Institution: Queen's University Belfast

Unit of Assessment: 3a Pharmacy

a. Overview

Since RAE 2008, the School of Pharmacy at Queen's University Belfast has continued to progress in respect of its research impact and income, staffing complement and facilities. The School, part of the Faculty of Medicine, Health and Life Sciences, is organised into two research divisions, or clusters: Pharmaceutical Science and Practice (PSP) and Molecular Therapeutics (MT). Each cluster is led by a Director of Research (DR) and has four key research themes. For PSP, these are Drug Delivery, Bioactive Biomaterials and Infection Control, Clinical Pharmacy, Primary Care; for MT, they are Natural Drug Discovery, Experimental Therapeutics, Proteases and Inhibitors, Chemical Biology and Medicinal Chemistry. These themes encompass a range of associated funded programmes, many of which are interdisciplinary and involve collaborations with leading national and international researchers. As a successful professional School, the University has continued to support Pharmacy during this assessment period, with infrastructure investment and new staff posts. The School is a major part of the University's vision for the development of a leading health sciences research campus comprising the Medical, Nursing and Pharmacy schools.

***Research Highlights in this assessment period include**:*

- Increase in FTE postgraduate researchers from 72.5 in RAE 2008 to *ca*. 100 in REF 2014
- New research grants of £14.2M awarded, including £3.7M (26%) from UKRC (BBSRC, EPSRC, MRC)
- Growth in Category A academic staff to 33 FTE (23 FTE in RAE 2008)
- Infrastructure investment *ca.* £3.5M
- Establishment of an International Scientific Advisory Board
- Major research awards to staff (BBSRC Innovator of the Year 2013, GSK Emerging Scientist Award 2012, RPS Science Award 2010 and 2013, NIHR Career Scientist Award, 2013 AAPS Pharmaceutical Research 'Meritorious Manuscript' Award)
- Development of a joint college (China Queen's College) in China for pharmaceutical sciences

b. Research strategy

Research strategy is developed by the School Research Committee, in the context of University research strategy, and forms part of the School Academic Plan, with implementation of individual policies and enabling actions by the relevant DR. An external International Scientific Advisory Board (Prof. David Thurston, King's College London; Prof. Kinam Park, Purdue University, Indiana; Prof. Barry Carter, University of Iowa) comments and advises on the relevance of the strategy to the School's aims, and on research within a wider international context. Thus, since RAE 2008, Pharmacy has expanded existing research strengths and introduced new programmes that fit the School's overall aim of delivering real benefits for patients. There is a focus on translational research, transforming early-stage innovations into potential new health products, attractive for industry, together with an emphasis on informing evidence-based health policy and practice. Specific priorities, taking account of external research drivers, are meeting global health challenges, notably HIV/AIDS; applying pharmaceutical sciences (drug delivery, biomaterials and drug discovery) to intractable diseases, notably cancer, infection, and respiratory problems; medicines for children; and improving health and wellbeing in an ageing population. Research in the School spans the major areas of the pharmaceutical sciences and the practice of the profession, as described under 'Themes and Programmes'.

Over the next period, the pharmaceutical sciences will be impacted by ongoing changes in societal attitudes to healthcare, a greater focus on intractable diseases and continued de-risking by large pharma companies through outsourcing of early stage discovery. Target identification and validation, systems biology, the increasingly important interface between formulation science and engineering, a continuing interest in natural sources of drugs and a growth in the capabilities of enabling technologies will be key drivers for change, with biologicals already taking a greater slice of industrial R&D budgets than small molecules. Economic aspects and an ageing population will lend traction to research aimed at securing more effective use of existing drugs. The School's

Future Research Strategy will be driven by these considerations and, as a result, will promote a greater integration between the physicochemical, clinical and biological aspects of research, reflecting the increasingly fluid interactions across programmes. Translation and commercialisation of research is now a UK priority in terms of research funding. MRC, in particular, have adapted to this with their focus on experimental medicine. The School's strategy is responsive to such national and international priorities, evidenced by the securing of two MRC DPFS awards during this assessment period. The School is well placed to further develop its focus on the biomolecular and physicochemical sciences, biomedical engineering, and on clinical and practice aspects with a focus on infection, the young and the elderly.

PSP CLUSTER RESEARCH THEMES AND PROGRAMMES *(Director of Research, Hughes)*

DRUG DELIVERY THEME

The ***HIV Prevention Programme*** (Malcolm, Woolfson, Kett & Andrews) has established world-leading expertise in vaginal drug delivery, notably elastomeric vaginal ring (VR) systems, for sustained/controlled delivery of HIV microbicides and mucosal vaccines. A number of novel vaginal ring systems have been developed and out-licensed to industrial partner Warner Chilcott. The programme also extends to gels and lyophilised solid mucoadhesive vaginal delivery systems. In this period, new grants worth £2.8M were awarded to the programme from the US National Institutes of Health (NIH), USAID/PATH and other leading US-based funders such as CONRAD and, notably, the International Partnership for Microbicides (IPM), the leading agency funding the HIV microbicide strategy to control the HIV pandemic. The programme is also partnering two funded EUFP7 programmes. A VR dapivirine ring developed by the programme is presently in Phase 3 multi-centre clinical trials in Africa sponsored by IPM and the US Government, through NIH. A combination VR, with two microbicides differing in mode of action and designed to further limit resistance, has also been developed for IPM. The programme is also working with leading industry partners (EU FP7 funding) on the challenge of mucosal vaginal HIV vaccine development. In the ***Solid Dosage Forms Programme*** (Andrews & Jones, both Royal Society industrial fellowship holders, in collaboration with Astra Zeneca and Almac, respectively), the focus is on the application of fluidised hot melt granulation and polymer extrusion/injection moulding technologies to produce solid dosage forms, multi-layered and targeted drug delivery systems, and dosage systems in which the solubility of poorly soluble therapeutic agents is enhanced through stabilisation of the amorphous state. In particular, this programme examines the molecular interactions between therapeutic agents and polymers, and between different polymeric components, seeking to engineer these interactions to achieve the optimal physicochemical and biological properties, and hence clinical efficacy. Funding in this assessment programme totalled £480k from Knowledge Transfer Programmes, the Royal Society and industry, for enhancing the solubility of BCS Class II compounds by hot melt technologies and for hot melt extruded controlled release solid dosage forms. The ***Microneedles Programme*** (Donnelly, Woolfson & Thakur) focuses on novel, rapidly swelling (in situ) polymeric microneedle (MN) arrays, for which patent applications have been made. Applications include transdermal delivery of small hydrophilic molecules and biopharmaceuticals, intradermal vaccine delivery and minimally invasive therapeutic drug monitoring via uptake of skin interstitial fluid. The work has developed from earlier studies by the team on the transdermal and gynaecological delivery of photosensitisers for photodynamic therapy, and from a long-term interest in mucoadhesive gels and their rheological characteristics. Its novel feature is a hydrogel-based MN array that swells in the skin to become, in effect, a rate controlling membrane, painlessly breaching the skin barrier and allowing large quantities of water-soluble conventional drugs or macromolecules to be delivered systemically from a polymeric reservoir layer behind the microneedles, Self-disabling, the swollen hydrogel MN are removed intact from the skin with no remaining residue. The work has been extensively supported (£1.9M) in this period by industry, Wellcome Trust, EPSRC and BBSRC, with Donnelly winning 3 major national research awards for this work since 2010. His paper on novel laser micromoulding of MN arrays won the 2013 AAPS Pharmaceutical Research Meritorious Manuscript Award. The first patent on the MN system has recently been granted (China) and major multinational industries (pharma, cosmeceutical and healthcare) are now in talks to licence the technology. Thakur (ECR) is presently extending the application of MN and other hydrogel technologies to ophthalmic delivery.

BIOACTIVE BIOMATERIALS AND INFECTION CONTROL THEME

The ***Photoactive Biomaterials Programme*** focuses on the use of photoactive biomaterials for the prevention of medical device-related infection (McCoy, Jones, Gorman). Research into ophthalmic devices with surface-localised photosensitisers has attracted funding (£318k) from a major multinational lens manufacturer (currently in out-licensing negotiations), and an on-going industrial partnership (£92k funding) is developing a urological product to reduce the incidence of catheter-associated urinary tract infection. A medical technology innovation company has funded (£58k) work to enable the translation of this technology, for which patent protection is being sought, to related fields where bacterial colonisation is problematic, including touchscreens, cables, and healthcare-related surfaces. A world-leading paint manufacturer is also co-developing a paint system based on the technology. In a related application, photoresponsive polymers have been developed whereby a bioactive agent is released following irradiation of the biomaterial with a defined wavelength of radiation, with funding from a technology innovation company. This technology has been successfully applied for the light activated delivery of a wide range of therapeutic agents. The application to respiratory biomaterials (endotracheal tubes) was funded by EPSRC (£346k). The ***Polymeric Medical Devices Programme*** (Andrews, Gorman, Gilmore, with Laverty & Carson-ECRs) involves the extrusion of multilayer catheter systems to provide controlled degradation and/or drug release to prevent urinary encrustation and infection. A novel multilayer catheter resulting from the programme has been outlicensed to a Spanish medical devices company, who are funding (£129k) its further development. Current research includes the isolation and identification of novel antimicrobial and quorum sensing inhibitors from marine microorganisms and extreme halophiles (Gilmore, £250K), and utilisation of bacterial proteinases as targets for specific inhibition during biofilm matrix formation (LasB/alginate, functional amyloid). Physical approaches to biofilm control include development of novel ionic liquid biocides (£150k, out-licensing of patent), antimicrobial peptides and novel biofilm eradication techniques employing cold, atmospheric plasmas (Gilmore, £125k, INI), an example of the emerging field of plasma medicine. Gilmore won the RPS Science Award 2013. The ***Sensor Development Programme*** (McCoy, Donnelly, Jones) involves the design of materials that can report with high sensitivity and selectivity on various important species. Work in this area utilising Raman spectroscopy was co-funded (£95k, Action Medical Research) with the microneedles programme, and work on novel hydrogel materials with embedded sensors involves international collaboration and was funded (£63k) by Enterprise Ireland.

CLINICAL PHARMACY THEME

The ***Improving Systems of Healthcare Delivery Programme*** led by McElnay is focused on improving patient care through developing systems that improve healthcare outcomes in patients while hospitalised or through interventions at outpatient clinics. The integrated medicines management approach involves input of clinical pharmacy staff at all stages of the patient journey while in hospital, to help improve medication appropriateness, decrease length of hospital stay and help delay/prevent rehospitalisation. This approach is being extended through continuing research on the implementation of pharmacy-run medicines management outpatient clinics and connected health programmes, utilising home self-monitoring by patients after discharge. Research has also commenced on the use of antibiotic cycling in the hospital setting, informed by interrupted time series analyses models of antimicrobial resistance development. Funding of £714k was received from Health &Social Care (HSC) R&D (NI equivalent of NIHR), NHS Trusts and medical charities. The ***Paediatric Clinical Pharmacy Programme*** (funding of £406k, MRC, HSC R&D) centres on the pharmacokinetics and pharmacogenomics of drugs in neonates and children, particularly those used in an unlicensed fashion (McElnay and Hawwa). This is underpinned by laboratory work on the determination of drugs and metabolites in low volume samples, including the novel approach of dried blood spot analysis. The latter methodology has also allowed the work to be extended to adherence research in children, including home sampling by parents and to recently commenced research on the toxicokinetics of formulation excipients in neonates. The ***Cystic Fibrosis & Airways Microbiology Programme*** (Tunney, NIHR Career Scientist Award holder, in clinical collaboration with Elborn, Medical School and Gilpin-ECR) focuses on the detection and treatment of polymicrobial infection in patients with respiratory diseases such as cystic fibrosis (CF), non-CF bronchiectasis and chronic obstructive pulmonary disease. The main work involves examination of

how bacteria contribute to the pathophysiology of infection and inflammation in these conditions and the molecular basis of antibiotic resistance amongst these bacteria. Projects are also ongoing to evaluate the efficacy of antibiotics and other agents under anaerobic conditions that mimic *in vivo* conditions in the lung and to examine whether changes in antibiotic treatment to target polymicrobial infection result in improved clinical outcomes for patients. Total funding in the period was £1.38M, including £850k (joint grant of £1.7M) for the role of anaerobic infection in CF patients, from a unique tripartite funding scheme supported by NIH (USA), HSC R& D (NI) and Health Research Board (RoI), and a £180k Knowledge Transfer Scheme based on diagnostic technology.

PRIMARY CARE THEME

The ***Quality of Care in Older People Programme*** (£415k funding, HSC R&D, HSB-RoI, medical charities) has a focus on the nursing and residential home setting, and also extended to primary care. This programme has its roots in Hughes's Harkness Fellowship in Healthcare Policy and her Primary Care Career Scientist Award. Cross-sectional, epidemiological and qualitative work, much of it cross-national (USA and New Zealand) has underpinned interventions (randomised controlled trials) that have been implemented in long-term care (e.g. the Fleetwood model for nursing homes) and primary care (Hughes). Research is on-going on palliative and end-of life care in those with dementia, with a focus on the appropriateness of prescribing in advanced disease and evaluation of patterns of prescribing in nursing home residents with dementia as they approach end of life (Parsons, Hughes). Ryan (ECR) has a Cochrane Fellowship (£42k), and is the third academic in the School to hold this fellowship, while HSC (R&D) have funded (£150k) work on pharmacy prescribing in NI (Hughes). The ***Pharmacoepidemiology Programme*** (Hughes) is in conjunction with colleagues from the Centre for Public Health, School of Medicine, Dentistry and Biomedical Sciences (Murray and Hughes). The current focus is on pharmacological exposures and associations with the risk and progression of cancers. Most projects are utilising datasets from the General Practice Research Database (GPRD). Potentially inappropriate prescribing in older people is also being assessed using nationally representative datasets from Northern Ireland and GB (Hughes). Overall, this theme attracted £860k funding in the period.

MT CLUSTER RESEARCH THEMES AND PROGRAMMES (*Director of Research, Scott***)**

EXPERIMENTAL THERAPEUTICS THEME

The ***Novel Tumour-Associated Proteins Programme*** (Robson, McCarthy, Furlong) is centred on the FK506-binding protein like (FKBPL) protein and Mitotic Arrest Deficiency Protein 2, MAD2. The prognostic and predictive power of FKBPL is currently being examined in breast cancer patients (funded by Breast Cancer Campaign). Furthermore, a fit-for-purpose biomarker assay has been created and is being validated through funding from the MRC DPFS scheme (£223K of £433K multi-partner grant led by Robson). A complementary programme (Furlong) is evaluating the diagnostic potential of MAD2 and its regulator miR-433, as novel markers of chemoresistance in ovarian and breast cancer (£66k, HRB, Ireland). In addition to the diagnostics interest, the therapeutic potential of FKBPL as a potent anti-angiogenic has been established. This discovery was out-licensed to Almac Discovery who partnered its preclinical development (£586k) and established a novel CD44-related mechanism of action (Robson). An FKBPL derived peptide will enter Phase I cancer clinical trials within the year. Investigation into the mechanism of action and the role of FKBPL in developmental angiogenesis using knock-out approaches is now underway (Robson, BBSRC £367k). Targeting the MAD2/miR-433 pathway is also being validated as a potential target for therapeutic intervention. This programme has secured a total of £1.1M in research income in this reporting period. The ***Nanoparticle Therapeutics Programme*** (McCarthy, Scott, Robson with Coulter-ECR) focuses on the design of nanoparticle based systems for application in cancer and pulmonary inflammation. The development of non-viral recombinant protein vectors for the systemic delivery of nucleic acids has attracted almost £0.5M in funding. This includes strategies to target breast and prostate cancer (Breast Cancer Campaign and Prostate Cancer UK, McCarthy and Robson), the delivery of iNOS transgene in RUNX2 positive tumours (CRUK), targeted FKBPL expression (RPSGB) and radio-sensitising gold nanoparticles (EPSRC and CRUK, Coulter and Robson). Funding has also been attracted from the Royal Society

and industry to support the use of this peptide delivery system to facilitate DNA vaccination. In addition to interest in protein-based nanoparticles, research on the optimised delivery of antibody targeted drug-loaded nanoparticles to tumours is also a focus area (£45K, MRC People Exchange Programme, Scott). These functionalised particles also have application in inflammatory disorders by targeting key cell-surface receptors. A novel anti-inflammatory nanoparticle targeting Siglec receptors, which blocks TLR signalling pathways in macrophages, has been funded by the MRC DPFS for application in Acute Lung Injury (£237K of £505K multipartner grant led by Scott). This strategy of targeting pulmonary macrophages with functionalised particles has further attracted industrial interest and led to Scott being recently awarded a Royal Society Industrial Fellowship (£87K) with GSK and funding from Astra Zeneca (£30K).

PROTEASES AND INHIBITORS THEME

The ***Activity Profiling of Proteases Programme*** (Walker and Martin) identifies and characterises novel protease targets using activity-based profiling approaches. Developments include new solid phase methods for the expedited synthesis of activity probes for the serine proteases, the generation of novel inhibitor and substrate-based assay methods for determining proteasome levels in haematological cancers, and the identification of key proteases promoting asthma. Several of these probes (Protease-Tags) are also in commercial development using a range of technology platforms (ELISA and lateral flow device) for protease biomarker analysis in point-of-care patient management with utility for patient stratification (Invest Northern Ireland, £200K). The ***Protease Inhibitor Programme*** (Walker, Martin and Scott) focuses on development of novel strategies for the inhibition of proteases implicated in cancer, bacterial biofilm formation, and ion-channel action. This has led to the generation of small molecule inhibitors of biofilm formation, caspases in apoptosis and serine protease inhibitors to delineate the role of proteases in the activation of sodium ion channels in cystic fibrosis (Martin and Walker, Cystic Fibrosis Trust, £165K). Research in this theme has also examined biologic inhibitory approaches towards the cathepsin L sub-family of tumour-associated cysteine proteinases. A key outcome of this work is an antibody developed towards cathepsin S, Fsn0503, supported by KTP funding and out-licensed to Fusion Antibodies Ltd., and which is anticipated to enter Phase I trials in 2013. The ***Characterisation of Proteases in Disease Programme*** (Scott, Walker, Burrows with Burden-ECR) involves the combination of cell and molecular biology in conjunction with gene knockout animals to study the roles of proteases in diseases such as cancer. Work is currently in progress to examine the role of the cysteine protease cathepsin S in promoting tumour angiogenesis and chemokine regulation (MRC, £365K). Additionally, research in the deubiquitinating enzyme USP17 has shown that this protease modulates another protease, Ras converting enzyme 1 (RCE1), which has major implications in proper GTPase processing in cells (funded through BBSRC in conjunction with Medical School staff, £165K).

NATURAL DRUG DISCOVERY THEME

The ***Natural Peptides Programme*** (Shaw, Chen, Zhou) focuses on identification of novel bioactive peptides and proteins of therapeutic interest from amphibian skin secretions that are rich sources of bioactive peptides. This has resulted in development of a series of potent bradykinin-like peptides, anti-angiogenics, anti-inflammatories and a range of novel antimicrobial peptides acting through membranolysis. This theme is the basis for the School's cooperative research activities with Chinese institutions, including the MPhil research degree programme and the new in-country China Queen's College, and attracted £120K from industrial funding and the Royal Society. Most recently, a spin-out company (Althexion) has been established with external investment to further exploit key lead drug candidates.

CHEMICAL BIOLOGY AND MEDICINAL CHEMISTRY THEME

This is a developing theme introduced during the present REF period, with new strategic appointments to strengthen the MT cluster in synthetic molecule development. The ***Enabling Novel Phosphorus and Aminoglycoside Chemistry Programme*** (Migaud) uses ionic liquids (ILs) to overcome insolubility of reagents in solvents and the decomposition of sensitive reagents/products over the course of synthetic reactions in collaboration with Hardacre, School of Chemistry (£113K, EPSRC). Similarly, aminoglycosides are powerful antimicrobials displaying limited man-made chemical versatility due to their poor solubility in standard organic solvents and

high level of functionalisation. These are currently being investigated under IL/mechanochemical protocols through funding with the EPSRC (£332K, in collaboration with Scott and also Taggart, Medical School). Migaud and Gilmore are partners in the recently announced UKRC-funded *SynbCite* Innovation & Knowledge Centre for synthetic biology, led by Imperial. The ***Bridging Chemistry and Biology of G Protein-Coupled Receptors Programme*** (Tikhonova) employs molecular dynamics to rationalise the biology of G protein-coupled receptors, a broad range of therapeutically important receptors. On-going research projects supported by the Royal Society include investigating the organization, dynamics and interactions of the bioamine receptors.

c. People, including:

i. Staffing strategy and staff development

In RAE 2008, the School of Pharmacy submitted 23 Category A staff for assessment, out of a total cohort of 25. Category A staffing throughout most of the assessment period (until June 2012) averaged 27 FTE, rising to 33 FTE currently, as a result of university investment in Pharmacy. The distribution of staff amongst the various grades is: Professors (11), Readers (5), Senior Lecturers (3), Lecturers (7) and Lecturers on Probation, within initial 3 years of appointment (7), with six such appointments in 2012. There were also 12 internal promotions to senior lecturer or above. The staffing increase, supported by 29 FTE support staff, has allowed the development of eight overall research themes, including a new theme in Chemical Biology and Medicinal Chemistry, a strategic decision to further facilitate collaboration with cognate disciplines in chemistry and biomedical sciences. The staff cohort, supported by 32 postdoctoral researchers (*cf.* 22 in RAE 2008), now provides for long-term stability and succession planning, with staff well distributed across the levels of the professoriate, reader/senior lecturer, lecturer and early stage career appointments. At a senior University level, the School currently provides the Dean of Faculty (Gorman) and Pro-Vice-Chancellor for Research and Postgraduates (McElnay).

Staff development is a strategic priority, given the continued expansion of the School during this period and the number of recent probationary staff appointments. The School currently has seven staff meeting the definition of 'early career researcher. Thus, as a School policy, probationary staff members are assigned lower initial teaching loads and minimal administrative duties in order to allow them to develop as independent researchers. In addition, the University provides newly appointed lecturers with a £10k 'start-up' career development award. An individually agreed, three year structured development programme forms an integral part of the academic probation process, monitored by a support group of senior staff. Each probationary staff member is assigned a senior member of staff as a mentor. The School also has a 'pump-priming' policy of funding a studentship for each new staff member and providing enhanced funds for conference attendance. A key aspect of support for new staff on their first academic appointment is the School's policy of funding a stay of up to 3 months for such staff in a leading international research centre relevant to their research. Thus, within the past two years, four younger members of staff were supported by the School to work in leading institutions abroad (USA, Australia, Singapore) to establish productive new research collaborations. This policy has now been in place for some years and has been highly successful, with maturing research collaborations, reciprocal visits and joint outputs published.

All staff members have their progress regularly reviewed against agreed yearly targets in a formal appraisal process carried out by the appropriate Director of Research. A university-wide Staff Development and Training Programme offers a range of courses appropriate to the development of research skills. All newly appointed staff, unless equivalently qualified, must pass (within the probationary period) the University's Postgraduate Certificate in Higher Education Teaching. All staff supervising postgraduate students must attend the course on 'Supervising Research Students' and those involved in academic appointments, including postdoctoral appointments, must attend a 'Selection Interviewing' course. All staff members are required to attend a training course on 'Equality and Diversity' and there are additional courses in this area for senior staff with managerial responsibility. All University policies, including those pertaining to REF, are compliant with current legislation in this area and the university has a well-established Equal Opportunities Unit that is responsible for developing policies, monitoring Equality and Diversity issues, staff training and compliance with relevant legislation. The School of Pharmacy holds a Bronze SWAN Award from Athena, reflecting its commitment to identifying and implementing good practices to

support the careers of female academics and all contract research staff. There is a policy of reduced teaching load for six months for returning academics following maternity leave to facilitate re-engagement with their research programmes. For contract research staff, there is full support for the University's Research Staff Development Programme and the national Concordat relating to this staff group. The School has a 'Good Practice' working group, chaired by Migaud, which is responsible for implementing the School's SWAN action plan and for support and advice for postdoctoral contract research staff in respect of career development. This group also monitors destinations of both postdoctoral and doctoral leavers.

ii. Research students

Studentship provision for postgraduate research is seen as vital to research development. The School contributes to research studentship provision directly from funds raised through its entrepreneurial distance learning programmes and other commercial activities. Total FTE research student complement has increased by ~25% in this period to *ca*. 100FTE, an indication of the vitality of the School and its research activities. Current research students come from 16 different countries and span a range of first degree disciplines in addition to pharmacy. Of particular note is the one year (by research) MPhil in Pharmaceutical Biotechnology, provided by the Natural Drug Discovery Programme, which now has an annual intake of 24 students from leading Chinese partner universities, led by the University of Fuzhou. Each year several of these students opt to continue their studies to PhD level. This highly successful programme has led directly to the recent signing of an agreement to establish the 'China Queen's College' on the new campus of China Medical University (CMU) in Liaoning Province PRC, as a joint venture college of Queen's University and CMU, offering Queen's degrees in pharmaceutical sciences developed and operated by the School of Pharmacy. The agreement also provides for research cooperation, staff interchange and development in the area of Natural Drug Discovery.

All research students must complete 30 days of skills training over the course of their 3-year research degree. To support postgraduate research students and help with their personal development, high quality training programmes that are compliant with UKRC recommendations have been established, incorporating a wide range of research seminars by distinguished visiting researchers. The School of Pharmacy also provides a number of specific compulsory courses for all postgraduates, including a School Induction Session, Health and Safety Training, Laboratory Demonstrator Training and Library Orientation. A Postgraduate Student-Staff Consultative Committee provides an opportunity for students to raise issues with staff in an open and supportive environment. A policy of joint supervision of research students operates in the School. There is a formal Annual Programme Review of research degree programmes.

Formal admissions and assessment procedures, studentships, allocation of supervisors and good supervisory practice are the responsibility of the School Postgraduate Research Committee (SPGRC), chaired by a DR (Hughes) and assisted by a Senior Postgraduate Tutor (McCarthy), with dedicated clerical support. SPGRC, responsible to the Head of School (Woolfson), operates within the School Research Strategy and the Quality Assurance Framework overseen by the University Academic Affairs Directorate. In particular, it is responsible for the annual review of student progress. For each student, there is an annual Progress Review Panel appointed by SPGRC. First and second year students provide a written report on their progress to date, an updated research plan and details of postgraduate training undertaken. Third year students additionally provide a sample thesis chapter. The panel meets individually with all students and makes recommendations to SPGRC with regard to progress, taking into account the primary supervisor's views. On this basis, SPGRC decides if a student can proceed to the next level. There is an established appeals process.

d. Income, infrastructure and facilities

The School of Pharmacy has a long history of knowledge transfer activities that is coupled with a much-expanded (since RAE 2008) portfolio of fundamental studies funded by the UK Research Councils, EU and leading charities. The importance of the work being done is also demonstrated by the large range of national and international collaborators from leading research centres now partnering many programmes, further enhancing the dissemination of internationally leading

findings to the global research community. The long-established relationship with local company Galen continues to the present day with its successors Almac Group and Warner Chilcott Inc. The connection with these companies resulted in their founders donating over £7 million to the School for strategic research development between 1998 and 2006, laying the foundation for the vibrant research environment that is evident today.

The School of Pharmacy received total new grant awards of £14.2M in this period. UKRC (BBSRC, EPSRC, MRC) grants were £3.7M (26%), a substantial increase compared to RAE 2008 (£1.4M). Research in Clinical Pharmacy and Pharmacy Practice (7 FTE) won £3.7M of new grants, Molecular Therapeutics (14 FTE) £3.8M (including £2.0M from UKRC), and the combined programmes in Drug Delivery and Biomaterials (12FTE) had new awards of £6.7M, including £1.5M from UKRC. Major funders were UKRC, CRUK, US National institutes of Health, Wellcome Trust, HSC R&D (NI) and NHS Trusts, Royal Society, EU Framework VII, leading national and international charities (particularly those connected with control of the HIV pandemic, where funding of £2.8M was secured), and industry. Knowledge Transfer Programmes (KTP) with industry were worth an additional £714k.

Major infrastructure developments in the period included: the completion of a new £1M laboratory for Medicinal Chemistry (funded by the earlier £2M King donation noted in RAE 2008); commissioning of new research laboratories (500 m^2) for Molecular Therapeutics; a new microbiology laboratory to accommodate a £850k funded programme on cystic fibrosis and infection; a new pharmaceutical engineering (extrusion and injection moulding) laboratory (£900k) for the HIV Drug Delivery Programme, funded by IPM. In the period, research equipment spend was £2.2M, including major items such as a new NMR facility. Infrastructure investment overall was *ca.* £3.5M, with further laboratory upgrades currently being undertaken by the Estates Directorate. Since RAE 2008, the School has expanded into neighbouring buildings on the Health Sciences Campus to accommodate these various developments and now occupies around 5600 m^2 of space compared to 4000 m^2 in 2008. Where appropriate, research in the School undergoes scrutiny by the Office for Research Ethics Committees in Northern Ireland (ORECNI) or equivalent.

e. Collaboration or contribution to the discipline or research base

Research conducted within the School of Pharmacy is multidisciplinary, entrepreneurial in nature, clinically relevant and facilitated through strategic collaborations locally, nationally and internationally. There is a vibrant invited research seminar series, with some 30 invited speakers in the period from 10 different countries. Selected productive **National/International Collaborations** in the period included: ***Bioactive Biomaterials and Infection Control*** Prof M Bruschi, State Univ. of Maringá, Brazil; Dr K Bica Technische Universität Wien, Austria; Prof H Ceri, Univ. of Calgary, Canada; Prof T Gunnlaugsson, Trinity College Dublin; Prof P Kruger, Univ. of Canterbury, New Zealand; Prof C Lee, RCSI Ireland; Ireland Prof Robin Rogers, Univ. of Alabama, USA. ***Drug Delivery*** Prof J.McGinity, Univ. of Austin at Texas, USA; Prof J.P. Remon/Prof. C. Vervaet, Univ. of Ghent, Belgium; Prof T. Rades/Prof. N. Medlicott, Univ. of Otago, New Zealand; Prof D. Brayden, Univ. College Dublin; Dr. B. Boyd, Monash Univ., Australia; Prof. J Moan, Norway Cancer Institute; Prof R Veazey, Tulane Univ. School of Medicine, USA; Prof J Moore, Cornell Univ., USA; Prof G Nabel – National Institutes of Health, USA; Profs P Augustins / J Brouwers - K.U. Leuven, Belgium; Prof R Le Grande, Atomic Energy Commission, France; Prof R Shattock, Imperial College, UK ***Primary Care/Clinical*** **Pharmacy** Dr. S. Byrne, Univ. College Cork,; Prof. V. Mor, Brown Univ., USA; Prof. K. Lapane, Virginia Commonwealth Univ./ Univ. of Mass,USA; Prof. N. Kerse, Auckland Univ., New Zealand; Prof. G. Doering, Univ.of Tübingen, Germany; Dr. L. Hoffman, Univ. of Washington, USA; Prof. R. Boucher, Univ. of North Carolina, Chapel Hill, USA; Dr. P. Ho, National Univ. of Singapore; Dr. B. Stuart, Queensland Univ., Australia; Prof. I. Lutsar, Univ.of Tartu, Estonia; Dr. H. Mulla, Univ.of Leicester, Prof. M. Beresford, Univ. of Liverpool. ***Experimental Therapeutics*** Profs J Bartlett/R Bristow, Ontario Institute for Cancer Research, Canada; Prof K Pacak, National Institutes of Health, USA; Dr A Hatefi, Rutgers Univ., USA; Dr C Vearing, InnovationXchange, Melbourne, Australia ***Natural Drug Discovery*** Prof P Verhaart, Univ. of Delft, Netherlands; Prof P Rao, Institute of Biotechnology of Fuzhou Univ., China; Prof A Ding, Pharmaceutical Univ. of Nanjing, China; Prof Ji Cai, China Medical Univ., China ***Proteases and Inhibitors*** Prof M. Hollenberg, Univ. of Alberta, USA; Prof T Langer, Universität Innsbruck, Austria;

Dr A Long, Trinity College Dublin; Dr M de la Vega, Emory Univ., USA; Univ. of North Carolina, Chapel Hill, USA; Dr J Joyce, Memorial Sloan Kettering Cancer, USA; Prof Gilles Lalmanach, Universite Francois Rabelais, Tours ***Chemical Biology/Medicinal Chemistry*** Prof. R. Bremner, Univ. of Iowa, USA; Prof. R. Sobol, Univ. of Pittsburgh, USA; Prof. M Siegler, Univ. of Bergen, Norway; Prof. J. Denu, Univ. of Wisconsin, Madison USA; Prof. D. Fourmy, Univ. of Toulouse, France. Several staff members (Donnelly, Gilmore, Gorman, Hughes, Jones, McCarthy, Shaw, Walker, Woolfson) held **honorary or visiting positions** with collaborating institutions in Norway, USA, Brazil, China, Canada and New Zealand.

Major Awards: BBSRC Innovator of the Year 2013, GSK Emerging Scientist Award 2012, RPS Science Award 2010, AAPS Meritorious Manuscript 2013 (Donnelly). RPS Science Award 2013 (Gilmore). **Fellowships**: Royal Society (Jones, Andrews, Scott), National Institute for Health Research (Tunney) and the R&D Division of the Public Health Agency (Parsons, Ryan).

During the period, staff made **Contributions to the Discipline** through grant and journal reviewing, plenary and invited conference presentations, guest editorships, chairing conference sessions, external examining and a range of specific activities, a selection of which are: **Journal Editorship** Journal of Pharmacy and Pharmacology; Drug Delivery (***Jones***); Recent Patents on Drug Delivery and Formulation (***Donnelly***) Associate Editor Journal of Cystic Fibrosis, PloS One, BMC Musculoskeletal Disorders (***Tunney***) **Editorial Board Membership** International Journal of Oncology, Pharmaceutical Patent Analyst (Scott); CRC Books (***Woolfson***); Journal of Clinical & Experimental Pharmacology (***Coulter***); International Journal of Clinical Pharmacy, International Journal of Pharmacy Practice, Current Drug Safety (***Hughes***); Pharmacy and BioAllied Sciences, Pharmaceutical Technology Europe, Recent Patents on Drug Delivery and Formulation (***Donnelly***); Journal of Pharmaceutical Sciences, Open Drug Delivery Journal, Open Biomedical Engineering Journal, Journal of Pharmaceutics (***Jones***); Therapeutic Delivery, Drug Development & Industrial Pharmacy (***Andrews***); Chemical Biology & Drug Design (***Gilmore***); International Journal of Clinical Pharmacy' International Journal of Pharmacy Practice (***McElnay***) **Chair/Committee Member of Scientific/Professional Organizations** Chair, British Pharmacopoeia Commission, Leader UK Delegation, European Pharmacopoeia Commission (***Woolfson***); Council Member Pharmaceutical Society NI (***Woolfson, Jones***); Chair of Pharmacy Practice Research Trust Bursary Awards Panel, Chair of Galen and Linstead Award panel, Pharmacy Practice Research Trust and Royal Pharmaceutical Society, Member of HSC R& D Fellowship Evaluation Committee, HSC R&D Institute of Hospice and Palliative Care Doctoral Fellowship Panel, Pharmacy Practice Research Trust Bursary Awards, Reference Group on Pharmacy Public Health Policy, Royal College of General Practitioners' Research Paper of the Year Award Panel, Royal Pharmaceutical Society's 'Scientific Roadmap' Committee (***Hughes***); UKI Controlled Release Society (***Malcolm***, Secretary & ***Andrew***s, Member); Member of the National Cancer Research Institute (NCRI) Clinical and Translational Radiotherapy working group, Radiation and Cancer Biology Committee, British Institute of Radiology, Secretary of the Association for Radiation Research (***Robson***); Society for Applied Microbiology Exec. Committee (***Gilmore***); NIHR Medicines for Children Research Network (MCRN) – Chair of Pharmacy and Pharmacology (***McElnay***); Society for General Microbiology Clinical Microbiology Research Committee (***Tunney***) **Research Assessment** REF 2014 sub-panel member, Member of International Review Board, School of Pharmacy, National University of Singapore' Research Assessment Exercise review for School of Pharmacy, University of Hong Kong (***McElnay***) **Conference Organisation** Practice Chair of the British Pharmaceutical Conference 2008, Member of the Practice Research Adjudication Panel for the BP/RPS Conference, Chair of Research Sessions at BPC/RPS (***Hughes***);1st International Conference on Metal Chelation in Biology and Medicine, Bath (2009), 1st International Conference on Microneedles, Atlanta (2010),Skin Vaccination Summit, Washington (2011) (***Donnelly***); Royal Pharmaceutical Society Conference 2012 (***Ryan***); European Society of Clinical Pharmacy, 40th ESCP Symposium on Clinical Pharmacy, Dublin (***McElnay***); 22nd European Conference on Biomaterials, 2009, Switzerland, The biological basis of infection control SGM Meeting, 2008, Edinburgh (***Tunney***); APSGB Amorphous IV 2012, Amorphous III 2010, APSGB Materials by Design 2011, UKICRS Research Symposium 2011 (***Andrews***); European Radiation Research Society Conference, 2013, Dublin (***Robson***).