Institution: Sheffield Hallam University

Unit of Assessment: 5 Biological Sciences

a. Overview

Research within the Biomedical Research Centre (BMRC) in the Faculty of Health and Wellbeing, is led by Head of Research Centre (HORC), Professor **Woodroofe**, and includes academic staff from the Department of Biosciences, seven postdoctoral researchers (PDRAs) and 41 PhD students focussed in four research groups: **Bioanalysis**, **Biochemistry**, **Disease Mechanisms,** and **Molecular Microbiology**. Each group is coordinated by a research group leader (RGL) with a track record in capturing external research income and high impact publications. Collaboration across groups is actively encouraged, specifically sharing innovation and expertise across our research portfolio, thus enhancing our capacity for generating new research approaches. The strategic recruitment of ten academic staff since 2008, including seven early career researchers (ECRs) has led to an increasing emphasis on biological sciences research in BMRC. Our commercial services business portfolio is a strong driver for engagement with external organisations and income generation and is managed by a business development manager with 2.5FTE scientific staff. The vitality of our centre is evidenced through publications, national and international collaborations, a large active PhD student body, contributions to national and international conferences, our weekly seminar programme, and public engagement activities.

b. Research strategy - Our research strategy for 2008-2013 had five key aims, progress against which is detailed as follows: **Aim 1) Develop the quality and volume of research in four thematic areas and build upon collaborations in the UK and overseas, through external funding from Research Councils (RCUK), industry, charity and FP7.** The success of aim 1 is exemplified by RCUK grants from BBSRC to **Smith TJ** in collaboration with Prof Murrell at Warwick University (now at UEA) and from MRC with Prof Akid, Manchester University and **Le Maitre.** Industry collaborations include: Waters Ltd and GlaxoSmithKline (GSK) with **Clench and Francese,** including 4 industry CASE studentship awards (2008-13); charities e.g. Cancer Research UK - **Clench** in collaboration with Prof Tozer, University of Sheffield (UofS), Multiple Sclerosis (MS) Society - **Woodroofe**, in collaboration with Prof Azzouz, (UofS); Yorkshire Cancer Research, Weston Park Hospital Charity Trust and Bone Cancer Research Trust, **Cross** in collaboration with Dr Chantry, UofS, International Centre for Biosciences, Geneva, Switzerland (**Le Maitre, Cross**); EU funding - BMRC is a partner in an FP7 training network grant supporting a research assistant in BMRC (2010-2013). **Aim 2) Ensure completion rates in excess of 70% within four years for current PhD students**. PhD student enrolment has increased from 25 full time PhD students in 01/08/2008 to 35 FT and 6 PT students enrolled at 1/10/2013. In this assessment period there have been 32 PhD completions compared with 33 in RAE 2008 (joint submission). In 2012/13 academic year, the completion rate was 100% for home/EU students but lower for international students. **Aim 3) Increase the international profile and enhance research activity through the secondment of international researchers into BMRC.** We have strengthened our collaborations with a number of international academic and industrial partners and hosted for periods of 3-12 months visiting researchers from Brazil (Science Without Borders Program), China (2), Egypt (funded by a distinguished scholar award from the Arab Fund Fellowship programme), Pakistan and the USA. **Aim 4) Build upon our successes in applied research to increase our engagement with industry and double our income from research consultancy**. Our contract and consultancy work has continued to increase in terms of volume and income. This includes consultancy and training courses for global and national companies e.g. Libyan Petroleum Institute, Unilever, Climostat Ltd, Glyndwr University (income per annum in 08/09 £65K cf £100K in 2012/13). **Aim 5) Exploit the opportunities for multidisciplinary research within SHU.** Success is exemplified by the award of an EPSRC *Bridging the Gap* Grant to SHU (EP/H000275), and a follow-on feasibility grant (EP/I016473/1) total income £934K with **Woodroofe** as co-investigator. This has significantly enhanced our multidisciplinary research e.g. projects were initiated with the Materials and Engineering Research Institute (MERI), Art and Design Research Centre and Centre for Sport and Exercise Science, with significant outputs including: patent applications for hydrogels GB2493933; WO2013/027051) by **Le Maitre,** and for a fingermark powder discharge device (PCT/GB2013/051838) led by **Francese**, which has been licensed to Consolite Forensics Ltd; research contributing to a PhD completion and publication by **Dalton** (Appetite 71, 2013, 369-378).

Research groupings and major achievements:

1. Bioanalysis (3 Cat A, 1 PDRA, 10 PGRs) (RGL - Clench): Research includes aspects of chemistry, physics, biomedical and forensic science and is focussed on the development of novel methodologies and improvement of existing ones. Since RAE2008, key grants awarded include: **Clench,** funding via the CRUK/EPSRC/MRC/DoH Imaging initiative in collaboration with University of Sheffield (Programme Grant C1276/A10345), an MRC/GSK CASE award and funding from GSK/Stiefel to support MS imaging research PhD studentships. **Francese,** Home Office funding to support fingermark analysis research and a BBSRC/GSK CASE award to study biomarkers of drug treatment responses. Selected key achievements include: (i) Incorporation of ion mobility separation into mass spectrometry imaging for the detection of: anti-cancer drugs in whole rat body tissue sections (**Clench 1**) and biomarkers of tumour response to chemotherapy (**Clench 2, 3, 4**). (ii) Development of mass spectrometric methods for enhancement of images and recovery of chemical information from fingermarks and hair samples (**Francese 4, Bassindale 1**). (iii) Patented methodologies for: improving the sensitivity of MS imaging experiments (EP2297770B), improving sensitivity in the analysis of latent fingermarks (GB2489215B) and identifying gender from latent fingermarks (pending WIPO Patent WO/2013/027011).

2. Biochemistry (4 Cat A, 6 PGRs) (RGL - Abell): Research includes: analysis of membrane-associated proteins and protein aggregation in relation to human disease and plant biotechnology. Key funding has been obtained from the BBSRC (BB/E01559X/1, 2006-2010 £ 441,382) (**Abell**), EPSRC (via institution-wide EPSRC award) to support collaborative ellipsometry research with MERI (**Abell, Smith D**), the Royal Society (RG2010R1], the British Mass Spectrometry Society, and a Charles Wallace Fellowship to Dr Sajjad (Pakistan) to work with **Smith D**. Key achievements include: (i)The first full analysis of plant tail anchored proteins (**Abell 1**), one of which was found to be a novel chloroplast chaperone receptor involved in protein targeting (**Abell 2**) and another involved in growth regulation was dual-localised, due to a cell-specific alternative splicing mechanism (**Abell 3**). (ii) **Abell and Smith D** in collaboration with Nabok (MERI, UoA 13) adapted ellipsometry analysis of thin layers, to allow quantification of protein binding at membranes from cells and organelles, with potential applications for screening membrane protein pharmaceutical targets (**Abell 4**). (iii) Development of mass spectrometry techniques to enable structural characterisation of amyloid precursors and oligomers (**Smith D 1-4**). (iv) Role of the C-terminal domain of a G protein coupled receptor (GPCR) for membrane interaction (**Conner 1**), dissection of aquaporin trafficking and the mechanisms underlying this, including roles for GPCRs (**Conner 2**), microtubule-driven vesicle trafficking and protein kinases (**Conner 3**). Conner's output 3 was featured on the cover of Biochemistry and on the cover of the 50th anniversary edition**.** Connor Output 2 was selected for inclusion in the Faculty of 1000 post-publication peer review, which selects the top 2% of medical/bioscience publications. The recent appointment of **Campbell** (ECR) with expertise in cell imaging (**Campbell 1, 2**) complements the research in the group.

3. Disease mechanisms (6 Cat A, 3 PDRAs, 16 PGRs) (RGL - Woodroofe): This group encompasses research in cancer (**Cross**), musculoskeletal (**Le Maitre**), neuroscience and immunology (**Wells**, **Dalton, Woodroofe** and **Laird**). Research is strengthened by clinical, academic and industry partners nationally and internationally. This group has received major funding from charities: UK MS Society, Yorkshire Cancer Research, Diagnostic Investigation of Spinal Conditions and Sciatica (DISCS). Key achievements include: (i) Identification of VEGF isoforms as mediators of tumour insensitivity to vascular disrupting agents *in vivo* with Prof Tozer, UofS (**Cross 1**), development of *in vivo* GFP-imaging models to facilitate tracking of tumour cell metastasis with Dr Eaton, UofS, and Prof Hamdy, University of Oxford (**Cross 2**), and using GFP-imaging in *in vivo* models to facilitate tracking of macrophage delivery of a hypoxia-induced oncolytic virus to tumours (**Cross 3**) with Dr Muthana and Prof Lewis, UofS. (ii) Elucidation of the role of cytokines and chemokines and the mechanisms involved in spinal disc degeneration and osteoarthritis (**Le Maitre 1-4**). Together with colleagues in MERI (UoA13), Smith and Nephew Extruded Films and NHS orthopaedic surgeons (Wilkinson and Chiverton, at Sheffield Teaching Hospitals NHS Foundation Trust (STH), **Le Maitre** is investigating delivery systems to inhibit degeneration and promote regeneration using growth factors and stem cells for disc, cartilage and bone repair. Patents for these materials are pending (Composite hydrogel, GB1114446A and Composite hydrogel-clay particles WO2013027051A). (iii) Identification of autoantibodies to transglutaminase 6 in gluten ataxia patients in collaboration with consultant neurologist, Hadjivassiliou at STH and colleagues at Cardiff University (**Woodroofe 1**) and (iv) Extension of research on chemokine involvement in the pathogenesis of MS (**Woodroofe 2, 3**).(v) **Woodroofe**

and **Clench** collaborated on a European Cosmetics Association funded project combining their expertise in immunology and mass spectrometry imaging to studying skin sensitivity (**Woodroofe 4**). (vi) Elucidation of cytokine, chemokine and CD56+ NK cell involvement in the pathogenesis of endometrial dysfunction in collaboration with consultant TC Li at STH (**Laird 1-4**) (vii) Dopamine binding to alpha-synuclein in different conformational states (**Dalton 1** with **Smith D**).

4. Molecular Microbiology (4 Cat A, 3 PDRAs, 9 PGRs) (RGL - Smith TJ): This group brings together expertise in microbiology, molecular biology and synthetic and analytical chemistry to address medically and environmentally relevant problems. Key achievements include: (i) Development of novel environmentally friendly coatings to prevent corrosion (**Smith TJ 1**) funded by EPSRC in collaboration with Akid, Manchester University; enzyme biocatalysis, funded by (BBSRCBB/F01449X/1) in collaboration with Murrell (UEA) (**Smith TJ 2**); bioremediation of environmental pollution (**Smith TJ 3**); evaluation of antibiotics for orthopaedic surgery in collaboration with NHS consultants at STH (**Smith TJ 4**). (ii) Identification of a potential anti-Staphylococcal agent, which has now been marketed in EU and USA as a nasal Staphylococcal decolonising agent (**Miller 1**); new insights into the mechanisms of antibiotic action and resistance (**Miller 2, 3**) as well as mutability of *Pseudomonas aeruginosa* biofilms, relevant to development of antibiotic resistance and pathogenesis of cystic fibrosis (**Miller 4**). (iii) Research into natural products has revealed novel synthetic and naturally occurring agents including inhibitors of histone deacetylase (HDAC) (**McCulloch 1**) and novel antimicrobials (**McCulloch 2**).

Future strategic aims 2014 – 2019: Building on the success of our previous strategy, we will sustain BMRC's activities and our International profile through the following key objectives:

1. Capacity building: Two staff will be recruited per annum based on retirement of current staff, targeting researchers with a track record which complements and builds upon current strengths.

2. Income generation: We aim to generate £1.2M per annum through exploitation of the expertise of staff in our four research groups and integration of our specialist skills. Applications will be targeted at RCUK priority themes and specific medical research charities. We will collaborate with existing partners, including external academics, clinicians and industry, whilst nurturing new, strategic partners as appropriate. Bids will be underpinned by publications in high impact factor journals. We will consolidate our current internal peer review system of external bids to enhance quality and seek feedback from our departmental pharmaceutical company advisory group, which has representation from Evotec, Astra Zeneca and Covance and from the University Research and Innovation Office (RIO). We will continue to build our commercial business services portfolio through improving our web presence, targeting external markets through invitations to our commercial Open Days (1-2 pa). which profile our strengths. We will work with staff in RIO to promote licence agreements for our current patents as well as patent protecting future inventions.

3. **PhD student recruitment**: We will support two internally funded PhD studentships per annum, for supervision by newly recruited staff together with experienced supervisors, in order to co-develop and integrate new staff into current research groups. We will target CASE studentships and charity-funded PhD studentships, as well as funding from partners in industry to co-fund studentships and to provide placement opportunities for our students. We will aim to maintain our recruitment of overseas government funded students (2-3 pa), where we have a good track record.

4. **Multidisciplinary research engagement**: We will promote multidisciplinary research through collaborations developed from within, but also external to, SHU by building on the success of the EPSRC *Bridging the Gap* project and follow-on multidisciplinary SHU funded *Imagine* research project, with external industrial partners, specifically with regard to our strength in biomaterials.

c. People, including:

i. Staffing strategy and staff development

Strategy: The BMRC staffing strategy prioritises recruitment of ECR staff with strong research track records, embedding them within one of our four research groups, where they are supported and mentored in developing their career by the RGL. This ensures group cohesion and facilitates joint projects for external bids. Each RGL has experience of publication, peer review, grant application procedures and external networking and is thus in a strong position to advise new group members. Sustainability of our academic staff research base is ensured through a dual teaching/research approach with the Department of Biosciences. The staffing strategy is framed by the principles of the '*Concordat to support the career development of researchers'*, which guides institutional policies and practice. In 01/2013, SHU gained the HR Excellence in Research Award from the European Commission.

Researcher Career Development: We actively support ECRs through reduced teaching loads in their first three years of appointment. Proven achievers, evidenced through grant income and publications, continue to benefit from reduced teaching loads, thus creating a sustainable staff base. Eleven staff returned in this assessment period have joined the centre since 2008 and all had reduced teaching hours; four of these staff have since been successful in grant applications. We encourage new staff to maintain collaborations with their previous research groups at UK and overseas universities and to develop joint grant proposals, which builds up their track record. In 2013, a Researcher Development Advisor was appointed by SHU to deliver a dedicated training programme for researchers at all stages of their careers, supporting the sharing of activities, processes and best practice. In addition, a training package was initiated within SHU (£80K investment) addressing research integrity and participation in an international collaborative project to develop Professional Skills for Research Leaders for early to mid-career researchers. The researcher career agenda integrates research staff and PGR training and development. **Woodroofe,** together with PDRA and PhD student representatives from BMRC are members of the University's Researcher Concordat Sub-Committee, ensuring dissemination of good practice across BMRC. Responsibility for career development is shared between the HORC and researchers via an annual appraisal process, which includes PDRAs with their PI. Within BMRC, support for staff and research students includes: specific funding for national and international conference attendance, (8 staff and 22 PhD students were funded to attend conferences in 2012-13), support for grant writing and writing for publication, with internal peer review and mentoring from senior colleagues. The effectiveness of our support for all staff is evidenced by the progression of **Smith TJ** and **Clench** to professorial titles during this assessment period. Success of our ECR support policy is exemplified by **Smith D** who has published seven articles since joining SHU in 2010 (including three REF outputs **Smith D** 3, **Dalton** 1 and **Abell** 4) and his first PhD student submitted her thesis in 11/2013. We have a high retention rate of quality staff, with only one leaving in this assessment period to take up a post at an Australian university. The results of a recent Career Researchers Online Survey (CROS, 2013) provided evidence of high retention rate of researchers at SHU and high levels of satisfaction with training received.

Equality and Diversity: Within BMRC, the recruitment, training, retention and career development of our staff is a priority, within an environment that respects the diversity of all. Our success in this is evidenced by the winning of a Bronze University award for the Athena SWAN Charter 'Women in STEM' initially in 2010 and renewed for a further 3 years in October 2013, recognising our foundation for eliminating gender bias and developing an inclusive culture. In 2012, BMRC was awarded SHU's only departmental silver Athena SWAN award and we are currently implementing our three year action plan, which includes increased mentoring of PhD students and ECRs as well as providing opportunities for staff to gain experience of management roles, through work shadowing. Two female academics appointed since 2008 are being mentored by professors within SHU as part of the ASPIRE mentoring scheme to enhance progression of academics towards a professorial title. 8 out of our 17 staff submitted to REF2014 are women, 2 of whom work part time.

Research students: The BMRC Postgraduate Research Tutor (PGRT) (**Smith TJ**) is responsible for PhD student recruitment, supported by a designated administrator. Admissions criteria align with the Quality Assurance Agency and UKBA guidelines. All applicants, whether home, overseas, self-funded or sponsored students, are interviewed by a panel including the PGRT or HORC together with a potential supervisory team. Induction takes place annually at University level and is supplemented with an electronic resource available on the SHU Research Student Blackboard site (virtual learning environment). Local induction includes health and safety training by a senior member of the technical team and a 'buddy' scheme, whereby new PhD students are paired with an appropriate senior PhD student to assist their scientific and social integration into the centre. The BMRC Blackboard site is a repository for local information and is available to all PhD students, PDRAs and staff. Our current student body is approximately equally split between home and overseas students. Home students are funded through: BBSRC CASE studentships with GSK, National Institute of Health Research (2010-2013) and the Hospital Infection Society (2009 – 2013) as well as internal university funding for studentships, awarded on a competitive basis. We encourage staff to seek joint funding from outside agencies for internal studentships and this has culminated in joint funding from the Home Office (**Francese**), Health and Safety Laboratory (HSL) Buxton and GSK/Stiefel (**Clench**) since 2011. We also recruit part time students from industry and

the NHS and currently (10/2013) have enrolled students from Astra Zeneca, HSL, and Transplant Immunology, St James's University Hospital Leeds and overseas government funded from Egypt, Iraq, Libya, Saudi Arabia and Thailand.

Our research student body is complemented by ERASMUS student visitors for periods of 3-6 months annually from partner universities in Portugal, Czech Republic and Germany. In addition, Wellcome Trust summer studentships, Nuffield student bursary and work experience school children all add to the vibrancy of our centre. Final year BSc and MSc project students have access to equipment in BMRC laboratories, which provides PhD students and PDRAs with an opportunity for supervisory experience. We hold an annual winter poster session and summer research conference, at which all PhD students present their work. We also offer a part time Professional Doctorate in Biomedical Sciences, which recruits 2 students per annum, predominantly from NHS pathology laboratories and the National Blood Service. Currently we have 10 enrolled DProf students with 2 completions in this assessment period. New PhD supervisors undertake the Research Supervisor Development Programme, a modular programme supported by Blackboard, which five BMRC staff successfully completed in the REF census period.

PGR student **monitoring** is managed by the SHU Research Degrees Sub-committee (RDSC). Student progress is formally monitored in the first 3 months for full-time, and 6 months for part-time students; an Approval of Research Programme (RF1) form is independently assessed by two rapporteurs on behalf of RDSC and includes consideration of ethics and training needs of the student. A rigorous assessment of the candidate's ability to succeed at doctoral level has been introduced in 2013 in BMRC at 10 months, encompassing an oral presentation and viva as well as a written report, which includes a literature review and the presentation of a draft manuscript for publication. **Training** operates at 3 levels; 1) training provision to attain competence in research methods, integrity and skills, provided through an MSc Research Methods and Statistics module; 2) training in laboratory skills and instrumentation relevant to the research programme; and 3) University wide and Faculty level transferable skills training in areas such as personal development planning, career choices, employability, time management and team leadership. Furthermore, sessions were held in 2012-13 for each of the four RDF domains (knowledge and intellect, personal effectiveness, research governance and impact). PGRs also have access to a series of CPD courses under the banner "*Realising Our Potential*" which includes employability skills, problem based learning and writing for publication. In 2012, initiatives with the UofS included an Industrial Careers Day aimed at both PDRAs and PhD students in life-sciences/engineering. In 2009, 2010 and 2011 a team of PhD students participated in the national Biotechnology Young Entrepreneurs Scheme competition. In 2012 and 2013 we organised a one day careers conference, which included PhD student alumni talking about their career progression, as well as external keynote speakers reflecting on their career pathway e.g. Liz Smythe, Professor of Molecular Cell Biology, UofS. In 2009, the University invested in the on-line skills training package Epigeum, which has 10 courses including project management, presenting and networking, intellectual property and getting published. All new students complete the Research Ethics 1 module and those using human or animal tissue in their research undertake the Research Ethics 2 module. Students present their work at annual external national conferences, as well as at least once at international conferences during their programme of study. Four of our research students (two now PDRAs in BMRC) have generated material to support patent applications granted in this REF period (with **Smith TJ, Francese, Le Maitre**). Expertise and resultant publications of research students, particularly in the area of mass spectrometry imaging has led to alumni of this research group being recruited by internationally renowned groups and companies (see Impact Case Study 1). Four former BMRC PhD students have been appointed to lectureship posts within the Bioscience Department at SHU (3 at 0.5FTE and 1FTE) and one is a lecturer at Swansea University. SHU took part in the 2013 HEA Postgraduate Research Experience Survey (PRES). Comparator data from this were excellent, placing SHU well above sector average scores. 93% of BMRC respondents (cf 83% for sector average in biological sciences) expressed overall satisfaction with their research degree experience and 100% of BMRC students agreed that they had regular contact with their supervisor (cf 86% for sector).

d. Income, infrastructure and facilities

i) Income - Success is evidenced by income of £5,973,000 from research and business-related activity (1/08/2008-31/07/2013) compared with income of £2,227,567 in the RAE2008 assessment period (BMRC was included in a joint submission to UoA12 in RAE2008). During the REF2014

assessment period, BMRC operated on an annual budget of ~£1.1M. In 2012/13 this was generated from research grants (RCUK and charity) (£405K), international and home research student fees (£357K), internal University investment (£288K), and KT and consultancy (£100K). This diversity of income streams is central to BMRC's financial sustainability. We have developed strategies including excellent staff, infrastructure and laboratory facilities, to enhance success in income generation and delivery of quality outputs with impact. Our success rates are enhanced through internal peer review of grant applications, mentoring of ECRs in bid writing, consolidating external partnerships with industry and other HEIs, and targeting specific medical research charities and CASE studentship awards. Our successes include; grants from BBSRC (BB/EO1559X/1, BB/F01449X/1), EPSRC (EP/H000275, EP/I016473/1) and MRC (STU029065, MR/J014656/1) totalling £856,000 for the 2008-2013 period. In relation to charity funding we have secured £671,000, with grants from The Multiple Sclerosis Society, Cancer Research UK, Yorkshire Cancer Research and DISCS. Externally funded UK PhD studentships include Hospital Infections Society, the MS Society and NIHR, the latter in collaboration with Transplant Immunology, St James's University Hospital Leeds. We have worked with the International Recruitment Team in the Faculty to more than double our income from international PhD student fees (£108K in 08/09 to £279K in 12/13). We have improved our procedures to ensure timely processing of applications and follow up to secure high quality international students.

ii) Infrastructure - The University Research and Innovation Office (RIO) provides central expertise and support to deliver the corporate vision of SHU as an exemplar in innovation, applied research and KT. Dedicated personnel (16.2 FTE) facilitate our applications for research funding, the exploitation of research and to create commercial technology transfer relationships with external organisations. Through the IP Commercialisation Committee an annual budget of £80K is invested in patents, legal fees and company spin-outs at the University. BMRC has benefitted from this expertise through 8 patented technologies, awarded between 2008 and 2013, two licensing agreements and one spin out company, Sheaf Innovations, a monoclonal antibody business; RIO staff continue to manage the relationship between this commercial enterprise and BMRC. RIO staff have also co-delivered grant writing training sessions to staff in BMRC as well as ensuring the quality of our internal PhD studentships awarded, through their expert input into our review process. The SHU Learning Centre integrates high quality academic library information resources in electronic and hardcopy format with excellent IT facilities, enabling students and researchers to obtain at-desk access to a wide range of journals and other materials. Last year SHU spent £2.9M on information resources of which £969,329 was spent on journals and £905,641 on electronic databases. A fast and effective Document Supply Service, with a budget of over £40K in 2012-13, obtains items not held in the University's collections. Expert help and training in sourcing and using information resources are provided by Information Specialists who deliver sessions (4 x 2hours) to new PhD students annually as part of their induction in BMRC. BMRC outputs are entered on to SHURA (SHU Research Archive) a "green" open access repository. The University Ethics Committee has established research ethics policies and procedures to ensure good practice and to support excellent research (http://www.shu.ac.uk/research/ethics/). The SHU research data archive allows data to be stored securely in line with data retention policies. A dedicated laboratory manager is responsible, together with the HORC, for health and safety in the laboratories. A team of 18 technical staff with expertise spanning the range of chemical and biological techniques manage and maintain the research and teaching laboratories and equipment base ensuring their smooth operation. 1.6FTE staff provide dedicated administrative support to research staff and students.

iii) Facilities - The research laboratories occupy two floors and provide specialised rooms for: cell culture (7 laminar flow hoods, 14 incubators), BD FACSCalibur™flow cytometer and Gallios 10 colour flow cytometer (purchased in 2013); microscopy (Zeiss confocal microscope, Olympus BX60 fluorescence microscope and an Olympus IX81 fluorescence microscope with electronic stage); molecular biology and biochemistry, with ABI real time PCR machine, pyrosequencer and Akta instruments and Li-Cor Odyssey infra-red imager; a dedicated microbiology laboratory houses a large fermenter; an organic chemistry laboratory with eight fume hoods and a large analytical laboratory suite with extensive equipment including: mass spectrometers, Synapt ion mobility mass spectrometer (purchased in 2012), MALDI-TOF, nano LC/MS/MS and NMR instrument (purchased in 2011). We have an annual investment in equipment through the university's capital investment fund, highlighting the University support for BMRC. We also invest significantly in the upkeep of the

equipment through annual service contracts and in-house technical support. Further equipment has been donated to us through our contacts with companies including an Applied Biosystems QStar XLQTof Hybrid Mass Spectrometry with oMALDI2 option, two Thermo/Finnigan LCQ LC/MS/MS Mass Spectrometers, a NewWave Research UP213 Laser Ablation Accessory for ICP-MS and a Waters Quattro Micro GC/MS/MS (total value as new £600K). We benefit from working collaboratively with staff in MERI through access to their equipment including: FTIR spectroscopy and imaging FTIR microscopy, electron microscopes and ellipsometry unit. Office space for PDRAs and PhD students, each with their own desk and PC, is located alongside academic staff offices, ensuring a close knit vibrant community which engenders a strong research culture. A dedicated BMRC meeting room was recently fully refurbished with interactive whiteboard.

e. Collaboration and contribution to the discipline or research base

Our **international collaborations** are a valuable resource and provide support to a number of our research programs exemplified as follows: **Abell:** Dr M Jung, Universitat des Saarlandes, Germany; Dr J Young, McGill University, Canada (co-author output 2). **Clench:** Prof K Dreisewerd, University of Muenster. **Conner:** Prof Neuttze and Dr Törnroth-Horsefield, University of Gothenburg Sweden; Prof de Groot, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany; Dr Wootten, Monash University, Australia. **Cross:** Dr Sayers, National Cancer Institute, NIH, Maryland, USA (joint supervision of PhD student in BMRC and visitor to BMRC in April-June 2013). **Francese:** Prof Moneti, Interdepartmental Centre of Mass Spectrometry (co-author output 1,3) and Dr U Seppala (joint first author output 3); Prof Turillazzi, Dept Genetic and Animal Biology, University of Florence, Italy (output 2); Dr Chaunan, Consumer and Clinical Radiation Protection Bureau, Canada; Dr M Jenab, International Agency for Research on Cancer, WHO; **Le Maitre:** M Risbud, Jefferson University, Philadelphia, USA (co-author output 4); T Smit: VU Medical Centre, Amsterdam, Netherlands**. Miller:** Prof L. D. Possani, Universidad Nacional Autónoma de México (UNAM), Mexico; Dr M. El-Rahman, Suez Canal University, Egypt (currently on a one year visiting fellowship in BMRC). **Smith D:** Prof R Cappai, Department of Pathology University of Melbourne Australia; Dr Sajjad Institute of Biochemistry, University of Balochistan Pakistan (BMRC visitor 3 months 2013); Oladapo Olaniru, University of Jos, Nigeria (BMRC visitor, 3 months in 2013). **Smith TJ:** M-H Zong, South China University of Technology; X-H Xing, Tsinghua University, Beijing, China (initiated through a BBSRC China partnership grant to **Smith TJ**, 2005-2009 on biocatalysis and environmentally friendly exploitation of renewable resources, led to 15 joint publications, 11 in current REF period); HKA Ong, Universiti Tunku Abdul Rahman, Malaysia (PM2 grant from British Council to **Smith TJ** for application of molecular microbiology to monitoring freshwater fish agriculture, 2 joint papers in REF2014 period); JD Lipscomb, Department of Biochemistry, University of Minnesota. **Woodroofe:** Prof Amor, Free University (VU) Amsterdam, NL (co-editor a book for J Wiley on Neuroinflammation, in press). **McCulloch:** Prof Kerr, University Prince Edward Island, Canada (providing valuable natural resources for a BMRC funded PhD studentship). Staff have relationships with **industrial collaborators,** sometimes longstanding, in the UK and overseas, including pharmaceutical companies exemplified by the Bioanalysis group and in Impact Case Study 1. **Clench:** Dr D Richards, Bruker; Dr R O'Malley, Waters Manchester; E Claude, Waters Manchester (co-author outputs 1-4); Dr K Oakes Elforlight, Daventry (licenced BMRC patent); Dr P Marshall, GSK and Dr A West, GSK (CASE award co-supervisor); Dr R Goodwin, Astra-Zeneca (joint part time PhD student supervisor); Dr Seppala ALK-Abello, Denmark (led to consultancy work with BMRC). **Cross:** Dr A Neeraj, Abbott Molecular, Des Plaines, Illinois, USA. **Francese:** N Denison, West Yorkshire Police; L Cherry, Crime Scene Investigator Unit, Leeds (providing access to crime scenes for piloting fingermark analysis by MALDI-MSI); Dr S Bleay, CAST, Home Office St Albans (co-supervisor PhD student); A Cressein, HTX technologies, LLC, NC, USA (led to a free instrument loan for 4 months and an application note). **Le Maitre:** Critical Pharmaceuticals, Nottingham; Smith and Nephew Extruded Films, Hull (development of hydrogel delivery systems for recombinant growth factors). **Miller:** Destiny Pharma; Theravance Inc.; Novartis Institute for BioMedical Research; Prolysis; Cubist Pharmaceuticals; MerLion Pharmaceuticals; Phico Therapeutics. **Smith D:** Biotest UK (consultancy work on antibody characterisation). **Smith TJ:** Corus PLC (now TATA Steel) (to pilot bioremediation of waste from steel making); Climostat Ltd. UK (enzyme synthesis work).

Collaboration with NHS clinical consultants is vital to the research of the disease mechanisms group, through provision of patient samples, clinical information and valuable contributions to research outputs exemplified as follows: **Laird:** Mr TC Li consultant gynaecologist, Jessop Wing,

STH (co-author outputs 1-4). **Le Maitre:** M Wilkinson, N Chiverton (co-author output 4; joint PhD student supervisors); A Cole, A Michael and L Breakwell, consultant orthopaedic and spinal surgeons at STH (provision of spinal discs). **Smith TJ:** I Stockley (co-author output 4); R Kerry (orthopaedic surgeons); R Townsend, consultant clinical microbiologist (co-development of antimicrobial coatings). **Woodroofe:** Consultant neurologists at STH; M Hadjivassiliou (co-author output 1); S Price (Impact Case Study 2); Dr Clark, consultant Transplant Immunology, St James's University Hospital, Leeds (Joint supervisor PT PhD and DProf students and NIHR Fellowship).

Contributions to the research base: Staff actively participate in the wider scientific community through invited talks, organisation and chairing of sessions at national and international conferences and contributions to learned societies. Staff are fully engaged in the peer view process for grants and journal articles, and several contribute as editors. We act as external PhD examiners at many universities and it is encouraging that recently appointed staff are being asked to fulfil this role, as well as established staff. Examples are provided below:

Recent Invited Talks - Abell: EMBO Meeting on Protein Translocation, Dubrovnik, Croatia, 2013. "Specificity of tail-anchored membrane protein targeting in plants"; SEB Main Meeting, Salzburg, Austria, 2012. "Subcellular targeting of tail-anchored membrane proteins in plants" **Clench:** BASF-CAAT Symposium on Metabolomics Berlin 2012; RSC Symposium, Swansea 2012; Trace Chemical Analysis 2012 Trabzon, Turkey; European Epidermal Skin Barrier Network Venice, Italy 19/9/12; MALDI Imaging Symposium, Gottingen Germany, 2012; DECHEMA Trends in Bioanalytical Imaging, Frankfurt Germany 2013. **Francese:** European Network of Forensic Science Institutes conference, 2012, Lyon, France (only 30 invited attendees); Annual Fingerprint Society Conference, 2013, Swanwick, UK; Proteomic investigation of tissues of medical interest by MALDI Mass Spectrometry Imaging; XXI Congress of the International Academy of Legal Medicine Lisbon, 2009; International Fingermark Research Group Meeting 2013 (only 25 invited attendees) Jerusalem, Israel; Keynote talk at Pharmaceutical and Biomedical Analysis Conference, Bologna, Italy, 2013. **Le Maitre:** DISCs research meetings: 2011, 2012 and 2013; Invited speaker: Philadelphia Spine Conference 2013. **Smith D:** Invited seminars: School of Bioscience University of Kent and Keele University 2012; GE Label Free user meeting Latimer Place, Chesham 2011. **Smith TJ:** International Conference on Antimicrobials Research, Valladolid, Spain, 2010; Hospital Infection Society, Liverpool 2010; Biotrans, Manchester 2013. **Woodroofe:** European Glia meeting, Berlin, Germany 2013.

Contributions to the discipline: **Abell:** Review editor for Frontiers in Plant Science; Reviewer for PLoS One, Journal of Cell Science, Nature Communications, JBC; PhD external examiner at Warwick and Sheffield Universities.**Clench:** Leader of the MALDI and Mass Spectrometric Imaging Special Interest Group of the British Mass Spectrometry Society; Member of EPSRC College 2006-12; associate editor "Journal of Spectroscopy". **Conner:** reviewer Molecular Biology of the Cell, British Journal of Pharmacology and Current Protein & Peptide Science; PhD examiner, University of Gothenburg, Sweden (2013). **Francese:** Reviewer for Royal Society, Science and Technology Facilities Council and National Science Centre, Poland; PhD examiner, De Montfort University. **Laird:** Associate Editor of the International Journal "Human Reproduction" 2005-2008 and 2010-present; Reviewer, MRC and Wellbeing for Women; PhD examiner at Newcastle and Southampton Universities. **Le Maitre:** Committee member and trustee of The Pathological Society of GB and Ireland; AO Spine UK delegate; Peer reviewer NHS endowment grants, Swiss National Science Foundation; PhD examiner at Bradford and Nottingham Universities. **McCulloch:** Guest Editor special issue 2013 of *Marine Drugs.* **Miller:** Editor, Journal of Medical Microbiology (2010 - present); Director and Trustee of the British Society for Antimicrobial Chemotherapy (BSAC) (2010-2013); Chairman of the annual 'Antibiotic Resistance Mechanisms Workshop' run by BSAC since 2009. **Smith D:** Reviewer for: BBSRC, MRC, EPSRC. **Smith TJ:** Editor, Journal of Applied Microbiology and Letters in Applied Microbiology 2005-2013; chaired session at European Science Foundation-EMBO Symposium Protein Design and Evolution for Biocatalysis, Spain (2008). **Woodroofe:** Chair, British Neuroimmunology Group; Committee member European School of Neuroimmunology; Grant review panel Daphne Jackson Trust; reviewer: BBSRC, MRC, MS Society of GB, Wellcome Trust; PhD examiner UCL, Imperial College London, Liverpool and Manchester Universities; Organised and chaired sessions at the British Society for Immunology meetings 2010 and 2013 and the British Neuroscience Association Festival of Neuroscience, 2013.