIHR Clinical Research Facility for Experimental Medicine (£4.5m) also based at the Christie Hospital. The CRUK Translational Cancer Medicine Centre situated at the Paterson Institute for Cancer Research has facilitated the development of biomarkers and attracting pharma, increasing the availability of new drugs for patients. The Proton Beam Therapy unit, a £250m NHS investment to be shared with UCLH, will establish this advanced radiotherapy treatment at the Christie, which is currently only available abroad.

South Manchester campus

Our third NIHR Clinical Research Facility (£3.4m), located here, is the largest clinical trials unit for Early Phase Asthma and COPD studies in the UK. The Nightingale and Genesis Breast Cancer Prevention Centre has the largest Family History Clinic in Europe and is conducting the NIHR-funded PROCAS study trialling prediction of breast cancer risk. This centre is closely linked to the Breakthrough Breast Cancer Unit at the Christie and the Centre for Genomic Medicine on the

CMFT campus. The National Aspergillosis Centre and Regional Mycology Laboratory are based here and work closely with the researchers in RMA.

Salford campus

SRFT has recently completed a £200m modernisation. **NorthWest EHealth** is a major health informatics partnership between UoM, SRFT, and Salford Clinical Commissioning Group, and has led to the incorporation of 1m anonymised patient records, including prescriptions, correspondence, test results and patient assessment notes, into its new EPR system. The software allows GPs to control the recruitment of their patients into clinical research, and permits researchers to analyse anonymised population level health record data. This underpins the Salford Lung Study (£30m, **Woodcock**), investigating novel interventional therapy in patients with chronic lung disease within a community-based study. The Dermatology units for Psoriasis Research and Photobiology (NIHR/MRC/industry) are based here, and interact with the Photon Science Institute on the central campus.

Cross-faculty research facilities

Core facilities

The **Biological Services Facility** (animal house), jointly run by FMHS and FLS, is one of the largest and most sophisticated University animal facilities in the UK, with a recent £30m extension and refurbishment. The BSF houses 1300m^2 dedicated barrier housing for transgenic rodents, with 4,500m^2 conventional multi-species animal housing. It is a key resource for the BBSRC-funded NorthWest Centre for Integrative Mammalian Biology. Other **biological core facilities**, many operated jointly with FLS, include bioimaging, bioinformatics, biomolecular analysis, electron microscopy, flow cytometry, fast reaction, fly facility, genomic technology, histology, macromolecular crystallography, NMR facility, protein purification, xenograft and transgenic facilities, and statistics. Continuing development is ensured by embedding research groups with a particular focus in technology around a facility (e.g. Stem Cell and Applied Proteomics Laboratory within the proteomics facility at WMIC (below), at the Christie Hospital campus.

The **University Library** is one of the five UK National Research Libraries, with 41,000 electronic journals and 500,000 electronic books, the largest collection of electronic resources of any UK library. Adjacent to the Library is the Alan Gilbert Learning Commons, a dedicated learning and study centre, open 24/7 to all students, and the FMHS Graduate School Hub offers private study and interaction space to research students, based in the Stopford Building.

Institutes

CRUK Manchester Cancer Institute is one of 6 core-funded CRUK institutes. The Institute houses 15 core funded researchers and 10 researchers from the Institute of Cancer, 9 with clinical responsibilities. It is contiguous with the Christie Hospital. Research capacity will almost double with the completion of the new MCRC in 2014.

Manchester Institute of Biotechnology (MIB), situated on the North Campus in the city centre, incorporates researchers from all 4 Faculties, working on advanced quantitative approaches in biotechnology. The MIB facilitates the establishment of flexible multi-skilled interdisciplinary teams with critical mass in computational biology, systems and biotechnology research.

The **Biomedical Imaging Institute** (BII) is a cross-Faculty University resource established in 2008, with the strategic aim to develop the university's expertise across a range of biomedical imaging areas, from preclinical research through to patient imaging within partner NHS trusts. It is part of the joint (with Cambridge) CRUK Comprehensive Cancer Imaging Centre (£5m). This will develop novel imaging biomarkers, based principally on advanced MR and PET imaging, through preclinical and validation studies into clinical translation. Major imaging and computing facilities dedicated to research include the £26m **Wolfson Molecular Imaging Centre** (WMIC) which houses both human and animal PET and 1.5T Philips MR imaging capabilities. There is a 3T Philips scanner in the Wellcome Trust Clinical Research Facility, and a 3T Philips human scanner sited at SRFT with a 7T animal imaging system on the Central site. 76% of the total membership of the BII (687 staff) are within FMHS, with particular interests of staff in UoA1 focussed on cancer, cardiovascular, and musculoskeletal and pulmonary imaging.

Other cross-Faculty Centres
The **Centre for Integrated Genomic Medical Research** provides genetic epidemiology expertise, laboratory facilities and access to biological samples from well phenotyped patients recruited through large longitudinal studies and manages extensive DNA collections including the UK DNA Banking Network for the MRC, and with University of Liverpool houses the UK DNA Archive for Companion Animals.
Centre of Excellence in Biopharmaceuticals is an interdisciplinary research centre part-funded by the European Regional Development Fund and the North West Regional Development Agency to enhance academic drug development. This facility has state of the art robotic technology available for biopharmaceuticals companies to stimulate more rapid, consistent and improved production of biopharmaceuticals.
The **Nowgen Centre** is a partnership between CMFT and UoM, a centre of expertise in Patient and Public Involvement and Engagement, and delivers educational activities for schoolchildren, patient groups and general public, in addition to UoM and NHS Trust staff. The centre delivers laboratory workshops to over 6,000 students and 650 teachers in the NW as well as providing courses for over 500 scientists, researchers and clinicians per year. Nowgen is part of a pan-European consortium that has secured over €7m from the Innovative Medicines Initiative Call 3: Fostering Patient Awareness on Pharmaceutical Innovation to develop the EUPATI project (European Patient Academy on Therapeutic Innovation).

Research governance policy and practice
Principles, standards and regulation of good practice surrounding the conduct of research are governed by the University's Code of Good Research conduct. The Research Governance and Integrity Team is responsible for developing and monitoring University policy and providing guidance and support to researchers in the area of research governance, integrity and ethics. The process is overseen at executive level by a University Associate Vice-President who is also an advisor to the Health Research Authority (HRA) and member of the HRA Collaboration & Development Steering Group. The UoM Good Research Practice web site provides advice and information for staff and students.

At Faculty level a Research Practice Coordinator and two team members work closely with the Faculty Training Team to deliver a number of training sessions on NHS ethics, University ethics and research governance to postgraduate researchers, research staff and academic staff. The Faculty provides on-line Good Clinical Practice (GCP) training to staff, in conjunction with CMFT. The MAHSC Research Office functions to harmonise research management and governance procedures between partner Trusts and FMHS.

e. Collaboration and contribution to the discipline or research base

Supporting research collaboration
UoA1 has a wide range of mechanisms to support and encourage collaborative research, including the overarching University of Manchester Research Institute, which provides seed-corn funding (approx. £1m pa) to support new inter-disciplinary collaborations.
NHS collaboration: this is specifically supported by MAHSC (for example the MAHSC Clinical Trials Unit, at Christie Hospital) and academic staff in UoA1 are heavily involved in NHS clinical care in Greater Manchester. There is extensive collaboration with NHS Research and Innovation: University academics from UoA1 head the Research & Development offices of each Trust (**Sibley** at CMFT, *Ray (S)* at UHSM, **Radford** at Christie and **Ollier** at SRFT); several academic staff hold key roles in management of CLRNs: **Clayton** (Dir: Greater Manchester NIHR Medicines for Children Research Network and Assoc Dir GM CLRN, the latter has a £15m budget, with 50,000 participants recruited into 850 studies, and is in the top 2 recruiters in UK; other UoM academic staff involved as Local Specialty Group leads include **Bundred** (Cancer), **Custovic** (Respiratory), **Griffiths** (Skin & wound healing), **Herrick** (Immunology & Inflammation), **McLaughlin** (Gastrointestinal), **Newman** (Genetics), **Symmons** (Musculoskeletal), **Tyrrell** (Stroke).
Industrial collaboration: major industrial-research collaborations include strong links with GSK and AstraZeneca (for example MCCIR (above), including long-term secondment of Farrow from GSK to UoM), and the Salford Lung study), and the AZ Alliance. Spin-out companies currently active

include *Karus* (**Townsend**) *Myconostica* (**Denning**), *Phagenesis* (**Hamdy, Thompson**), *Vibio* (**Hampson**), *Renephra* (*Brenchley*), *CG Ceutics* (**Griffiths**), *Gelexir* (**Freemont**), *Iduron* (**Gallagher**), Cellular Therapeutics (**Hawkins and Gilham**) *Phototherapeutics* (acquired by Photomedix for £13m in 2009); *IF Sensing* (*Brenchley*), and *Curapel* (*Gibbs*). 273 Disclosures have been made since 2008, with 16 Priority Patent Filings, and 6 Licence agreements.

Other examples of scientific collaboration that have led to scientific advance are given in the document, with specific examples relevant to each grouping (section b), together with some of the structures and mechanisms that have been introduced to promote this (sections c and d).

Contributions to discipline and research base

Of the 150 staff returned in UoA1 59 have received prizes or awards and 14 hold senior fellowships, including 9 NIHR Senior Investigators. Examples are given below of contribution to national and international collaborative work. Over 60 staff are involved in UK or international peer review, and over 50 hold clinical or scientific leadership roles. Key examples include:

Representation in UK and international peer review:

Bishop: MRC Training Fellowship Panel (2011-); **Boulton:** NIH external advisory board for DCCT/EDIC studies, USA (2008-13); **Crow**: MRC Molecular & Cellular Medicine Board (2012-); **Davis**: MRC Population & Systems Medicine Board (2008-13); BBSRC Integrative & Systems Biology panel (2010-14); INSERM review group for Aeres, France (2013); **Denning**: Wellcome Trust Expert Review Group on Pathogen Biology & disease transmission, ad hoc member 2013-); **Dive**: CRUK Science Committee; CRUK Biomarker Expert Review Panel (chair); **Eisner**: Academy of Medical Sciences, sectional committee (2009-); BHF fellowships committee (2006-11); REF UoA5 panel member (2010-); Flanders (Belgium) Research Council (2012-); Portuguese Foundation for Science & Technology Evaluation group (2008-10); **Hagan**: CRUK Biological Sciences Committee; **Hanley**: MRC Training Fellowship Panel (2012-); NIHR postdoctoral fellowship panel (2008-11); Wellcome Tust clinical fellowship interview committee (ad hoc member 2012); EU Innovative Medicines Initiative panel on drug-induced liver injury (2010-11); UK Stem Cell Network Advisory Board (2008-12); **Hawkins**: MRC Molecular & Cellular Medicine Board; Swedish Academy Sciences, Medicines of the Future grant committee; **Illidge:** CRUK Clinician Scientist Committee (chair); CRUK Clinical Training & Development Board; **Keavney**: MRC Training Fellowship panel (2005-08); BHF Fellowships committee (2008-12); **Kitchener**: CRUK Science Committee and CRUK CTAAC (chair, 2009-2012); **Lacaud**: CRUK Biological Sciences Committee; Human Frontier Science Program (HFSP) review committee; **Jones**: CRUK Chief Scientist; Marie Curie Funding committee; Scientific Advisory Boards, member: Gurdon Institute Cambridge, International Agency for Research on Cancer, CRUK Executive Board; **Malik**: MRC Developmental Pathway Funding Scheme Committee; Juvenile Diabetes Research Foundation Medical Research Committee; **Malliri**: AICR Scientific Advisory Committee; **Marais**: CRUK Science Funding Committee; Member CRUK Scientific Advisory Board (vice chair), CRUK Biological Sciences Committee; **Nelson**: NIH O'Brien Urology Center grants review board (2008-09; co-chair, 2013); NIH Cardiovascular ion channels panel (chair, 2010); **Ogilvie**: CRUK Drug Discovery Expert Review Panel; **Ray**: MRC Training Fellowship Panel (vice-chair, 2012-); **Saha**: Leukaemia Lymphoma Research Review Panel; LLR site visit member; **Thompson**: Wellcome Trust Physiological Sciences panel; **Trafford**: BHF project grants committee (2011-14); **Tyrrell**: Chair, Stroke Association Research Awards Committee (2012-); NIHR HTA Advisory panel (2008-13); **White**: MRC Studentships Committee (chair 2008-12); MRC Training and Career Group 2010-11; Senior Fellowship panel, Health Research Board, Ireland, 2012.

Specialist society and clinical or scientific leadership roles

Boulton: Europ Assoc for Study of Diabetes, President (2011-14); **Clayton**: Soc Endocrinol Council (2008-12); Eur Soc Paed Endocrinol, Council (2012-) and Chair, Corporate Liaison Board; Int Growth Hormone Res Soc, Council (2008-12); co-author NICE Guidelines, use of GH in children, 2010; **Davis**: Society for Endocrinology Clinical Committee, member (2011-14); **Eisner**: European Federation Physiological Societies, President (2011-); Int Soc Heart research (President-elect, 2011-)**;** IUPS International Scientific Programme Committee (chair); **Griffiths:** President, International Psoriasis Council 2013; **Heagerty**: British Hypertension Society, President

(2011-13); International Society of Hypertension, President (2008-10); BHF Council member (2004-10); International Society of Hypertension Scientific Committee (2008); **Heazell**: International Stillbirth Alliance Board member (2011-); **Illidge:** NCRI Clinical and Translational Radiotherapy Group (chair); Roy Coll Radiol, National Academic training lead; International lead for Radiotherapy guidelines in Non Hodgkin Lymphoma; **Keavney**: International Scientific Advisory Board, UK Biobank (2008-); **Myers**: NICE Hypertension in Pregnancy quality standards expert group (2013); **Ray**: Society for Endocrinology, General Secretary (2012-15); **Rhodes:** President, European Society for Photobiology, 2013-2015; **Rutter**: NHS Islet transplantation taskforce (2010-); **Saha**: International BFM Study Group Resistant Disease Committee (chair); NCRI, CCL Leukaemia Subgroup (chair); **Sibley**: International Federation of Placenta Associations, President 2008-12; **Symmons:** Chair UKCRN National Musculoskeletal Specialty Group (2009-); **Trafford**: Federation of European Laboratory Animal Science Associations working group (2010-); **Tyrrell**: NICE Acute Stroke Guideline, Clinical lead (2006-08); RCP Stroke Programme, Associate director (2008-); **White**: Society for Endocrinology, Council member (2012-15); **Woodcock**: British Thoracic Society, President (2012-13).

Other new awards and prizes to academic staff since 2008
Fellows of Academy of Medical Sciences: **Cooper**, **Denning**, **Griffiths**, **Woodcock;**
EMBO Fellows: **Hagan**, **Labib**, **Marais;**
Fellows of Society of Biology: **Davis**, **Day**, **Neyses**, **Rhodes**, **Whetton**, **White**;
Fellow of Royal College of Obstetricians and Gynaecologists *ad eundem*: **Sibley**.

Barton Michael Mason prize, Brit Soc Rheumatol, 2008; **Boulton** Harold Rifkin Award Am Diab Assoc, 2008; **Bruce** Sydney Watson Smith Lecture, RCP Edin 2013; **Clayton** Eur Soc Paed Endocrinol Research Award lecture 2010; **Cooper** World-class New Zealander award for Biotechnology & Medicine, NZ govt, 2008; **Davis** British Society for Neuroendocrinology Annual Lecturer 2009; **Dive** Pasteur-Weizmann/Servier International Prize 2012; **Dixon** Linacre Lecture, RCP, 2013; **Felson** Lifetime achievement award, Osteoarthritis Research Society International; **Forbes** Gábor Than award in Placentology, Int Fed Placenta Assocs, 2012; **Griffiths:** American Skin Association Lifetime Achievement Award 2008; Hellerstrom Lecture, Karolinska, Stockholm 2010; **Heazell** William Blair Bell memorial lectureship, RCOG, 2011; **Heagerty** Pfizer prize, Int Soc Hypertension, 2010; **Hyrich** Michael Mason prize, Brit Soc Rheumatol, 2011; **Jones** Gibb Fellowship 2011; **Jordan** Fellow RSC; **Labib** Hooke Medal, British Society for Cell Biology 2010; **Marais** AACR Team Science Award 2012; Society for Melanoma Research Estella Medrano Memorial Award 2011; **Myers** William Blair Bell memorial lectureship, RCOG, 2009; **Nelson** Fellow of Biophysical Society; **Paus** Paul Langerhans prize 2008, ADF; **Ray** Clinical Endocrinology Trust Lecturer 2014; **Sibley** Australia Lectureship, Phys Soc 2008; Dawes Lectureship, Fetal & Neonatal Physiol Soc 2010; **Thompson**: Arthur Hurst Memorial Lecture and Prize 2009; **Vestbo** Prize of honour, Danish Respiratory Soc 2010; Christensens award, Danish Med Assoc 2012; Odd Fellow Order (Denmark) research prize 2013.

Senior Fellowships:
Hanley Wellcome Trust Senior Clinical Fellowship; **Marais** Wellcome Trust Senior Fellowship;
Saha Wellcome Trust Margdarshi Fellowship; **Trafford** BHF Senior Fellowship.
NIHR Senior Investigators include: **Black**, **Bruce**, **Bundred**, **Evans**, **Griffiths**, **Jacobs**, **McCollum**, **Symmons**, **Thompson**, **Woodcock.**

Journal Editorships:
Boulton Associate Ed, *Diabetes Care;* **Cartwright** Associate Ed, *BMC Physiology;* **Clayton** Assoc Ed, *Hormone Res*; **Davis** Associate Ed, *Physiological Reports;* **Dive** Senior Ed, *Molecular Cancer Therapeutics;* **Dixon** Advisory Ed, *Arthritis Rheum*; **Eisner** Editor-in-Chief, *J Mol Cell Cardiol*; Senior Consulting Editor, *Circulation Research;* **Felson** Assoc Ed, *J Rheumatol;* **Gibbs** Assoc Ed, *J Invest Dermatol*; **Griffiths** Assoc Ed, *J Invest Dermatol*; **Hamdy** Editor-in Chief, *Neuroenterology;* **Marais** Senior Ed, *Cancer Research*; Editor, *FEBS Letters*; **Paus** Editor, *Exp Dermatol*; Assoc Ed/Section Ed, *J Invest Dermatol;* **Ray** Deputy Ed *J Endocrinol;* **Rutter** Associate Ed, *Diabetic Med*; **Singh** Exec Ed, *Brit J Clin Pharmacol*; **Vestbo** Int Advisory Board, *Thorax.*