Institution: University of Manchester

Unit of Assessment: UoA5

a. Overview

This unit of assessment (UoA5) maps directly onto the Faculty of Life Sciences (FLS), where research in biological sciences at the University of Manchester is focussed. FLS was created to be unconstrained by organisational boundaries; as such it has a single department structure that maximises opportunities for interdisciplinary and collaborative research. It has the necessary scale, composition and facilities to permit the formation of effective interdisciplinary research teams that are essential to address successfully the principal biological challenges faced in the twenty-first century.

Research in FLS covers the wide range of processes that enable life. The complexity of underpinning biological mechanisms is such that effective progress requires questions to be posed at different levels of organisation and involves the application of a range of technological approaches. Enquiries by researchers are at the level of individual atoms in biological processes, through to studies at the cellular, tissue and organismal levels, and ultimately the impact of the environment on all of these processes.

Research is organised and supported through 13 thematic Research Groups in which cognate researchers with common research interests and methodologies are co-located. The Research Groups are:

- Biophysics and Structural Biology
- Cell Organisation and Dynamics
- Computational and Evolutionary Biology
- Developmental Biology
- Environment, Ecology and Evolution
- Eye and Vision Sciences
- Gene Regulation and Cellular Biotechnology
- History of Science, Technology and Medicine
- Immunology and Molecular Microbiology
- Molecular Cancer
- Neurosciences
- Physiological Systems and Disease

FLS hosts a number of internationally recognised research centres and institutes, all of which have significant external, long-term funding. These centres coalesce clusters of researchers from within and outside FLS, who are committed to working across discipline boundaries, thereby catalysing interdisciplinary research.

Highlights in the REF period include:

- Establishment of the Manchester Collaborative Centre for Inflammation Research (initial £15m joint investment with industry)
- The opening of the Manchester Institute for Biotechnology (current research portfolio £46m)
- 34 outputs in Nature, Science and Cell by FLS staff
- Recruitment of ten Chairs and 28 Research Fellows

This REF return for UoA5 (144 FTE) is lower than in RAE 2008. This is because UoA5 is concentrated wholly on FLS and not on two separate UoAs (14 and 15) as in the previous RAE, which as a consequence included a significant number of staff from other Faculties.

b. Research strategy

1. FLS Research vision

The FLS research vision is ambitious, addressing four global **Research Challenges**: 'Understanding Life', 'Disease Biology', 'Biotechnology for Industry' and 'Sustainable Environments'. To realise this vision, the FLS strategy has six essential components which it has delivered on during the REF period:

1. To promote interdisciplinary research by developing world-leading clusters of researchers or research centres in areas of both existing strength and strategic importance. (Progress: *two cross faculty sLoLas of total value £8.3m awarded in 2012, over 30% of outputs returned in REF are interdisciplinary*)
2. To recruit established world leaders in research and attract early career researchers through externally funded independent fellowships. (Progress: *ten external Chairs and 28 Fellows recruited during the REF period*)
3. To house staff in new buildings that encourage interaction and facilitate access to essential technologies. (Progress: *£36.5m invested in new buildings and refurbishment over the REF period*)
4. To recruit high calibre research students and support their development in an effective manner to contribute to internationally leading research. (Progress: *500 PhD students graduated during the REF period, with an 88% completion rate*)
5. To maximise interactions with other disciplines and with industry, thereby increasing industrial funding and optimising pathways for research impact. (Progress: *300% increase in industrial income from all sources since 2008)*
6. To allow staff to realise and maximise their research ambitions and recognise and reward this through effective management of their contributions to the Faculty. (Progress: *introduction of contribution mapping management tool and 30% reduction in small group teaching for the top 25 most active researchers since 2011*)

1.1 Promotion of interdisciplinary research

Research across the breadth of biology is a central aspect of our strategy and has been addressed in a number of ways:

a) The structure of FLS, a single department, unconstrained by organisational boundaries, maximises opportunities for interdisciplinary, collaborative research. Within this structure, the 13 thematic Research Groups serve primarily to co-locate cognate researchers who share research interests and methodologies. However, these Research Groups are extremely porous as evidenced by their track record of inter-group collaborative research. For example, 27% of externally funded grants have investigators from two or more Research Groups and currently over 50% of all externally funded grants involve two or more researchers from FLS.

b) FLS hosts a number of well-established and internationally recognised research centres and institutes defined by significant external long-term funding. These centres serve to coalesce clusters of researchers that catalyses and delivers interdisciplinary research. Many of these centres include staff from all four faculties of the University.

- FLS is a major contributor to the research community in the Manchester Institute for Biotechnology (MIB) relaunched in 2012. MIB is home to a multi- and inter-disciplinary group of researchers who are trained in physics, chemistry, mathematics, computation, engineering and biology, and committed to working across discipline boundaries. Researchers in MIB currently hold research grants valued at over £46m of which £17m is attributable to FLS investigators. Funding is largely derived from the UK Research Councils, BBSRC (45%) and EPSRC (12%), with a growing contribution (33%) from the European Commission, industry and charities. Currently, MIB has cross-campus collaborations with over 80 investigators and active collaborations with over 500 different research institutions in 65 countries.
- Wellcome Trust Centre for Cell-Matrix Research (WTCCMR). Established in 1995 as a Centre, it investigates the role of cell-matrix in health and disease. It currently has 16 Principal Investigators (PIs) and 40 Post Doctoral Research Associates (PDRAs). During the REF period WTCCMR researchers have been awarded research grants to the value of £22m.
- Healing Foundation Centre for Tissue Regeneration. The Centre was established in 2006, following a £10m commitment from the Healing Foundation charity and the

University of Manchester. The Centre uses interdisciplinary approaches to advance the understanding of wound healing and tissue regeneration. During the REF period, researchers in the Centre were awarded £3.4m in research grants.

- The Centre for the History of Science, Technology and Medicine (CHSTM). Supported since 1986 as a Wellcome Trust Centre, CHSTM is one of the largest groups of history of science, technology and medicine in the UK, and is unique in being embedded in a life sciences faculty. Researchers in CHSTM work collaboratively across the University, with externally funded research projects with staff in all four faculties. During the REF period, CHSTM attracted research grant funding of £4.1m.
- The Centre of Excellence in Biopharmaceuticals (CoEBP) was established in 2009 through collaboration between the North West Development Agency and the European Regional Development Fund (total value £3.6m).
- The Manchester Centre for Biophysics and Catalysis began in 2010, and has attracted a diverse portfolio of external funding, including a joint BBSRC sLoLa (£4.1m), EPSRC Established Career Fellowship (£1.0m) and other BBSRC, EPSRC and industrial funding (£4.3m).
- The Systems Microscopy Centre established in 2010 has current funding that includes a BBSRC sLoLa (£4.2m), and MRC (£1.3m) and EU (£2.6m) grants.
- The KNH Centre for Biomedical Egyptology was established in 2003. The Centre focuses on medical and forensic Egyptology using multidisciplinary approaches such as medical computerized tomography, alongside osteological and palaeopathological methodology.
- In 2012, the Institute for Science Ethics and Innovation (iSEI) joined FLS and is embedded within CHSTM. iSEI explores the moral imperatives and public interest that underpin the theory and practice of science. The housing of iSEI within FLS was a strategic decision to maximise interactions between researchers in FLS and iSEI, and thereby add an ethical dimension to new and existing research projects, in addition to offering novel pathways to research impact. Evidence of interactions is exemplified by involvement in the ethics work package for the recently launched SysmedIBD project (EU FP7, €12m).
- The Manchester Collaborative Centre for Inflammation Research (MCCIR) was established in 2012. MCCIR is a £15m joint investment between the University and two industrial partners, AstraZeneca and GlaxoSmithKline, jointly hosted by FLS and the Faculty of Medical and Human Sciences (FMHS). This model of triangulating fundamental science with clinical and industrial partners and co-locating staff from each organisation in one centre, offers a new vehicle for maximising the impact of the research in FLS and FMHS in preventing and curing disease.

c) Biomedical research in FLS partners closely with FMHS and the Manchester Academic Health Science Centre (MAHSC). Twenty eight FLS PIs are co-located with 15 FMHS clinician scientists in the AV Hill and Core Technology Facility buildings, which optimises joint working on clinically-focused research projects in areas such as immunology, inflammation and neurobiology. During the REF period, the success of this approach is evidenced by the 92 grants held jointly between FLS and FMHS and 160 joint publications. Through representation on the MAHSC Executive team, FLS is able to contribute to MAHSC's two key goals of delivering world-class excellence in basic science relevant to medicine and health and conducting translational and clinical research to link discovery science to patient benefit.

d) FLS actively promotes inter-disciplinary research through considerable internal investment. Since 2010, FLS has invested £150k in pump-priming research projects. This internal support has resulted in three successful external grant awards in 2013, worth £1.3m (MRC £617k, BBSRC £555k and Kids Kidney Research £111k). In 2013, this policy was extended to support interdisciplinary projects between FLS and FMHS in which each Faculty contributes £250k p.a. The Wellcome Trust Institutional Strategic Support Fund, awarded jointly to FLS and FMHS

(£1m p.a. since 2011) is used in part (£212k p.a.) to support cross-Faculty biomedical research consortia. To explore the biomedical applications of graphene, since 2012 FLS has invested £40k p.a. to pump-prime interdisciplinary research with the National Graphene Institute.

1.2 Recruitment of world-leading scientists

The recruitment of world-leading scientists has been driven by the four global Research Challenges that underpin FLS's current research strategy. In total during the REF period, ten Chairs appointments have been made. Between 2008 and 2010, three Chair appointments were made: Systems Biology (White M), NMR for Structural Biology (Waltho) and Neurosciences (Sattelle). Since 2011, this recruitment policy has been supported by the University's Project Diamond initiative to appoint world-leading minds (120 new staff have been recruited to the University since 2011). In 2012, Chairs in Synthetic Biology (Takano), Pathway Engineering (Breitling) and Computational Systems Biology (Rattray) were recruited to support synthetic biology, specifically in the area of bioenergy, which is a component of our Research Challenge 'Biotechnology for Industry'. We foresee synthetic biology underpinning many aspects of the biosciences research agenda in the next decade.

The developments in MCCIR have been supported by investment in two Chairs in Immunology (Davis and MacDonald) and three fellowships (Lopez-Castejon, Travis and Fildes), reflecting targeted support to this new research centre and the 'Disease Biology' Research Challenge. To address the FLS Research Challenge of 'Sustainable Environments', considerable recent investment has been made in environmental biology in 2012/13, including a Chair (Bardgett), three Lecturers (Gilman, Sansom and Fitzpatrick) and three fellows (De Vries, Schultz and Rowntree). In 2012 a new director (Chamberlain) was appointed to the KNH Centre for Biomedical Egyptology to further develop molecular multidisciplinary biomedical Egyptology research.

This external recruitment policy was complemented by FLS's internal promotion policy to recognise and reward performance. During the REF period, there have been 27 promotions to Chair and 39 promotions to Senior Lecturer.

FLS's recruitment strategy is also to appoint early career academic staff, predominantly through the externally funded fellowship route. This is supported through an externally targeted FLS Fellowship Scheme, in which FLS offers one or two additional years of salary funding, allowing the fellow up to six years to develop their academic career.

During the REF period, FLS has attracted external funding for 28 career development and postdoctoral fellowships funded by MRC, BBSRC, Wellcome Trust, NERC, Royal Society and ERC etc. In 2011, three of the five BBSRC David Phillips fellowships, were awarded to FLS (Brown, Bechthold and Paszek). During the REF period, FLS has underwritten all but one of its externally funded fellows, as a first step into permanent academic positions. This reflects the effective way in which FLS nurtures fellows, allowing them to develop successful independent research programmes.

FLS has attracted funding during the REF period for 12 senior personal fellowships and awards. FLS hosts one of only two BBSRC Industrial Fellows (Rhodes M), he has played a central role in developing interactions with industry for CoEBP (see Section 1.5).

1.3 Location of research staff in new buildings

During the REF period, FLS has continued its ambitious capital building programme to re-house all FLS staff. The AV Hill building, completed in 2008 at a cost of £40m, houses 28 PIs in Neuroscience, Immunology and Molecular Microbiology, and Physiological Systems and Disease Research Groups. These staff are integrated with 15 complementary PIs from FMHS. The animal facility was refurbished at a cost of £30m over 2008-2010. In 2011, the Carys Bannister building that houses Optometry and the Eye and Vision Sciences Research Group, was opened after a £3m refurbishment. This building also includes Eurolens Research, which provides clinical evaluation and consultancy services to the contact lens industry worldwide. In 2013, the top floor of the AV Hill building was furbished at a cost of £3.5m to provide joint research space for FLS and FMHS, to facilitate interdisciplinary biomedical research and

accommodate new recruits. Further capital building is ongoing, with an anticipated additional £30m investment in FLS buildings for the period up to 2018. This investment forms part of an ambitious University Estates Masterplan, with £750m investment to 2018 and a further £300m investment to be made by 2022.

1.4 Recruitment of high calibre research students

This is detailed in Section 4.0 below.

1.5 Maximising interactions with industry

Our overall aim is to translate the knowledge that derives from our research into tangible, lasting benefits that impact on health and wealth. Engagement with industry and other end-users offers additional funding streams, and access to new scientific and technical expertise, and can optimise the pathways to impact. As part of this, CoEBP was established in 2009 (see Section 1.1) and brings together expertise to accelerate the development, and provide certainty, in the production, harvest and utilisation of biopharmaceuticals. Since its establishment, the Centre has empowered interdisciplinary (biology, chemistry, chemical engineering, pharmacy, systems biology) engagement with industry. CoEBP has engaged with 52 companies, both SMEs and larger organisations in the UK and internationally. It has generated research income of £6m including 6 BBSRC BRIC projects, total value £4.4m, a BBSRC Industrial impact Fellowship (Rhodes M), £396k, and 16 industrial CASE studentships.

To augment the FLS partnerships with industry, an Associate Dean for Business Development (Kimber I, previously at Syngenta) was appointed to this role in 2009. Since 2010, FLS has invested in three PhD-qualified Research Business Managers, whose role is to develop and facilitate partnerships with industry. This has facilitated active partnerships and collaborations with more than 65 companies (from start-up biotechnology/biopharmaceutical companies, through SMEs, to large multinational companies). Among our long-term strategic industrial collaborators are AstraZeneca and GlaxoSmithKline with whom FLS and FMHS have jointly funded the establishment of the MCCIR (see Section 1.1). One indicator of the increasingly productive alignment of FLS with industry is the value of industry income from all sources (contracts, services supplied and consultancy) deriving from industrial collaborations, which has more than tripled in the last 5 years from £1.0m per year in 2008 to over £3.2m in 2013. In addition, during the REF period, FLS has been awarded an MRC MICA (total value £1.9m) and four BBSRC IPAs (combined total value of £2.1m from BBSRC and £320k from industry).

1.6 Recognising and rewarding contribution

Critical to maximising research productivity is to balance the workloads of all academic staff in order to provide them with time for creativity and innovation. To this end, in 2011, FLS introduced a process of individual assessment of relative contributions to different areas of academic activity, using an HR tool called Contribution Mapping. This process is described in detail in the Staffing and Staff Development Section below (see Section 3.1). This approach has allowed evidence based decisions to be taken about an individual's contributions, resulting in a 30% reduction in small group teaching for the top 25 most active researchers since 2011. FLS also recognises and rewards contribution in all areas of academic endeavour equally, thereby helping to align staff contribution with individual skills and ambitions.

2. Research culture

Essential to delivering on our research strategy is maintaining a vibrant research environment. The research culture is not only a reflection of the commitment of the researchers in FLS but is also dependent on the research infrastructure, providing effective mechanisms for the dissemination of research and maximising impact.

2.1 Research infrastructure

The high quality of research infrastructure in FLS is in part a consequence of continued capital investment (see Section 1.3). As a result, research is undertaken in a series of exceptional buildings, all built in the past decade. Research infrastructure has been enhanced by

investment in 12 core experimental research facilities, ranging from imaging and genomic technologies, to protein expression and biomolecular analysis. These core facilities, available to all staff and students, house advanced equipment and resources and are fully supported with 15.5 Senior Experimental Officers, 9 Experimental Officers and 13 technicians. Since 2008, over £20m has been invested in equipment to furnish the core facilities, these funds being a mixture of internal investment and external equipment funding. The core facilities have an annual budget of £200k for ongoing equipment maintenance. Research is further supported by a cadre of 71 highly skilled research technicians.

2.2 Research dissemination

To maximise dissemination of research, FLS has introduced the following focused schemes:

- An annual Research Symposium, to showcase research excellence across all Research Groups, involving over 800 delegates. This includes oral presentations from PDRAs and postgraduate students (PGR) who have published the best first author research paper in a top journal of international repute during the previous year. All second year postgraduate students give poster presentations, and there is a special seminar from the FLS Researcher of the Year. At the symposium industrial collaboration is also recognized with awards for the 'Best New Industrial Collaboration' and 'Most Promising New Innovation'.
- A series of annual symposia organised by individual Research Groups, such as the North West Microbiology Research Symposium, which offer opportunities for PDRAs and PGR students to present their research.
- In 2012, we initiated a twice-yearly event when leading biosciences journal editors (e.g. Nature, Science, PLoS Biology and Current Biology) are invited to Manchester. Editors outline the editorial policies of the journals and have the opportunity to appreciate first-hand the quality of research in FLS. This is a long-term strategy to increase the number of outputs in high quality journals and build a long-term relationship with key journal editors. As an example of its efficacy, there has been an increase in outputs published in Current Biology from two per year in 2010/11 and 2011/12, to 16 in the current year.

2.3 FLS strategy for developing impact

The University's vision is that we will be at the leading edge of realising impact from both research and training. This is achieved through the commercialisation of intellectual property, working with business, linking fundamental science to patient benefits, providing the evidence base for public policy (especially in the context of societal challenges) and public engagement (see Sections 2.4, 2.5 and Impact Template). In addition, FLS provides training and support in enterprise and entrepreneurship (see Section 3.2). FLS is leading on a University bid to the BBSRC Excellence with Impact competition 2013-16. During this process the current FLS strategy for developing impact will be refined and revised with guidance from the BBSRC during the competition.

2.4 Business development

Commercialisation and business development is managed by a University subsidiary company (UMI^3). From 2008 to 2013, FLS had achieved total proof-of-principle funding of £1.4m, a total grant income associated with IP of £4.7m and 283 disclosures. These developments have been enabled by a substantial, well-established support infrastructure that aims to optimise business engagement with a view to generating significant economic impact. This infrastructure includes an Associate Dean for Business Development, three Business Development Managers within FLS and three Commercialisation Managers in UMI^3 to support technology transfer from FLS. During the REF period, two established spin-out companies have been further successfully developed (Gentronix and Ai2) and a new spinout Conformetrix/C4X Discovery has become well established with significant external investment (see relevant impact cases for turnover and staffing levels). In addition three more spin-outs have been launched in the last 12 months (Alegenetica, PharmaKure and Microsensor). See Section 1.5 for FLS strategies for maximising interactions with industry.

2.5 Public engagement

In 2010, an Associate Dean for Social Responsibility position was created (Cobb). Core to this role is supporting members of the Faculty to be involved in public engagement activities and critically to develop FLS's involvement in the local community. This position is supported by dedicated posts for public engagement and communications with an operating budget of £50k p.a. In 2011, FLS initiated an annual Faculty Community Open Day event. During the third Community Open Day in July 2013, scientists from FLS and FMHS hosted over 750 visitors with interactive educational activities, laboratory tours and family friendly demonstrations of experiments. In addition, FLS participates in a series of annual national and regional public engagement events each year. For example:

- Jodrell Bank Live (July, August 2013, 5000 visitors)
- Manchester Science Festival (October 2012, 3000 visitors)
- National Science and Engineering Week (March 2013, > 800 school children attended)

Since 2011, FLS has published a fortnightly podcast highlighting its research (>700 downloads per episode). FLS has also created a series of subject focused activities (Body Experience, The Brain Bus, The Worm Wagon, Why Flies?) which are regularly taken into public spaces communities (e.g. local train stations and libraries) or museums (e.g. the Manchester Museum and Manchester Museum of Science and Innovation). FLS also has schemes for directly involving children from local widening participation schools in research, through a work experience programme (240 school students have attended the work experience programme between 2010 and 2012) and by sending final year students (48 students in 2013) into local schools as part of their undergraduate projects.

In 2012, Ochu, previously an honorary Fellow in Public Engagement in FLS, was awarded one of only two Wellcome Trust Engagement Fellowships. The fellowship is to develop her career in public engagement, explore the wider use of citizen science to engage audiences in biomedical science and further the field of public engagement building on the excellent base already in place at FLS.

c. People:

3. Staffing strategy and staff development

FLS is committed to the delivery of high quality training and career development for all academic and research staff. This allows staff to realise their research aspirations and develop their careers. In the University Staff survey conducted by Capita in 2013 (response rate of 64%) the Faculty results identified a high level of job satisfaction in FLS:

- 94% say the Faculty is a good place to work
- 80% feel valued by the people they work with
- 84% are satisfied with their job overall
- 91% say research staff are valued as part of the Faculty community

3.1 Support of the research work of staff

To support research and balance workloads, in 2011 FLS introduced a process of individual assessment called Contribution Mapping (CM). CM involves academic staff reviewing with their line manager how their effort is currently apportioned and how it can be allocated most effectively in the future to deliver individual or Faculty goals. This information forms the basis for differentiating allocation of activity across FLS and to enable staff to spend the optimum time and effort on research. The evidence of the effectiveness of this approach is an increased differentiation of activities across FLS resulting in a 30% reduction in small group teaching for the top 25 most active researchers since 2011.

CM sits alongside the annual Performance and Development Review (PDR) process, in which academic managers agree the targets, training needs and development of an individual. In 2009/10, the PDR completion rates were 94% for academic staff (who use an online system) and 72% for research staff (who currently use a paper-based system, shortly to be moved over

to an online system in a drive to improve completion rates).

3.2 Bespoke training and development opportunities

Training and development is delivered through targeted programmes to different staff groups. New junior academic staff attend the New Academics Programme (NAP), which covers the spectrum of issues encountered by an academic within FLS, with the teaching units accredited by the Higher Education Academy. The programme has dedicated administrative support with two academic leads. Attendance at the NAP and successful completion of the assessments are mandatory aspects of passing probation.

3.3 Implementation of the Concordat to support the career development of researchers

The current cohort of PDRAs numbers over 250. Implementation of the Concordat has resulted in a dedicated annual training and development programme for these PDRAs. This provides over 50 opportunities to access training, which include conference style events, information sessions, interactive workshops, practical demonstrations, work shadowing and coaching or mentoring. In 2010/11, 43% of all PDRAs in FLS engaged with the optional programme. In 2013, a mandatory career planning unit was provided for all new PDRAs.

The 'Careers of Researcher Online Survey', which is completed every two years, provides valuable data on the progress of implementation of training. Of the respondents in 2013, 85% agreed that they had access to the necessary training and, of those who completed training, 90% rated the training as useful/very useful.

3.4 Support for early career researchers

In 2008, FLS set up an annual Career Development Award of up to £1500 for PDRAs at a pre-fellowship stage of their careers to undertake short periods of independent work and provide pilot data for independent fellowships or other funding applications. Since 2008, 28 awards have been made, six have led to external fellowships.

FLS provides a supplement of three months salary support at the end of PDRA contracts to facilitate new employment. On a case by case basis, internal bridging funds to support talented PDRAs between grants are available (£120k allocated in 2012/13).

Since its award in 2011, each year £75k of the funds within the University Wellcome Trust Institutional Strategic Support Fund (ISSF) has funded an internal 'Stepping Stone' two-year fellowship scheme. This scheme provides funds for PDRAs in FLS and FMHS to generate research data and write fellowship grant applications. To date, three such fellows have been awarded, one of whom has subsequently been awarded a Sir Henry Dale Fellowship (Woolner), a second has recently accepted an academic position outside of Manchester and the third is applying for external fellowship applications. In 2013, the Stepping Stone fellowship scheme has been extended to three years and is now open to external candidates.

In the case of fellows, as a result of the two-year fellowship extension outlined above (see section 1.2) since 2008, over 95% of existing fellows have successfully transferred to tenured academic positions.

New lecturers have a dedicated period of three years during which their teaching loads are maintained at a low level to enable them to focus primarily on their research. During this time they have a mentor from a pool of senior academic staff who provides advice and guidance during the establishment of their research laboratory and the acquisition of research funding.

3.5 Supporting equalities and diversity

In 2009 FLS gained an Athena SWAN Silver award that was renewed in 2013. This recognised our commitment to changing the culture and gender balance in decision making and ensuring gender balance in the recruitment and development of staff. In 2008 the Women in Life Science (WiLS) group was set up to support equality and diversity. The group is composed of women from all career levels throughout FLS and provides a networking forum and support for women throughout their career in FLS. It offers potential peer-based solutions to issues faced

by women in the scientific environment.

In 2010, FLS set up an Equality and Diversity Leadership Team (EDLT) of senior academics and professional support staff to explore the issues that affect women and minority groups. FLS conducted a Faculty survey in 2011 to assess the impact of WiLS and EDLT. When asked *'Do you regard FLS as having a female friendly and inclusive culture?'*, 93% of female respondents replied 'Yes', 80% of female respondents felt confident to speak at meetings and 78% felt they were listened to at meetings. As part of the programme of addressing gender equality within FLS, a series of workshops using external qualified executive coaches has been run. As a consequence of this commitment, the proportion of female staff holding a lectureship within FLS has increased steadily over the last five years to equal that of male colleagues, with two internal promotions of women to Chair positions in FLS in 2013. The EDLT has now set up an Athena SWAN working group in to develop an application for a Gold SWAN award.

4. Research students

All aspects of postgraduate activity including recruitment of the most talented students, supervisory record, student research progression, transferable skills training and thesis preparation and submission are carefully monitored by a team of academic staff and dedicated professional support staff. This activity is supported by a single, integrated Faculty Postgraduate Support Office that administers all aspects of postgraduate activity. FLS has an effective and sustainable doctoral training record as evidenced by the data below:

4.1 Funding and recruitment of PhD students

The total number of PGR students registered in FLS has risen from 328 in 2008/09 to 364 in 2012/13. This has been achieved by a combination of significantly increased investment of internal resource (£420k in 2008/09 to £840k in 2012/13), and a targeted and sustained effort to recruit more top quality international students (67 in 2008/09 to 113 in 2012/13). In 2012, the University was awarded a BBSRC Doctoral Training Partnership (DTP), the only DTP awarded by BBSRC to a single university, in which FLS was the major partner (21 BBSRC studentships p.a.). FLS hosts a Wellcome Trust four-year PhD programme (5 studentships p.a.) and has a joint PhD scheme with the Singapore A*STAR Research Institutes (10 studentships p.a.). In 2013, FLS was awarded two Marie Curie training networks, one led by Scrutton (€3.5m) that will fund 12 PhD studentships at Manchester, and another led by High (€2.8m) that will fund 12 PhD studentships in total (two at Manchester). Looking forward, FLS has just been awarded an EPSRC-MRC Centre for Doctoral Training in Regenerative Medicine, led by Kielty as Director, which will fund 60 students from September 2014 (over five annual intakes).

Since its inception in 2011, the University President's Doctoral Scholar Awards scheme has supported outstanding PhD students in FLS. The awards are open to all nationalities and either offer a £1k stipend enhancement to home students with RCUK funding or provide partial bursaries for international students. In 2012 six home and five international President scholarships were awarded to PhD students in FLS.

All supervisors wishing to recruit PhD students advertise projects on the FLS/University website and on FindaPhD.com. Applications for PhD studentships are submitted online and are circulated electronically to supervisors by the Graduate Office, which conducts a qualification assessment prior to circulation. Applicants are interviewed face-to-face (directly or online) by an independent Faculty PGR tutor or committee, to ensure they are of sufficient quality to succeed in obtaining a doctoral degree and to contribute positively to the Faculty.

In the 2013 'Postgraduate Research Experience Survey', in response to the question *'Overall I am satisfied with the experience of my research degree programme'* 87% of FLS students agreed (this was in the top quartile nationally). FLS also exceeded the national average for all of the following categories: supervision, resources, research culture, progress and assessment, responsibilities, research skills and professional development. Furthermore, the students ranked their overall experience in the upper quartile of national scores for both questions namely, satisfaction with the training and confidence that completion will be on time.

4.2 Supervisor selection

New academic appointees attend the NAP, which includes training on student recruitment and selection, supervision/co-supervision, engagement with eProg (the University's online progression monitoring system), project management, research teams and networks, and student support. New staff are mentored through their first PhD supervision by an experienced member of staff and must have a student complete successfully before they can assume full responsibility for a PhD student. Experienced supervisors whose submission rates drop below 80% cannot be the main supervisor on any Research Council funded studentship and must agree co-supervisory arrangements.

4.3 Training and progression monitoring

FLS has an integrated PGR student training and progression management systems. Initially developed in FLS, the online student progression platform eProg was implemented successfully across the University in 2010 for all PhD students. The system is now marketed to the HE sector as 'ProgressPlatform' and is in use in a cluster of HEIs. eProg integrates progression monitoring, skills training provision and management, personal/career development, feedback mechanisms and recording of personal achievement. All students have a personal advisor and postgraduate tutor. Students discuss their training needs with their supervisory team and mutually agreed targets are recorded and reviewed at subsequent progression meetings, this eventually forms the student's personal portfolio of skills and record of achievement.

Transferable training and employability skills are also managed through the eProg system. Training is delivered through compulsory intensive (one or two day) workshops. In year two, this includes the Careers Pathways Event (shortlisted for a Times Higher Award in 2010), an innovative workshop that draws expertise from the University's Careers Service, Research Councils and industrialists, providing opportunities to explore potential career choices. In years 3 or 4, training is linked to more immediate needs such as CV preparation, interview technique and viva preparation. All FLS PhD students can communicate their science through public engagement and communication events (e.g. Manchester Science Fair), as well as teaming up with PDRAs for entrepreneurial challenges such as Biotechnology YES. In 2010, FLS won this national competition overall, with awards in specific categories in 2008 and 2012.

FLS has a vibrant Postgraduate Society that organises a mix of academic and social activities. This includes a prestigious annual lecture (recent presenters include Bruce Alberts, Lord Robert Winston, Sir Alex Jefferies and Steve Jones), the annual FLS PhD student conference run by the students, and the annual Faculty Ball for all staff and PhD students.

4.4 Industry linked PhD studentships

Industrially linked PhD studentships are almost all funded at home/EU fee levels and represent approximately 20% of all home student registrations. 25% of FLS Research Council studentships are linked to industry in the form of CASE awards. Major CASE sponsors include: Aligent, AstraZeneca, Boehringer-Ingelheim, GlaxoSmithKline, Lonza, Medimmune, Novatis, Pfizer, Procter & Gamble, Smith & Nephew and Unilever. Approximately 5% of FLS home/EU students hold industry fully-funded studentships that are sponsored by Boehringer, Braekspear, Bruker, Dionex, Edimer, Newtricious, Novimmune, Royal Philips Electronics and Shell.

d. Income, infrastructure and facilities

5. Research income to FLS

Over the REF period, FLS has maintained its research income of ~£29m p.a. Across the HEI sector, FLS is currently the recipient of the largest amount of BBSRC responsive mode funding (£17m in 2012/13). Industrial income from all sources (research contracts, services supplied and consultancy) deriving from industrial collaborations has more than tripled in the last five years from £1.0m per year in 2008 to over £3.2m in 2013. Within this, industrial research contract income has grown from £606k in 2008/09 to £1.2m in 2012/13. Likewise EU government funding has doubled from £899k to £1.86m over the same period.

5.1 Highlight funding awards to FLS in the REF period

Large interdisciplinary research grants include:

- Two BBSRC sLoLa awards in 2012, joint with Faculty of Engineering and Physical Sciences (FEPS)
  - 'Systems Biology Analysis of Biological Timers and Inflammation' (£4.2m; White M)
  - 'Rapid Evolution of Enzymes and Synthetic Microorganisms for the Development of Industrial Biocatalysts' (£4.1m; CoIs: Scrutton and Leys)
- Three Wellcome Trust Institutional Strategic Support Fund awards made to FLS (joint with FMHS) of £1m each in 2011/12, 2012/13 and 2013/14 to enhance research strategies in biomedical sciences (Kielty)

Centre funding awards include:

- The Manchester Collaborative Centre for Inflammation Research (MCCIR), joint with FMHS (£15m, funded jointly by GlaxoSmithKline, AstraZeneca and the University; Kimber I; 2013)
- The Wellcome Trust Centre for Cell-Matrix Research, renewal funding (£3.7m; Streuli; 2009)

FLS coordinates large collaborative EU FP7 projects and Marie Curie Training Networks:

- 'Systems Medicine of Chronic Inflammatory Bowel Disease' (€12m, including £2.6m to Manchester; Muller; 2012)
- 'Systems Biology for Functional Validation of Genetic Determinants of Skeletal Diseases' (€11.9m, including £970k to Manchester; Boot-Handford; 2013)
- 'Magnetic Innovation in Catalysis' (€3.5m; Scrutton; 2013)
- 'The Biogenesis of Tail-Anchored Membrane Proteins: Knowledge and Exploitation' (€2.8m; High; 2013)

FLS is involved as a collaborative partner on many EU FP7 projects, including:

- ARISE (£600k; Rothwell; 2008), CISSTEM (£133k; Bergman; 2008), DirectFuel (£446k; Leys; 2010), LEUKOTREAT (£288k; Pavitt; 2010), PANACEA (£422k; Poulin; 2010), RADIANT, (£477k; Rattray; 2012) and RENEWALL (£213k; Turner; 2008)

Large equipment grants include:

- Regenerative medicine instrumentation, flow cytometry and cell printing (MRC; £674k; Kielty; 2013)
- Nikon A1R confocal system for the imaging of live embryos (Wellcome Trust; £303k; Amaya; 2011)
- Drosophila core facility (Wellcome Trust; £287k; Baines; 2009)
- Multi-colour LSR11 flow cytometer (Wellcome Trust; £203k; Travis; 2009)

Major personal fellowships and awards include:

- Bechtold – BBSRC David Philips Fellowship (£948km; 2011)
- Briggs – Wellcome Trust Senior Research Fellowship (£1.4m; 2009)
- Brown T – BBSRC David Philips Fellowship (£977k; 2011)
- Brown TA – ERC Advanced award (£593k; 2011)
- Buckley – Royal Society University Research Fellowship (£443k; 2012)
- Couper – MRC Career Development Award (595k; 2012)
- Hay – BBSRC David Philips Fellowship (£911k; 2010)
- Humphries M – MRC Senior Non-clinical Fellowship (£1.3m; 2012)
- Hurlstone – ERC Starter award (£1.2m; 2011)
- Kirby – Wellcome Trust New Investigator Award (£487k; 2013)
- Lucas – ERC Advanced award (£2.0m; 2011)
- Meng – MRC Career Development Award (964k; 2009)
- Papalopulu – Wellcome Trust Senior Research Fellowship (£2.0m; 2009)
- Petersen – CRUK Senior Research Fellowship (£672k; 2009)
- Scrutton – EPSRC Established Career Fellowship (£1.0m; 2012)

- Shultz – Royal Society University Research Fellowship (£441k; 2012)
- Taylor – CRUK Senior Research Fellowship (£659k; 2010)
- Thompson – Wellcome Trust New Investigator award (£2.0m; 2011)
- Woolner – Wellcome Trust Sir Henry Dale Fellowship (£859k; 2012)

In addition to MCCIR, examples of successful collaborations with a wide range of industrial partners include: AstraZeneca (£200k; Dunne), Bruker (£391k; Scrutton), GlaxoSmithKline (£539k; Loudon), Johnson & Johnson (£100k; Morgan), Lilly (£480k; Luckman), Lonza (£401k; Dickson), Ono Pharmaceutical (£354k; Gurney), Newtricious (£174k; Murray), Novartis (£228k & £117k; Kimber I), Optegra (£153k; Radhakrishnan), Sauflon (£200k; Morgan), Shell (£821k & £258k; Leys), Syngenta (£146k; Kimber I), Unilever (£230k & £416k; Kimber I). FLS has also secured three Knowledge Transfer Partnerships, one with Crawford Healthcare and two with Epistem.

5.2 Research governance

Senior members of the University (including the President, Vice Presidents for Research, Deans, Associate Deans for Research and Heads of School/Research Groups) provide direction and leadership for research activities. This ensures that a research climate is created, and a culture embedded, that requires researchers to conduct research within the principles of good practice. The Associate Dean for Research (ADR) sits on the University Research Strategy Group, which provides overall leadership for the University's research strategy. Similarly the Associate Dean for Postgraduate Research (ADPG) sits on the Manchester Doctoral College, which provides leadership and oversight for the University's plans for postgraduate research students. It is also noteworthy that the University has an Associate Vice President for Research Integrity who reports directly to the President and Vice Chancellor.

5.3 Faculty research governance policy and practice

The ADR and ADPG sit on the Faculty Management Team and ensure that the University's research governance is prosecuted within FLS. All research projects conducted by Faculty staff or students that involve human participants in a way that might harm, disturb or upset them, or where they can be deemed to be in a vulnerable or disadvantageous situation, must adhere to research governance regulations and best practice and be carried out in line with the University's policies including the Code of Good Research Conduct. The University has five central research ethics committees and a dedicated research governance team to advise on such projects, as well as local expertise including a Faculty ethics panel providing more targeted advice within FLS. For any clinical projects, FLS has access to specialised expertise within FMHS and local NHS Trusts, with whom we collaborate closely via MAHSC.

Research within FLS necessitates the use of animals and the University's BSF (animal facility) is the largest stand-alone such facility in Europe. The University maintains the highest standards of animal welfare and invests heavily in its facilities. Fully trained care staff in the BSF hold degrees in animal care and qualifications accredited by the Institute of Animal Technology (IAT). Animals are housed in social groups wherever possible and provided with a rich and varied environment to allow a range of natural behaviours. A full-time animal care and welfare officer and a veterinary surgeon are employed to ensure best practice.

5.4 Research infrastructure

All of the research in FLS is undertaken in purpose built, state-of-the-art, research accommodation, designed to remove physical barriers to collaboration. This infrastructure combined with internal organisation of porous Research Groups provides an environment conducive to undertaking the highest quality research. At the heart of the estate, located at the centre of the campus, aerial walkways are in place connecting the Michael Smith, AV Hill, Stopford and Core Technology Facility buildings, thus creating an integrated biomedical complex housing more than 300 research groupings. The FLS research infrastructure is detailed in Section 1.3.

5.5 Research facilities

FLS maintains a broad range of state-of-the-art analytical research facilities. These facilities are available to all staff and students and are maintained by dedicated personnel who provide expertise in planning and running experiments, interpreting data, as well as technical support and training for routine and specialist techniques. Through the provision of centralised facilities, housed in custom-built laboratories, all researchers in FLS have access to the best available equipment that would be beyond the budgets of most individual research groups. The value of equipment in these facilities exceeds £20m, an essential resource that is maintained and continually updated through a mixed portfolio of external research grants and Faculty/University contributions (£200k per year). These facilities are supported by 15.5 Senior Experimental Officers, 9 Experimental Officers and 13 technicians.

The list of core facilities is: Bioimaging, Bioinformatics, Biomolecular analysis, Electron Microscopy, Flow Cytometry, Fly Facility, Genomics Technologies, Histology, Macromolecular X-Ray Crystallography, Mass Spectrometry, Protein Expression and Transgenic Technologies. *In vivo* work is supported through the animal facility that has been refurbished during the REF period at a cost of £30m.

The University of Manchester's Library is one of only five National Research Libraries in the UK and is a significant resource supporting research within FLS. With more than 4 million printed books and manuscripts, over 41,000 electronic journals and 500,000 electronic books, as well as several hundred databases, the library is one of the best resourced academic libraries in the country.

e. Collaboration or contribution to the discipline or research base

6. Collaboration and interdisciplinarity

6.1 Interdisciplinarity

Collaboration and interdisciplinarity are key components of the research philosophy within FLS (see Section 1.1). As such, researchers in FLS are widely engaged in large number of collaborative projects facilitated by research centres and institutes such as MIB (see Section 1.1). Currently over 50% of all externally funded projects involve two or more researchers in FLS. Interdisciplinarity is further evidenced by the two sLoLas currently held, both of which involve extensive collaboration with FEPS, with industry and with researchers outside of the University of Manchester. In addition, FLS (Muller) coordinates a large FP7 grant 'SymmedIBD' (€12m), involving nine partners in other HEIs across Europe and three SMEs. Biomedical research in FLS is integrated with FMHS and MAHSC and in the last two years FLS and FMHS have invested considerable funds (£350k) to promote interdisciplinary biomedical research that spans the two Faculties (see Section 1.1).

FLS has extensive international collaborations including formal links with the Weizmann Institute of Science in Israel (funded via a £100k Alliance Get Connected grant), A*STAR Institutes Singapore, the Chinese Academy of Sciences (funded via BBSRC and EPSRC partnering awards), Sumarco National Park, Ecuador, as well as numerous active individual international collaborations including NIH and EU funding.

6.2 Interactions with industry

Maximising effective interactions with industry by instilling an entrepreneurial culture where the commercialisation and exploitation of research is encouraged, supported and rewarded is a key tenet of FLS research strategy and is detailed in Section 1.5. Partners span the whole spectrum of companies operating in the life sciences and related disciplines, and include global pharmaceutical, agrochemical, industrial chemical, food and personal care and cosmetics industries. In addition there are flourishing collaborations with start-up companies and SMEs with similar portfolios. Currently FLS has active collaborations with more than 65 companies and this number is steadily increasing. Among these companies are those with whom we have signed strategic agreements that embrace not only research collaborations, but also agreements for share of equipment, laboratory facilities and training. FLS has recently established two initiatives that have facilitated innovative partnerships with industry:

- CoEBP brings together biologists, chemists, physicists, engineers, mathematicians and clinically-related scientists (see Section 1.5). Since 2011, contracts with 10 different companies (Neurophage, Elanco, Norgren, ABL, Thermoscientific, Pharmholdings, Intertek, Protein Technologies, Recipharm, SciVac) have been undertaken.
- MCCIR represents an equal partnership between the University of Manchester (FLS and FMHS), GlaxoSmithKline and AstraZeneca (see Section 1.5). Investigators in this Centre are seeking to discover new biological pathways in the induction, regulation and resolution of inflammation. It aims to identify new leads and targets for future drug discovery pipelines.

During the REF period, 17 PIs in FLS have held consultancies with companies such as GlaxoSmithKline, AstraZeneca and Sanofi.

6.3 Contribution to the peer-review process

Staff in FLS influence and make a substantial contribution to the broader research community. This is exemplified by contributions to, and leadership of, both national and international grant peer-review panels. During the REF period more than 70 staff have served on RCUK research committees and chaired key committees e.g. BBSRC C and D committees (Hubbard and Bardgett), BBSRC Training Awards Committee (Roberts), the MRC Studentships Panel (Kimber I) NERC Standard Grants Panel (Brown T) and NC3R Board (Kimber I). FLS staff have made vital contributions to committees of a number of non-government funding agencies including the Arthritis Research UK, CRUK, Leverhulme Trust, the Royal Society and the Wellcome Trust. FLS staff have also served on international funding agencies including Finnish Academy of Sciences, French Research Agency, German Research Foundation DFG, Science Foundation of Ireland and Singapore National Medical Research Council. Rothwell is Co-chair of Prime Minister's Council for Science and Technology which advises the Prime Minister on science and technology policy issues.

6.4 Editorial boards

During the REF period, over 60 FLS staff have served on editorial boards of journals. In addition, FLS staff act as senior scientific editors on a number of journals, current examples include:

- Archives of Microbiology: Takano (Editor)
- BMC Developmental Biology: Amaya (Section Editor)
- British Journal of Pharmacology: Weston (Senior Editor)
- Cell Calcium: Verkhratsky (Co-Editor in Chief)
- EMBnet: Attwood (Deputy Editor in Chief)
- FEBS Journal: Scrutton (Editor)
- Journal of Ecology: Bardgett (Editor)
- Nucleic Acid Research: Sharrocks (Executive Editor)
- Neuropharmacology: Allan (Senior Editor)
- Membrane Transport and Signaling (Verkhratsky (Editor)
- Parasite Immunology: Grencis (Co-Editor in Chief)
- Social History of Medicine: Burney (Co-Editor)

6.5 External fellowships and awards

Major honours and awards to FLS staff since 2008:

OBE for services to science	Kimber I (2011)
Wolfson Merit award	Davis (2008), Scrutton (2009), Thompson (2013)

Senior personal fellowships and awards externally funded in FLS since 2008:

BBSRC Industrial Impact Fellowship	Rhodes M (2010)
CRUK Senior Cancer Research Fellowship	Petersen J (2009), Taylor (2010)
EPSRC Established Career Fellowship	Scrutton (2012)
ERC Advanced Grant	Brown TA (2013), Lucas (2011)
MRC People Exchange Research Leader Fellowship	Robertson (2011)
MRC Professorial Fellowship	Rothwell (renewal 2008)
MRC Senior Non-clinical Fellowship	Humphries Mark (2012)
Research into Ageing Senior Research Fellowship	Hardman (2010)
Wellcome Trust New Investigator Award	Kirby (2013), Thompson (2011)
Wellcome Trust Senior Investigator Award	Grencis (2013)
Wellcome Trust Senior Research Fellowship	Briggs (renewal 2008), Papalopulu (2009)

Career development and postdoctoral fellowships externally funded in FLS since 2008:

BBSRC/RSE Enterprise Fellowship	Almond (2008)
BBSRC David Philips Fellowship	Bechtold (2012), Brown T (2012), Hay (2010), Paszek (2012)
Breakthrough Breast Cancer Fellowship	Lu (2010)
ERC Starting Fellowship	Hurlstone (2012), Leys (2008), Turchetti (2009)
Healing Foundation Research Fellowship	Millard (2008)
MRC Career Development Award	Couper (2012), Meng (2009),
NERC Postdoctoral Research Fellowship	Buckley (2010), Hagar (2008), Rowntree (2012), Samson (2012)
RCUK Academic Fellowship	Tammaro (2008)
Research into Ageing Research Fellowship	Hardman (2008)
Royal Society University Research Fellowship	Buckley (2013), Leys (renewal 2008), Shultz (2013)
Royal Society Dorothy Hodgkin Fellowship	Shultz (2012)
Wellcome Trust Research Career Development Fellowship	Brough (2008), Caswell (2010), Herbert (2011)
Wellcome Trust Engagement Fellowship	Ochu (2013)
Wellcome Trust Sir Henry Dale Fellowship	Woolner (2012)