Institution: University of Warwick

Unit of Assessment: A1 – Clinical Medicine

A. Overview Although smaller and younger than almost all Russell Group Medical Schools, our vision is to rank alongside the leading schools in terms of impact through discovery, translation and delivery of new therapies and diagnostics. We will achieve this through excellence in focused areas of basic biomedical research.

Warwick Medical School (**WMS**) was established in 2000 as Leicester-Warwick Medical School, and was granted independent degree-awarding status in 2007. Staffs from the Divisions of Health Sciences and Mental Health & Wellbeing are being returned to Unit of Assessment (UoA) 2. The first clinical medicine researcher was appointed in 2003 and the **Clinical Sciences Research Laboratory** (**CSRL**) at the **University Hospital Coventry and Warwickshire** (**UHCW**) opened in 2006. The objective during this REF period has been to build on the promising start in RAE2008. A new Dean [Winstanley], appointed in 2010 (and returned in UoA2), has overseen restructuring and expansion to achieve critical mass in our focused areas of cancer discovery, metabolic stress, reproductive outcomes and microbiology & infection. We added Divisions in Biomedical Cell Biology and Microbiology & Infection to existing areas of Reproductive Health and Metabolic & Vascular Health. Each Division has its own research and methodological focus across a spectrum from discovery science to translation:

- **Biomedical Cell Biology** - mechanisms of cell division; advanced light microscopy
- **Metabolic & Vascular Health** - cellular and whole-body responses to metabolic stress; human metabolic analysis, Human Metabolism Research Unit and proteomics
- **Microbiology & Infection** - bacterial population genetics, infection and pathogenesis; high-throughout genomics, metagenomics and bioinformatics
- **Reproductive Health** - prediction and prevention of pregnancy disorders; biomarker analysis, biobank and ultrasound imaging

We are returning 32.35 FTE researchers from across these four Divisions to Panel A01.

During the REF period:

- Research income (Section D) doubled to £4M per annum (£16.4M over the period, with an additional £8M of research-funded capital investment in infrastructure)
- Income per individual tripled to over £120k per FTE
- PGR awards doubled, with increasing recruits through UoW's Doctoral Training Centres

We have invested significantly in infrastructure and facilities (Section D). We have laboratories at two locations; a biomedical interface at the UoW Gibbet Hill Campus (adjacent to Life Sciences and close to other university departments) and a clinical interface at CSRL (adjacent to UHCW Hospital). Our research environment and culture is distinctive in its interdisciplinarity, with a particular emphasis on cross-campus collaborations involving Systems Biology, Life Sciences, Mathematics, Physics, Chemistry, Warwick Manufacturing Group and Warwick Business School (Section E). We have built on our relationships with NHS trusts and partnerships (the NHS provides over £2.3M per year for posts). More broadly across the regional health economy in the West Midlands we are co-leads of the **Science City Research Alliance** (**SCRA**), helped establish the West Midlands (South) **Health Innovation and Education Cluster** (**HIEC**), the **Academic Health Sciences Network** (**AHSN**) and **Collaborations for Leadership and Applied Health Research in Care** (CLAHRC). These provide a solid platform for translating our discovery science into clinical and public health practice. External collaborations are encouraged by UoW through provision of research funds and opportunities for interactions and we have significant partnerships with **University of Birmingham** (through SCRA), **Liverpool School of Tropical Medicine** (LSTM) (through the **Centre for Applied Health Research and Development**, CAHRD - most of this activity is captured in A02) and **Queen Mary, University of London**. Internationally, we have strategic partnerships with **Monash University** (Australia) and **Boston University** (USA).

B. Research strategy

B.1 Overview of strategy

To achieve our aim of making significant breakthrough discoveries in clinical medicine, our **core principles** are to focus on:

- **excellence in biomedical discovery research** by identifying priority areas
- **interdisciplinarity** and **collaboration** within UoW, regionally, nationally and internationally
- selected **impact areas** based on areas of clinical research excellence and in close

engagement with key NHS and industry partners and other stakeholders
- **strategic partnerships** with other academic institutions in our areas of excellence

We achieve these by:
- creating **research centres** to build critical mass and support research excellence, in partnership with UoW departments, other universities and NHS and industry partners
- investing in world class **research platforms** providing cutting-edge technology
- maintaining a vibrant **research culture** where excellent researchers thrive
- **developing and nurturing talent** through coordinated doctoral training programmes and by supporting development opportunities for early career researchers

Our strategy is informed by UoW's **Vision 2015** and supported by the University's **Global Research Priorities** (**GRP**) **Programme**. Vision 2015 sets ambitious goals for our 50th anniversary in 2015, focusing on excellence in 'research and scholarship', 'student experience', 'internationalism', 'stakeholders' and 'sustainability'. The GRPs foster cross-campus collaborative research around global priorities, and was described recently as an exemplar for fostering inter-diciplinarity in EPSRC's Maxwell report on interactions between engineering and physical sciences, and health and life sciences. The **Science and Technology for Health GRP** has publicised our research, attracted business partners and supported ~£50m of multidisciplinary bids for research funding (including the successful AHSN and CLAHRC bids).

B.2 Strategic development during the REF period

The appointment of a new Dean [Winstanley] in 2010 accelerated the expansion of clinical medicine at WMS to cover the spectrum of basic biomedical, experimental and translational research, with an emphasis on interdisciplinarity. We have built on existing strengths in Metabolic & Vascular Health and Reproductive Health and developed Biomedical Cell Biology and Microbiology & Infection. Organisation into Divisions encourages creation of research communities with shared aims and technologies, engendering a culture that supports and challenges staff (through peer discussions and work-in-progress seminars) and allows all staff to participate in discussions that shape strategy. Each Division has a vibrant seminar series, open to all and often shared across Divisions, and regular research symposia.

B.2.1 Responsiveness to national and international priorities

The Division structure helps to focus our research to national/international priorities. This is further enabled by the GRPs, which facilitate interdisciplinary working to respond to local, national and international challenges. We will continue to be responsive as we build platforms for future research beyond current projects, including, for example, Translational Systems Medicine, Medical Microbial Bioinformatics, Biomedical Research Unit (Reproductive Health) and Human Metabolic Research. We are also developing global health research: for example, our work on maternal and newborn clinical services in sub-Saharan Africa [O'Hare, Quenby] has trained 150 non-physician clinicians and resulted in national curriculum changes in Malawi.

B.2.2 Multi- and inter-disciplinarity

Our research investigates complex processes comprising multiple, interacting homeostatic mechanisms throughout the body and our appointments prioritise researchers with expertise that enables them to capitalise on multidisciplinary approaches. A cross-campus programme of meetings organised by the Health GRP facilitates interactions. 15 PGR students from UoW's interdisciplinary Doctoral Training Centres (Section E) currently undertake projects in WMS.

B.3 Division of Biomedical Cell Biology (BCB)

Research focus is on understanding the mechanisms of cell division. The Division was formed in 2010 with the recruitment of four groups from the former Marie Curie Research Institute (supported by £3.85M of transitional funding from Marie Curie Cancer Care) and the appointment of Millar (MRC programme grant holder). Mishima (CRUK programme grant holder) and Royle (CRUK Senior Cancer Research Fellow) joined in 2012, and Balasubramanian (Wellcome Trust Senior Investigator), De Piccoli (CRUK Career Development Research Fellow) and Sampath (BBSRC funded) joined in 2013. We are currently recruiting two joint professors with Monash (funded through the Monash-Warwick Alliance) using advanced imaging (super-resolution light microscopy, cryo-electron microscopy and correlative light and electron microscopy CLEM) for the structural and functional analysis of cellular machines. Research themes include signalling and cell division regulation [Ladds, Meadows, Millar], DNA replication [Dalgaard, De Piccoli], kinetochore-

microtubule interactions [McAinsh, Royle], microtubules and motors [Cross, Sampath, Straube] and cytokinesis [Balasubramanian, Mishima]. All PIs have significant long-term funding, with around £10 million of new awards in the past 12 months. BCB is based in the new **Mechanochemical Cell Biology (MCB) Building** on Gibbet Hill (opened in 2012, Section D). The key research platform is imaging and the MCB Building hosts the **Image Factory**. With a full-time university manager, we have 10 microscopes and a clean room for the development and production of the **Warwick Open Source Microscope** (WOSM). Supported by a university technician, and supported by the Warwickshire Private Hospital Charitable Trust, the WOSM provides a stable, bright, modular optical microscope platform for biophysical cell biology. BCB researchers use model systems (yeast, nematodes, cultured cells and, following a £300k UoW investment into a new facility, zebrafish) to study cell division. We are now linking our basic findings to new therapies and diagnostics for diseases arising through defects in this fundamental process. Current groups are working on collaborations and new technologies to facilitate this, but we are also targeting this area specifically in our recruitments (including a new initiative in Translational Systems Biology being developed with Monash).

B.4 Division of Metabolic and Vascular Health (MVH)
Research focus is on cellular and whole-body responses to stress, with emphasis on the aetiology of chronic metabolic diseases (obesity, type 2 diabetes, polycystic ovary syndrome [PCOS] and kidney disease). Themes include lipotoxicity and insulin resistance [Zammit], protein damage associated with glucose metabolism malfunction [Thornalley, impact case originator], protein structure-function relationships [Klein-Seetharaman], glycobiological basis for antibody-incompatible renal transplantation [Mitchel, Zehnder, impact case originator] and signalling mechanisms involved in diabetes [Bastie], pregnancy, PCOS and cancer [Grammatopoulos, Randeva]. Groups work at Gibbet Hill (with access to animal models) and at CSRL, where links with clinical research are strongest and include the **Warwickshire Institute for the Study of Diabetes, Endocrinology and Metabolism** (**WISDEM**) and the **Human Metabolism Research Unit** (**HMRU**, Section D). Future developments will strengthen translational research by linking the study of fundamental biochemical mechanisms to whole-body responses.

B.5 - Division of Reproductive Health (RH)
Research focus is on prediction and prevention of pregnancy disorders, ranging from infertility and early pregnancy loss to disorders of parturition. WMS returned research in reproductive health to RAE2008, and we have built further on this with the appointments of Bosens, Quenby and Tan. Main themes include endometrial biology and implantation [Brosens, Quenby], and disorders of metabolism and parturition [Tan]. The Division is based at CSRL, where co-localisation of laboratories and clinics underpins the translational focus. In 2012, WMS and UHCW invested £500k in an independent **Biomedical Research Unit in Reproductive Health** (**BRU-RH**) for systematic sample collection (biobank), deep clinical phenotyping (database), advanced ultrasound imaging, and laboratory analyses. Women at risk of reproductive failure or obstetric complications are seen in dedicated research clinics before pregnancy. BRU-RH supports a range of research in reproductive health: we have developed and demonstrated the value of uterine natural killer (uNK) cell testing to stratify women at risk of miscarriages, completed a feasibility trial of prednisolone treatment ahead of a multicentre randomised clinical trial, and have a drug discovery project for parturition disorders (with MRC-T, Ferring, GSK).

B.6 - Division of Microbiology & Infection (M&I)
Research focus spans from model organism biology to translational research on hospital and community-acquired infections. The Division was established following a strategic review in 2010 and through working closely with NHS partners at UHCW, Heart of England Foundation Trust (HEFT) and University Hospital Birmingham (UHB). A £4.5M UoW investment supported the recruitment of research leads [Achtman, Pallen, Waterfield, Young], early career researchers and clinical researchers. Researchers share common interests in high-throughput sequencing, genomics and bioinformatics to understand the ecology, evolution, epidemiology and pathogenicity of bacterial and viral pathogens. Themes include genomic epidemiology of hospital and community pathogens [Pallen], population genetics and the evolution of global pathogens [Achtman], invertebrate and vertebrate models of infection [Waterfield], and Epstein-Barr virus latency in virus-

associated tumors [Young]. The Division is based on Gibbet Hill (including a Category III containment suite) with variable atmosphere incubators, Illumina MiSeq benchtop sequencer and a dedicated data server. Expansion and further development of **EnteroBase**, a database containing genotypes from several 100,000s of model organisms and pathogens, is a research priority. Future research will extend into parasitology and strengthen links between basic science and clinical infectious diseases. WMS, in partnership with Swansea, Cardiff and Birmingham, are developing a **Consortium for Medical Microbial Bioinformatics**, an interdisciplinary facility for the academic, industrial and healthcare communities.

Significant research achievements by WMS during the REF period include:

- revealing phylogenetic diversity through analysis of the *Y. pestis* genome [Achtman]
- analysing constriction of the cytokinetic ring in vivo [Balasubramanian]
- defining signalling pathways that regulate energy metabolism and body weight [Bastie]
- demonstrating the role of SGK1 deregulation in reproductive failure [Brosens]
- showing biased binding of kinesin to microtubules [Cross]
- defining the roles of key proteins at DNA replication termination sites [Dalgaard]
- linking mitochondrial phosphotransfer to membrane lipid transfer [Klein-Seetharaman]
- revealing kinetochore-microtubule dynamics and chromosome oscillations [McAinsh]
- defining spindle checkpoint silencing by PP1 [Millar]
- confirming the mechanisms for clustering of central spindlin during cytokinesis [Mishima]
- uncovering the maintenance of intestinal epithelial barrier function [Murch]
- providing enhanced diabetes care to patients of South Asian ethnic origin [O'Hare]
- analysing the genome of the Shiga-toxin-producing *E. coli* O104:H4 [Pallen]
- understanding the causes and treatments of recurrent reproductive failure [Quenby]
- demonstrating the inhibition of clathrin-mediated endocytosis during mitosis [Royle]
- defining the maternal control of nodal signalling in development [Sampath]
- showing that migrating cells require stabilisation of their trailing adhesions [Straube]
- identifying important virulence factors using a bacterial genome library [Waterfield]

C. People

C.i.1 Staffing strategy

Our strategy is to make academic appointments on the criteria of research excellence, and to complement academic appointments with relevant joint clinical appointments in our partner NHS Trusts and strategic partners (including LSTM, Monash and Boston). Appointments during the REF period strengthened MVH (7) and RH (3) and created two new Divisions (10 posts in BCB, 4 in M&I with additional appointments in clinical posts). We are building critical mass in key areas to support discovery science and translational medicine. We match nationally funded clinical lectureships to build local capacity and develop early career clinical researchers.

We are conscious of **job insecurity** inherent in posts reliant on grant funding. Contracts of fixed-term staff are reviewed regularly and open-ended contracts are offered where appropriate. We have an established policy to support staff on personal fellowships and underwrite an academic post, subject to performance standards, for recipients of externally funded fellowships. Our growth over recent years has provided a good level of security for our research staff.

Equality and diversity is a key part of our staffing policy. UoW implements the principles of the 2009 Concordat agreement between funders and employers of researchers and was recently awarded the HR Excellence in Research. A **Single Equality Scheme** and associated Equality Objectives explicitly cover all staff. UoW has an institutional **Athena Silver Bronze Award**, and WMS was one of the first medical schools with a **Silver Award** (April 2013) and is working towards a Gold Award application. The Athena Action Plan is amalgamated into UoW's Equality objectives. Our self-assessment team, the **Welfare Strategy Group** (**WSG**), embraces the wider departmental working, environment and culture. Members are from all parts of WMS with a wealth of experiences in staff and student welfare. The co-chair of UoW's Athena SWAN Group sits on our WSG. We strive to take a strategic, rather than responsive, approach to achieving and being perceived to have achieved fair working practices across the organisation.

C.i.2 Staff development

Academic staff are assigned mentors, and all staff (full-time, part-time and fixed-term) participate in the Annual Review process to identify personal development goals. Staff on Fixed-Term Contracts hold regular career review meetings with their supervisor. Joint appraisals are carried out for all

NHS/WMS appointments. All staff have an individual learning account that accesses a personalised training portfolio supported through UoW's **Learning and Development Centre** (**LDC**). Programmes are delivered against the **Vitae Researcher Development Framework**. Staff supervising research students attend an Introduction to Research Supervision workshop. The **Postgraduate Certificate in Academic and Professional Practice** has been created to recognise, support and develop the varied roles of new academic staff with a specific module on research activities. UoW provides a portfolio of management development activities including the **Warwick Leadership Programme** and the **Warwick Coaching and Mentoring Scheme**. A UoW **Research Staff Forum** serves a networking function and provides a focus for gathering staff views on issues such as induction, training and development. With a representative on the University Research Committee, the Forum helps inform UoW's policy and practice, improving the experience of being a researcher at Warwick. The **Wolfson Research Exchange** is a community space that offers peer support and a forum to promote interdisciplinary collaboration. Specific activities include the **Early Career Researcher Network**, **Special Interest Groups** (aligned to the GRPs), and **Piirus** (a searchable online system for researchers to discover collaborators).
The **Institute of Advanced Study** (**IAS**) offers personal development support to researchers, including its **Academic Careers and Employability** (**ACE**) Programme, which is focused on preparation for academic employment. There are also targeted IAS fellowship programmes for early career researchers. We are returning one 5-year Global Research Fellow in Biomedical Cell Biology [Meadows] and host a number of 2-year Early Career Fellows.

C.ii Research students
Research students are valued members of WMS. Our PhD programmes provide a stimulating environment for postgraduate researchers to meet and interact in an interdisciplinary setting and to develop core research skills. PGR numbers have grown significantly during the REF period. Annual awards doubled between 2008 and 2012, and we currently have 69 students registered for PhDs in Clinical Medicine. A further 15 PGR students are supervised within Clinical Medicine but registered through UoW's Doctoral Training Centres (DTCs) and Doctoral Training Programmes (DTPs) - UoW has been awarded the largest number of RCUK-funded DTCs and DTPs amongst UK HEIs, evidence of our acknowledged excellence in PGR training and support:

- **Molecular Organisation and Assembly in Cells**: EPSRC interface of mathematical biology/biomedicine and biophysical chemistry
- **Systems Biology**: EPSRC/BBSRC, biology, biomedicine and systems modelling
- **Complexity Science**: EPSRC, control/design in complex systems
- **Midlands Integrative Biosciences Training Partnership in Life Sciences**: BBSRC, Warwick partnership with the universities of Birmingham and Leicester
- **Interdisciplinary Biomedical Research** (hosted in WMS, first intake in 2012); MRC, imaging for biomedical research.

The DTCs and DTP are funded by the UK Research Councils and are multidisciplinary centres that follow the pattern of a one year taught MSc followed by a three year PhD. Dedicated facilities provide training in relevant scientific techniques and transferable skills, as well as a supportive and dynamic environment for research. Warwick was awarded 5 new DTCs in the recent EPSRC programme.
UoW offers three other **studentship funding opportunities** suitable for WMS PhD programmes:

- **Chancellor's Scholarships** and **Chancellor's International Scholarships** provide 3.5 years of full-time support – WMS was awarded 10 studentships in the last academic year.
- **Warwick Collaborative Postgraduate Research Scholarships** provide up to 50% of a PhD studentship, with an external funder (philanthropic or industrial) providing the rest.

All PhD students have at least two supervisors (at least one with a substantive contract, at least one with experience of supervising a research degree and all supervisors attend mandatory training every 3 years). Progress is monitored continuously and rigorously with annual reports, and overseen by an Advisory Committee (not including supervisors). Students pursuing a PhD register initially for an MPhil, and undergo a formal upgrading process involving a written report and seminar. UoW offers training and personal development programmes to support research students at all stages of their studies. This includes sessions on academic writing, oral communication, networking, team working and teaching skills, consistent with Research Council requirements. WMS runs an active programme for postgraduate student and staff including a regular seminar

series with local, national and international speakers, and focused training sessions designed to develop the research skills. There is an annual research day at which students present their work (posters, oral presentations) to peers and staff. Students also participate in our Research Team Leaders Programme and research/academic skills training.
UoW and WMS offer a range of facilities to promote specific and transferable skills. The **Effective Researcher Programme**, developed in collaboration with Vitae, provides students with a solid foundation in core research skills. The Programme is aligned to the national Researcher Development Framework and includes project management, effective communication, problem solving, leadership and collaborative working. Participants join Student Action Learning Sets, which provide peer-support to build a cohesive and self-supporting research community. Staff-student liaison committees foster a two-way exchange of ideas. The **Postgraduate Certificate in Transferable Skills in Science** helps prepare PhD students in the sciences to become successful post-doctoral researchers. It helps graduates to use the skills they master during their PhD in other areas of work and improve employability following completion of their studies. The University pays the registration fees for all Science and Medicine students. The **Postgraduate Hub** is a dedicated postgraduate facility at the heart of the University campus that provides advice and support as well as work and study facilities. The **Wolfson Research Exchange** supports specialised postgraduate activities, including: **PhD Life Blog** (an online community of postgraduate researchers, sharing experiences of life, research and study) and **PhD Network** (an interdisciplinary community offering events and online networking). The **Research Students Skills Programme** is a programme of workshops, events, support and resources run by **Student Careers and Skills**. The programme provides students with opportunities to meet the wider University research community and translate their skill set to the job market. The **Warwick Portfolio** is an online space that enables research students to access and build records of personal and professional development. Provided by the Graduate School, the Portfolio provides access to information and tools to record and reflect on training and development under eight skill sections; communication, leadership, networking, language, practical, critical thinking, ethics and research and enterprise.

D. Income, infrastructure and facilities

D.1 Income

We have a desire for and commitment to multi-sector funding for our priority research areas, and have targeted research funding to support posts and facilities in our priority areas. We have achieved a significant increase in research income during the period, and increasingly high profile awards and personal research fellowships, augmented by philanthropic and commercial income. Research income has approximately doubled from £2.2M in 2008 to £4M per annum (£16.4M over the REF period, with an additional £8M of research-funded capital investment in infrastructure). Income per FTE has tripled during the period. Research awards in the last 12 months have been more than £12M.
Recent major awards include:

- Marie Curie Cancer Care research funding (£3.8M) - Cross, Dalgaard, McAinsh, Straube
- Wellcome Trust Senior Investigator Award (£2.8M) - Balasubramanian
- EU FP7 Co-operation Grant (£1.9M) - O'Hare
- MRC Programme grant (£1.8M) - Millar and McAinsh
- CRUK Senior Research Fellowship (£1.4M) - Royle
- CRUK Career Development Fellowship (£1.3M) - De Piccoli
- CRUK Programme grant (£1.2M) - Mishima

Approximately 40% of our funding is from the UK Government, 29% from AMRC Charities, 14% from RCUK, 11% from Industrial and 4% from EU. Our collaboration agreement with Novo Nordisk (2005-2015) provides ~£240k per year for a joint initiative to improve clinical research in diabetes research. The WMS philanthropic campaign **50 Forward** proactively raises money from UK Trusts, Charities and other donors for research into healthcare and has so far raised £14M for key research programmes. We also have a growing commercial portfolio (Section E).

D.2 Infrastructure

We are committed to developing our physical environment, and have made major investments during the REF period. An ongoing programme of refurbishment ensures our laboratories at CSRL (clinical interface at UHCW, opened in 2006) and the BMRI (biomedical interface on Gibbet Hill, opened in 2002) remain state-of-the-art as we expand our research. The laboratories at

CSRL/UHCW were awarded NIHR experimental medicine status in 2010. Our £6.4M state-of the-art **MCB Building** was opened by Sir Paul Nurse in April 2012. Built to the highest environmental standards, and funded by UoW in partnership with the **Regional Development Agency** and the **Wolfson Foundation**, the building contains laboratories and the Image Factory (Section D.3). Phase 2 extension of the MCB Building is planned for 2014/2015.
Clinical research has been facilitated by the building of **UHCW**, a £400M PFI University hospital (opened in 2006). The hospital has six well-equipped patient research interface suites for clinical research, and the **Human Metabolism Research Unit (HMRU)** was commissioned in 2010 following a £2M investment from UoW, UHCW and SCRA. The HMRU houses the most advanced whole-body calorimeters in Europe as well as a bodpod for air displacement plethysmography, magnetic resonance imaging for brown adipose tissue and facilities for cardio-pulmonary exercise testing. The unit supports research into the determinants of human obesity and its metabolic sequelae and enables the study of metabolic profiles associated with other endocrine conditions. The HMRU is affiliated to the WISDEM Centre and uses laboratory facilities at CSRL. We are developing infrastructure for early phase clinical trials of new drugs in metabolic health. The first human trial of a nutriceutical developed in collaboration with the Warwick Crop Science Centre and a commercial partner will start in 2014. A recently installed PET-CT and three MRI scanners are also available for clinical research.

D.3 Facilities
UoW has made substantial investments in the REF period to underpin our research, including over £4M of SRIF funding for core equipment for proteomics, genomics, imaging and medical systems biology. Investments include:

- Image Factory (advanced light microscopy) - UoW invested £1.5M in new microscopes (2010), and an equivalent amount of equipment was transferred from MCRI.
- Biological Proteomics facility - developed jointly with SLS and supported by Waters, the facility will include a new Orbitrap Mass Spectrometer (£750k in 2013).
- Biomedical Services Unit - a WMS / SLS unit providing animal support. A £300k UoW and Wellcome investment will adapt the aquatic facility from frogs to zebrafish (2013).
- Bioinformatics - a WMS / SLS / Systems Biology initiative includes refurbishment of space and 3 new posts to increase bioinformatics support across biomedicine and life sciences.
- Human Metabolism Research Unit - Section D.2
- Mechanochemical Cell Biology Building - Section D.2
- Biomedical Research Unit in Reproductive Health - Section D.2

UoW is currently developing several of its research facilities (such as Biomedical Sciences Unit, Proteomics Unit and Electron Microscopy Suite) into University Research Platforms with academic directors and centrally funded technical support.

E. Collaboration or contribution to the discipline or research base
E.1 Collaboration
UoW has multiple approaches to support inter-disciplinary research underpinning health and disease. Our programmes span molecular, genetic, cellular and whole organism physiology; and we have appointed clinical and non-clinical translational personnel whose research includes basic science, patient-based clinical investigation, clinical trials and population studies. We have created a culture that supports collaborative working in clinical medicine, and most projects involve multiple investigators and institutions. We encourage staff to make use of the university support available for collaborative work. The **IAS** awards peer-reviewed funds to promote cross-disciplinary working, both internally and externally to the University and supports international academic visitors - recent awards include a 5-year Global Research Fellow [Meadows]. The UoW **Research Development Fund** provides awards up to £50k to support the development of new research initiatives - we received 7 awards during the REF period, including £49k to investigate carbohydrate-specific cellular signalling [Mitchell] and £48k to explore the pharmacological potential of a novel domain in membrane receptors [Grammatopoulos]. The UoW **HEIF Strategic Impact Fund** was launched in 2011 to increase capacity and capability to deliver innovative Impact - we received 9 awards, including £240k for new research projects, £225k to support business engagement activities and £160k to employ an Impact Officer and a manager for the Imaging Facility. The **Science and Technology for Health GRP** hosts seminars and visits from national and international collaborators, and has distributed £75k of support for collaborative project development. The

Science City Research Alliance (SCRA, 2008-2018) is a strategic research partnership between UoW and the University of Birmingham. This funded ~£10M translational medicine research capacity in clinical trials and experimental medicine to assist businesses in the West Midlands expand the knowledge economy. Capital investment at UoW included the Clinical Trials Unit, MCB Building and the HMRU. We have created and safeguarded >110 jobs and provided ~170 new business assists, and the 10-year targets for 'impact' were all achieved within the first 3 years. Across the regional health economy, WMS helped establish the West Midlands **Academic Health Sciences Network** (AHSN) and **Collaborations for Leadership and Applied Health Research in Care** (CLAHRC). These provide a solid platform for translating our world-class discovery science into clinical and public health practice. Our partnership with the **Liverpool School of Topical Medicine** (LSTM), including a joint **Centre for Applied Health Research and Development** (CAHRD) is captured through our return to A02. Initially established around Health Sciences, our partnership with LSTM will expand to include fundamental biomedical research, particularly in the area of infection where we already have cross-campus collaboration through the new **Warwick Infectious Disease Epidemiology Research** (WIDER) Centre. A new **Centre for Nutrition & Health** (developed jointly with SLS) will also include LSTM. In 2011, UoW established a research alliance with **Monash University** (Melbourne) and both partners have made substantial investments in infrastructure and joint appointments. WMS staff work with colleagues from Monash on projects involving polymer chemistry, nanomedicine and advanced imaging - we are recruiting to two joint professorial posts, developing a joint PhD programme, and submitted an application to the Australian MRC for a Centre of Excellence in Advanced Imaging ($AUS28M). Our next Alliance initiative is in Systems Medicine. This will link UoW's expertise in biomedicine discovery and Systems Biology to the biomedical strengths in Monash Medical School, the Monash Institute of Pharmaceutical Sciences, and the Australian Regenerative Medicine Institute. UoW also has partnerships with **Queen Mary, University of London** and **Boston University** (USA).

E.2 Commercialisation and research partnerships with industry

We encourage collaboration with commercial organisations and support staff establishing spin-out companies focused on translational medicine to maximise impact. During the REF period, we have obtained ~£2.5M in commercial research collaborations, including:

- **AstraZeneca** - hypolipidaemic and anticancer drug development.
- **Bayer** - includes a >£1M award for a trial of the treatment of venous thromboembolism in cancer patients, and a study of testosterone therapy for obese men.
- **Bosch** - WMS partnership with Warwick Manufacturing Group and UHCW to establish a "Learning Lab" for optimisation of prototype devices.
- **Ferring** and **GSK** - treatments for uterine dysfunction and pre-term labour.
- **GE Healthcare**, with UoW, UHCW NHS Trust and Coventry City Council, developed the **Warwick Healthcare Partnership** to support research and provide a framework for new technologies. The Breast Cancer Clinical Pathway was selected as one of 5 world centres by GE Healthcare.
- **Li-Cor Biosciences** - novel functional bioimaging technology.
- **NovoNordisk** - strategic collaboration (WMS, UoW and NHS partners) to establish the WISDEM Centre for research into diabetes, obesity and other metabolic disorders. Specific projects include treatments for diabetes and PCOS.
- **Omnyx** - WMS, UoW and UHCW partnership was awarded the Omnyx Centre of Excellence in Digital Pathology following a Europe-wide competition, and established the Omnyx Demonstrator site at UHCW.
- **Roche** - anticancer phase 2 clinical trials (contract research).
- **Unilever** - functional food development.

We use UoW's **Research Support Services (RSS)** to support academics to identify and develop strategies to raise impact from their resrach, signposting them to sources of expert advice within Media and Communications (dissemination), Corporate Relations (business engagement) and **Warwick Ventures Ltd** (WVL, commercialisation). WVL is a wholly owned subsidiary of UoW that supports researchers in generating impact and extending reach by working closely with industry and investors through specialist commercialisation managers. WVL supports technology development, advises on intellectual property protection and licensing, and helps researchers at all

stages of development. WMS has had 99 disclosures, 9 patents, (most licensed, assigned or in development) and 4 spin-out companies, including:

- **Neurosolutions Ltd** (value >£900k) has a drug development programme and a contract research arm that works with pharmaceutical companies including GSK (UK), Eli-Lilly (USA), Sepracor (USA) and Organon (UK). The company, in partnership with Sosei (Japan) and Ampika (Cambridge), has small molecules and natural product extracts entering trials.
- **Apnee Sehat CIC** is a social enterprise tailoring lifestyle programmes to the needs of Britain's South Asian community. The company raises awareness and screens for vascular disease risk, and won a Big Venture Challenge Award in 2013.

E.3 Committees, award giving bodies and editorships

Achtman: Co-inventor of MLST (Multi-Locus Sequence Typing) for identification of bacteria; Associate Editor for PLoS Genetics; Section Editor for PLoS Pathogens (2008-2010).
Balasubramanian: Awarded Singapore National Science Medal (2008); Member of Wellcome Trust India Alliance (2011-2014); Member of Faculty 1000; Editorial Board member for Cytoskeleton and eLIFE.
Barber: Advisory Panel member for the European Medicines Agency (EMA) and Medicines and Healthcare Products Regulatory Agency (MHRA); Awarded the Society of Endocrinology Young Endocrinologist's Clinical Prize Lecture (2009).
Brosens: Advisor for Ectopic Pregnancy Trust (2010-2011); Editorial Board member for Molecular & Cellular Endocrinology, Molecular Endocrinology, Hormones & Cancer.
Cappuccio: Director European Society of Hypertension Centre of Excellence; Director WHO Collaborating Centre for Nutrition, Member of WHO Panel on Nutrition, Technical Expert on Population Reduction in Salt Intake (WHO, Geneva), European Salt Initiative (WHO, Copenhagen), Cardiovascular Disease Prevention Through Salt Reduction (American Health Organization, Washington); Associate Editor of Sleep and International Journal of Hypertension.
Grammatopoulos: Expert Panel member National Council for Research and Technology, Greece; External member Hellenic Quality Assurance for Higher Education; Member of National Scientific Committee, Association of Clinical Biochemistry and Laboratory Medicine.
Klein-Seetharaman: Margaret Oakley Dayhoff Award of the Biophysical Society (2008); Editorial Board member for BMC Biophysics.
Levi: Director of INSERM UMRS 776 for Biological Rhythms and Cancer (France).
McAinsh: Committee Member British Society of Cell Biology.
Muller: Scientific Committee member of North West Cancer Research Charity (2008-2013).
Murch: Member of Federation of International Societies of Paediatric Gastroenterology Working Group (Relapsing Inflammatory Bowel Diseases); British Society of Paediatric Gastroenterology, Hepatology and Nutrition – Council Member, Chair of working Group on Coeliac Disease, and Member of Working Group on Paediatric IBD.
O'Hare: Chair of National Training Committee for Eye Screening; Associate Dean for Academic Training, West Midlands Postgraduate Deanery; Trustee of Novo Nordisk Foundation; Chair and Trustee of Diabetes, Endocrine and Immersion Research Trust.
Pallen: Member of Blackett Review into Biothreat Agents (chaired by Sir John Beddington).
Quenby: Chair of Early Pregnancy Special Interest Group, European Society for Reproductive Endocrinology; MHRA Expert Panel for Women's Health; Scientific Advisory Committee RCOG; Associate Editor for BMC Pregnancy and Childbirth.
Randeva: Co-Chair for Polycystic Ovary Syndrome Special Interest Groups (British Endocrine Society and Society for Endocrinology); Editor for British Journal of Pharmacology.
Royle: Committee Member and Meetings Secretary British Society of Cell Biology; Editor for BMC Cell Biology; Liverpool Cancer Centre Research Committee Member (2010-2012).
Straube: Lister Institute Research Prize (2013).
Thornalley: Member BBSRC-National Institute of Aging (USA) Collaborative Programme on Ageing; Founding co-editor for Glycation section of Amino Acids; Founding Editorial Board member for Redox Biology.
Young: Chair of CORE Research Award Committee; Non-executive Director of Birmingham Children's Hospital (2008-2010); President International Association for Research on Epstein-Barr Virus and Associated Diseases (2008-2010).
Zammit: Editorial Board member for Journal of Lipid Research and Progress in Lipid Research.