Institution: University of Birmingham

Unit of Assessment: UoA5

a. Overview

Research in UoA5 is based entirely in the School of Biosciences, one of four Schools within the College of Life and Environmental Sciences (LES). The School is medium sized with a diverse portfolio of research activities organized around four themes, ***BioSystems and Environmental Change; Microbiology and Infection; Molecular Cell Biology and Signalling; Plant Genetics and Cell Biology***. Research in each theme is coordinated by a theme lead and underpinned by on-going investments in state-of-the-art technologies and the development and delivery of a research strategy that seeks to enhance existing areas of research excellence and to identify and promote new opportunities to augment the Biosciences research portfolio. A strong emphasis is placed on creating and developing opportunities for multi-disciplinary research, aided by excellent links within LES and University, notably with the Medical School, Chemistry, Chemical Engineering Computer Science, with other academic institutions and strategic alliances with private sector organizations, such as Thermo-Fisher. As a result the School is ideally-placed to operate in a financially challenging environment and adapt to the national and international trends for large scale, consortium-based research. This organization is designed to provide a vibrant environment that enables individual academics to undertake high quality, internationally competitive research that directly impacts on areas of strategic importance for society, exemplified by our expertise in such topics as tuberculosis research, environmental genomics focussed on the Daphnia model system, nervous system development and the control of meiotic recombination in plants.

b. Research strategy

Changes in the Research Environment since 2008 The last 5 years has seen exciting development and refocusing of Biosciences research. ***A number of initiatives have been implemented supported by University of Birmingham (UoB) funding, reflecting the Institution's recognition and support for research development in Biosciences***. This has enabled key appointments and investment in new technology platforms and facilities. The School has been particularly successful in attracting outstanding early-career scientists through the Birmingham Fellows scheme which provides research support for 5 year towards an open-contract position. The most significant developments have been the formation of both the Microbiology and Infection (IMI) and BioSystems and Environmental Change (BEC) research themes. IMI, established in late 2011, is based around the UoB's strength in microbiology and infection. It has been created through a strategic alignment of microbiologists from Biosciences and Immunity and Infection, strengthened by 5 new appointments (see Research Groupings) all located within Biosciences. IMI research is further supported by the recent establishment of the Birmingham Drug Discovery Facility (BDDF) funded by a UoB Capital Investment award (£670K) which provides a platform for translation of IMI research. Formation of BEC reflects the strategic commitment to repositioning the Biosciences research portfolio to capitalise on "omics"-based approaches to organismal and environmental biology. Particular developments in this area have been a move to integrating and modelling data using computational biology and pioneering the development and application of metabolomics approaches in relation to environmental biology which has opened up-new strategic links with the Beijing Genomics Institute and Thermo Fisher Scientific (see below). In addition to these two new themes, the existing themes of Molecular Cell Biology and Signalling and Plant Genetics and Cell Biology have benefited from a total of 8 new appointments, with 4 recent appointments through the Birmingham Fellows scheme allowing them to initiate new exciting areas of research (see Future Research Plans) alongside existing areas of excellence.

Future research plans It is our intention to develop and focus our research portfolio in areas of research strength combined with critical mass. We aim to maximise the inter-theme synergism and to continue to promote participation in interdisciplinary and consortium-based research. This will enable us to deliver and sustain world class fundamental research and promote translational aspects of our research through the continued development of our facilities and strategic links with stakeholders. Biosciences research will be greatly enhanced through strategic partnerships with Thermo Fisher and the newly established hub of the Beijing Genomics Institute (BGI) which have been led by academics in BEC. A particular goal is to use the BGI presence on campus to further

develop our omics and bioinformatics activities. To this end a memorandum of understanding has been signed (July 2012) to establish a ***Joint BGI-Birmingham Environment and Health Centre (JEHC)*** which aims to establish a world-class academic, research and training environment through the integration of state-of-the-art sequencing, metabolomic and bioinformatics technologies and expertise. An associated Doctoral training programme involving co-supervision by UoB and BGI academics is being established which includes "distance-learning" PhDs. Biosciences has been selected as a ***Thermo Fisher Scientific Alliance Partner***, the only one in Europe. This alliance will underpin the School's pre-eminent position in environmental metabolomics. This is supported by the establishment of an Aquatic Mesocosm facility to strengthen environmental research and to promote collaboration with the School of Geography, Earth and Environmental Sciences. Since much of the research activity in MCB and PGCB is dependent on cutting-edge microscopy further development of the ***Birmingham Advanced Light Microscopy*** facility is planned. Specific proposals include: linking all light microscopy across UoB under one facility (Rappoport, Biosciences as director); to become a EuroBioImaging Node; increasing capacity through external funding of new instruments, focussing on super-resolution microscopy. PGCB research will focus on our areas of excellence in ***Food Security***. These include: the development of improved strategies for plant breeding based around expertise in recombination and plant reproduction and through increased collaboration with breeding companies underpinned by EU projects in this area (see below); gaining new insights into the ***control of plant growth through the use of mathematical modelling*** to explore the fate of single cells in relation to the development of the mature plant; understanding the impact of stress on plant development. Similarly new appointments in MCB will allow a new research focus on ***RNA processing and activities of non-coding mRNAs*** to be established. Research in IMI will be directed towards the ***development of new antimicrobial reagents*** aided by the continued development of the Birmingham Drug Discovery Facility (BDDF), through improving facilities by the upgrade of a BSL-2 laboratory to BSL-3 standards (UoB/Wolfson funded). This will facilitate further grant support within Biosciences and across UoB. Indeed Wellcome Trust and MRC funding that relies on BDDF has recently been obtained. Future research plans involve responding to new opportunities in the global research environment. One such example is the development of our ***Synthetic Biology*** research strength (*http://www.birmingham.ac.uk/research/activity/synthetic-biology/index.aspx*). This is a multi-disciplinary, cross-college initiative involving Biosciences, Chemical Engineering, Maths, Chemistry, Medical School and Law coordinated by Biosciences. It has developed with RCUK support via a Sandpit. Work in this area has already yielded considerable success with grants funded (including collaborations with other UK HE institutions and a number of commercial entities) by EPSRC, BBSRC and TSB in excess of £20 million. This includes UoBs involvement in the Synthetic Biology Integrated Knowledge Centre based in Imperial College which provides a conduit for translating Synbio research into economic impact.

Responsiveness to national and international priorities and initiatives Biosciences has a strong commitment to responding to opportunities for development of our research in line with our strategic goals and the mechanisms to respond to them (see next section). This is illustrated through our research in Environmental Genomics, Big Data, Health, Food Security and Synthetic Biology, areas identified in the recent speech to the Royal Society by George Osborne (9/11/2012) as priorities for government investment in science. Formation of BEC has enabled Biosciences to develop new synergies that have been instrumental to responding to the national and European strategic priorities in environment, pollution and human health. This includes the development of research focussing on the potential toxicities of nanomaterials which is funded by UK (NERC/EPSCRC/MRC) and EU FP7 (nanoMILE - Engineered nanomaterial mechanisms of interactions with living systems and the environment: a universal framework for safe nanotechnology) project grants. Research in PGCB has responded to the prioritization of Food Security at both national and EU levels. Fundamental research on meiotic recombination has been in part re-focussed to include plant crop species resulting in funding through the BBSRC-LoLa programme, which in turn provided the basis for a UoB coordinated EU-FP7 collaborative project (MeioSys) and a recently funded Marie-Curie ITN (COMREC). Research in the conservation of plant genetic resources has also gained EU-FP7 (PGR-Secure) support, as has marine biofouling (AMBIO MC-ITN Callow-see impact case study). A significant driver in establishing the IMI was to organize UoB's microbiological research such that it is more effective in responding to challenges

particularly the re-emergence of old diseases and the increased incidence of antibiotic resistance. Funding includes EU (ITN-EID with GSK), Wellcome Trust and MRC programme grants totalling over £3 million to combat TB.

Effective mechanisms for the development, promotion and dissemination of research
A variety of mechanisms are in place designed to enable staff to develop and deliver high-quality research. Development of Biosciences research strategy is a remit of the ***School Executive Committee-Research (SEC-R)***, and achieved in conjunction with the ***College Research and Knowledge Transfer Committee***, which plays an important role by co-ordinating School research development in the context of the College and more broadly across UoB. This is illustrated by the formation of the IMI. Individuals within the School are able to input into the development of School research strategy via their research themes and through the ***Biosciences Research Colloquium*** which is a monthly research discussion forum aimed at informing staff of on-going research and identifying new opportunities to promote and enhance research activity. The four theme leads play an important role in the development of new research and in conjunction with a Research Facilitator from within the ***LES Research Support Office***, they manage the ***Biosciences research grant application review process***. All applications are reviewed prior to submission by expert and non-expert readers to determine if they are of sufficient quality for submission or if they require revision. To promote best practice, successful applications are available for reference and individuals are encouraged to discuss applications with successful grant holders.

The School has various integrated routes to gather research intelligence with the College and School research committees acting as hubs to coordinate the targeted dissemination of the information. Intelligence arises through the involvement of Biosciences academics and UoB colleagues, on advisory and executive committees plus funding committees and colleges of experts (see section e). This is an important factor in shaping the development, sustainability and delivery of Biosciences research.

The LES Research Support Office along with ***UoB Research and Innovation Services*** provides additional support including the identification of research funding opportunities, workshops based around individual funding agencies and grant writing workshops. Research and Innovation Services also provides an excellent European grant support group for collaborative and individual programmes and support for obtaining collaborative funding with industry through TSB and KTP schemes. The development of International research links are promoted through both the University International Office and College Research Committee. University-managed funds originating from Wellcome Trust, MRC BBSRC and EPSRC support pump-prime funding, interdisciplinary work, travel, follow-on type funding and early stage commercialisation.

Recognizing that obtaining research funding is increasingly competitive with successful applications often requiring considerable preliminary data, Biosciences strategically targets ~40% of its non-staff budget to promoting research. This enables all staff to be allocated a small personal research budget to underpin their research and that of their postgraduates. In addition the implementation or development of new techniques in order to accumulate preliminary data for grant applications is encouraged by allowing academics, particularly ECRs, to run pilot projects using core facilities at cost-price. The College and University also run a variety of internal competitions for research funding, such as the “Big Idea” with funding up to £10,000.

Biosciences researchers of all levels are expected to disseminate research data at International Conferences. This is a component of the postgraduate Doctoral Researcher (DR) Training Programme with financial support from the School. Individuals are encouraged to take an active role in Learned Societies, Funding Agencies and Conference organization (see Section e). Staff are encouraged to publish work to achieve maximum impact particularly through promoting the use of Open access (supported by Wellcome Trust and RCUK). Dissemination of research to the general public is strongly encouraged and this is achieved through a variety of routes for example School visits, media (traditional and new) presentations, links with the Birmingham Science Museum and NIAB Innovation Farm, public awareness sessions at conferences (see impact statement for additional information).

Research groupings, activities, rationale, operation and achievements As introduced above Biosciences has four research themes, BioSystems and Environmental Change *(BEC)*; Microbiology and Infection *(IMI)*; Molecular Cell Biology and Signalling *(MCB)*; Plant Genetics and Cell Biology *(PGCB)*. Inter-theme collaboration is promoted by underpinning technical facilities.

BEC During the past 5 years research in environmental and whole organism biology has refocused and expanded considerably to 13 academic staff, leveraging from retirements as well as 3 strategic new appointments from Lectureship to Chair. The most notable of these was a £2M investment in 2012 to recruit Colbourne, Dunn and Orsini. BEC's primary strategy is to exploit the synergies from a range of advanced technologies (in particular genomics, transcriptomics, metabolomics, robotics and computational biology), as well as physiological and behavioural responses to understand environmental change across rapid, seasonal and evolutionary timescales. The theme focuses on individual organism fitness and population-level responses to both natural evolutionary changes (Chappell, Reynolds, Thorpe) and those driven by environmental pollution and nanomaterials (Chipman, Colbourne, Viant), climate change (Bale, Hayward, Viant) and disease (Dunn). A deeper mechanistic understanding of organism physiology and toxicology (Chipman, Hodges), and its adaptation, is achieved by data modelling using computational biology (Colbourne, Viant). The long term strategy of the theme is to solve scientific challenges in biodiversity and environmental health protection through Systems Biology approaches. Stakeholder engagement is a central strategy of this theme, one which we have grown through our international research profile: e.g. the Joint Birmingham-BGI Environment & Health Centre with the world's largest provider of genomics sequencing (2012) and the Technology Alliance Partnership with Thermo Fisher Scientific, specialising in metabolomics and proteomics (2013). We collaborate extensively with the end-users of our research, e.g. the UK Environment Agency, DEFRA, the Centre for Environment, Fisheries & Aquaculture Science, and internationally with the US EPA and Environment Canada. Our research profile helped to secure a further achievement, hosting the NERC national facility for environmental metabolomics (2009-present).

IMI The IMI theme represents a strategic development from its predecessor Molecular Microbiology, aimed at maximising our research potential in microbiology across Biosciences and the College of Medical and Dental Sciences (MDS). It is housed in re-furbished laboratories in the School and comprises 18 academics from Biosciences with a further 7 members from MDS (submitted in UoA 1). Importantly, since 2008 existing expertise has been supplemented by the recruitment of 5 ECRs. Major advances have been made in highlighting strategies for controlling tuberculosis and other pathogenic micro-organisms through the investigation of potential new drug targets and removal of antibiotic resistance as well as investigations of host immune responses (Alderwick, Besra, Bhatt, Krachler, May, Thomas, Futterer, Hyde). While some groups in this theme focus on exploiting their research in diagnostics and the production of high value materials through industrial collaboration (Dafforn, Macaskie), the majority work to some extent with industrial partners (UCB Celltech, Abingdon Health, GSK, Daiichi Sankyo, Syngenta, United Utilities) and/or third sector partners (NHS Trusts, Public Health England). Several investigators in IMI work primarily on the fundamental processes of gene expression and responses to stress (Busby, Grainger, Huber, Lovering, Lund, Kreft) and along with other members of the theme have an extensive network of overseas collaborators. The work in these various groups is underpinned by investments and expertise in 'next-generation' sequencing (Loman and others in this UoA), high throughput screening (Alderwick, the BDDF facility), a class 3 suite and our involvement in leading the microbiology aspects of the NIHR Surgical Reconstruction and Microbiology Research Centre. The combined influence of the IMI on the field is evidenced by the fact that since 2008 IMI investigators have published >630 papers, attracting over 11,000 citations (h-index of 50) which places it at the forefront of national and international bacteriology focused centres.

MCB Biosciences has a strong record in cell surface receptor-mediated signalling. Our strategy has been to augment this by recruiting to provide a breadth of complementary technical and theoretical expertise and also to establish a new focus in the emerging area of RNA processing and activities of non-coding mRNAs. Since 2008 there have 4 new academic appointments in MCB bringing the total to 15. Our long-standing focus on cancer cell biology, growth factor receptors and downstream signalling (Heath, Hotchin and Bunce) has been strengthened by the appointments of Hellberg, Khanim, Rappoport and Fan, ensuring continuing strength and breadth of activity and technical expertise in this area. Similarly, our second area of focus, G-protein receptor activation and downstream signalling events, particularly those mediated by Ca^{2+}, (Wheatley, Michelangeli, Publicover) has been strengthened and expanded by the recent recruitment of Tomlinson working on regulation of signalling processes by tetraspanins. Advanced microscopy techniques are crucial to many of the activities in MCB and other themes and the ongoing development of the Birmingham Advanced Light Microscopy facility has been given renewed vigour by Rappoport

(dynamics/regulation of endocytosis). Another approach which has provided important biological insights is the use of Drosophila as a genetically malleable model. Our Drosophila facility initially established by Hidalgo to study nervous system development and nerve growth factors is now used by Fan (see above), Brogna and Soller who have established a new focus on the processing and non-coding actions of RNAs. The recent recruitment of Kanhere (non-coding RNA, transcription factors and epigenetic regulation of gene expression) strengthens this latter area and provides a systems approach to a number of areas of research, exemplified by the Systems Science for Health initiative.

***PGCB**:* Research in PGCB is focussed on the genetic and cellular control of plant growth and development in model species, crops and their wild relatives using genomics, proteomics, systems biology and advanced light microscopy. The theme comprises 11 academics this includes the recruitment, since 2008, of 4 ECRs, 3 appointed through the Birmingham Fellows scheme. The ECRs ensure sustainability of PGCB research through the introduction of new expertise and development of strategic links with existing theme members to create a cohesive, focussed research unit. The theme has particular strength in plant reproductive biology with internationally leading groups in the areas of meiosis and cell- signalling during pollination and self-incompatibility (Franklin, Franklin-Tong, Armstrong, Sanchez-Moran). Since 2008 the meiosis group have coordinated three network grants, viz a BBSRC LoLa project to manipulate meiotic recombination in Barley, an EU-FP7 project: Systematic analysis of factors controlling meiotic recombination in higher plants (MeioSys) and a MC-ITN: Control of meiotic recombination (COMREC). The former has provided important new insights into recombination in cereals and was recently highlighted on the BBSRC Website *(http://www.bbsrc.ac.uk/news/food-security/2012/121214-f-turning-up-heat-on-plant-sex.aspx).* Quantitative genetics of complex traits (QTL) (Luo, Leach) continues to be a feature of PGCB research. The appointment of Leach further develops this through her experience in the application of next generation sequencing to QTL analysis which is creating new opportunities, for example a programme to identify QTLs controlling meiotic recombination in polyploids. Plant genetic diversity and conservation is an important contributor to PGCB research and the influence of this work has provided one of the Impact case studies (Maxted). The evolution of cellular developmental processes (Coates) has been strengthened by the recruitment of Bassel who introduces expertise in image analysis and computer modelling into plant cell development. Similarly, the recent arrival of Gibbs will develop research on the genetics and physiology of plant stress (Pritchard).

Mechanisms and practices for promoting research, and sustaining and developing an active and vital research culture

A transparent work-load model which recognizes each individual's teaching, research and administrative duties is used to allocate load to maximise delivery of high quality research across the School. Biosciences fosters a collegiate approach to achieve a vibrant research culture promoted via a variety of routes. The seminar programme plays an important part in this. 2-4 weekly seminars are held throughout the year and are open to all UoB researchers. In the case of DRs and final year undergraduates, seminar attendance is an integral component of their training programme. Seminar speakers are invited by each theme, but coordinated at School level to ensure that at least one seminar each week is a broad interest topic to maximise participation. This programme is supplemented by annual prestigious seminars (eg Huxley, Jinks Lectures) given by high profile speakers. The annual two day ***Biosciences Doctoral Symposium*** gives DRs an important opportunity to present their research. The Biosciences Research Colloquium (see above) which is held in a refurbished seminar/coffee room, designed to promote informal staff interactions, is an important element in our research culture, providing a forum to inform staff and an opportunity for them to contribute their opinions in relation to School research. Also, it enables colleagues to inform each other about their on-going research. This increases awareness and promotes collaborations between staff in the different research themes. An annual away-day provides an additional route to fostering awareness and a collegiate atmosphere. A monthly themed discussion session in Systems Biology is also designed to promote interactions. The research-led environment of the School is enhanced by the provision of high-quality undergraduate and Masters research projects and through Undergraduate Summer Studentships funded via various schemes (eg Nuffield, Genetics Society, Biochemistry Society etc).

Multi-/interdisciplinary developments

In recent years biology has become ever more interdisciplinary. The School and its staff have recognised this sea-change and its importance as a way of increasing the quality and impact of research. To enable the development of such multi/interdisciplinary projects the School and College have implemented a number of activities. This includes financial reward (seed funding) for new interdisciplinary projects in the form of the "cutting edge" research competition. Interactions between staff in different disciplines are encouraged at all levels through joint Doctoral Training Centres (e.g EPSRC Physical Sciences of Imaging in the Biomedical Sciences between Biosciences, Maths, Chemistry, Medicine and Computer Science). The recently established Institute of Advanced Studies is specifically aimed at developing interdisciplinary research and provides another opportunity for members of the School to develop their research. Externally funded sandpits (see above) and Institutional investments (eg the IMI) have crystallised a number of high quality externally supported joint projects between Biosciences and other Schools within both LES and the other Colleges widening grant capture to funders not normally associated with Bioscience (eg. ESRC, EPSRC etc). This is illustrated by the Systems Science for Health Initiative which involves the metabolomics facility, computational biology and translational medicine.

c. People, including:

i. Staffing strategy and staff development

Staffing strategy in relation to research strategy and infrastructure: Staffing strategy within the School of Biosciences is an important component in the implementation and future development of the research programme. Our approach is to focus resources to ensure a critical mass of activity within areas of research excellence and to develop new opportunities. This is achieved through a combination of the creation of new positions and strategic replacements following retirements. Over the REF period we have made a total of 17 new appointments in an overall academic staff total of 58. We have been particularly successful in the Birmingham Fellows scheme which has contributed 6 ECRs. In addition, we seek to recruit promising individuals who hold Personal Fellowships (eg BBSRC David Phillips, British Heart Foundation, Royal Society etc.) with a view to subsequent transfer to open contract positions. Eight of our current academic staff have been recruited through this route. This overall strategy is proving an important factor in enabling reorganization and development of the research scope within the research themes.

Sustainable staff structure: Through the appointments described above we have maintained a steady staff-student ratio. To mitigate the impact of increased demand for contact time with undergraduates on research active staff we have increased the number of staff on teaching focussed contracts to 5. A sustainable staff structure is achieved through a policy of making appointments at both the ECR and senior levels. The current (2012/13) percentage of staff at each grade are: 55% Research Staff; 4.5% Birmingham Fellow; 10% Lecturer; 9% Senior Lecturer; 7.0% Reader; 14.5% Professor. The age profile is such that there is an even distribution of staff in their 30s, 40s, 50s and 60s, which provides an ideal combination of new blood and experience. This leads to a vibrant and progressive research environment which is reflected by the fact that a substantial proportion (~30%) of colleagues at Reader/Professor grades are currently below 50.

Career development of researchers: The ***Personal Development Review*** **(PDR)** is a key component in career development. The scheme involves each academic providing a summary of their overall activity in research, teaching and administration during the preceding year. The PDR also includes a reflection of each individual's progress towards achieving a set of goals established as a result of the previous PDR. This information is then used as the basis of a PDR meeting with a member of a selected group of senior academic staff within Biosciences. During the meeting each individual has an opportunity to discuss their achievements during the year; the impact of their science in relation to both the academic community and other beneficiaries; how an individual's activity can be sustained and developed; to identify factors that are detrimental or barriers to research progress and discuss how they can be addressed; to discuss opportunities and targets for the following year (and beyond); to discuss issues such as promotion and how this can be realized. Although, the PDR is nominally held on an annual basis additional meetings can be scheduled if required, for example to provide specific advice/feedback relating to a grant application or compilation of a promotion application. Workload in the School is managed in a flexible way so that staff are entitled to apply for a one-semester sabbatical every fourth year.

Early Career Researchers (ECRs): ECRs are allotted a mentor, who is an experienced senior academic. The mentor provides advice on all aspects of career development during the probationary period of the new staff member and is available thereafter to provide additional advice to supplement the PDR. The ***mentoring scheme*** is an important component in ensuring the integration of new staff into the wider research culture. Start-up support funds are available to enable new lecturing staff to initiate their research programme whilst applying for external funds. The College Research Support Office is proactive in helping new staff identify and access external funding opportunities. ECRs are also given priority to ensure that they are allocated a DR at the earliest opportunity following their appointment. During the probationary period new staff have a reduced teaching load to enable them to focus on developing their research programme.

In consultation with the School's non-tenured researchers the School has developed a ***Postdoctoral Concordat*** that is designed to promote their career development. A PDR and mentoring system provides fellows with an academic mentor who can give help and guidance in relation to career development. A ***Postdoctoral Fellows Forum*** provides an opportunity for non-tenured researchers to discuss matters, including career development that specifically relate to this group and feedback to SEC-Research. The School provides advice and support for fellows seeking Independent Fellowships, this includes reviewing applications and "mock" interviews.

Supporting equality and diversity: Biosciences is governed by the UoB 2011-2015 Equality Scheme which has been developed within the context of the Equality Act 2010 and the UoB Strategic Framework for 2010-2015. It seeks "to promote equality, prevent discrimination and promote greater understanding between different groups of people". To engender this, Biosciences staff are now obliged to undertake the UoB diversity training course. Current figures (see above) indicate that an important challenge for the future will be to redress the gender imbalance within the School. At present around 60% of our postgraduate DRs are female, but this is not yet translated into satisfactory representation further along the career pathway with numbers decreasing from 44% in fixed-term postdoctoral positions, to 26% in open contract positions, with only 17% at the Professorial grade. The School recognises that there are specific challenges that face women, those with disabilities and colleagues with caring responsibilities and is working to create an environment that addresses these issues. To support and promote the participation of women in science Biosciences has implemented the ***Athena SWAN*** (Scientific Women's Academic Network) ***Charter*** **and has recently gained an Athena SWAN Bronze Award**. A specific task of the School Executive Committee is to ensure female representation on all key committees and in senior research roles, such as theme leads (PGCB and MCB have female theme leads). We apply a system for the allocation of research, teaching and administrative roles that takes into account individual circumstances. We ensure a culture of inclusivity through timetabling the majority of key meetings and seminars to enable all staff to attend. Academic awareness of equality issues is promoted by a "for carers" section to the school website. Although challenges remain, a survey in preparation for our Athena Swan application indicated that staff are generally very happy with the flexible working arrangements within the School.

ii. Doctoral Research Students (DRs)

The School has a large and diverse postgraduate DR population (averaging 110 since 2008). A recent major development is the **Midlands Integrative Biosciences Training Partnership** (MIBTP) which is a BBSRC-funded doctoral training partnership between the Universities of Birmingham, Leicester and Warwick. MIBTP delivers innovative world-class bioscience research training and the School of Biosciences is one of the major partners in this programme. Similarly, the School is a partner in a recently awarded NERC-funded DR training programme ("CENTA"). Our DRs are funded by a variety of Research Council (BBSRC, MRC, NERC, and the EPSRC - Physical Sciences of Imaging for Biological Sciences programme) schemes and Charities (Cancer Research-UK, British Heart Foundation, Leukaemia and Lymphoma Research). Around 18% of DRs have industrial or government agency support. These include CASE awards with partners such as: BioBest, Kopert UK, LimaGrain UK, ASB Agri, Astra Zeneca/GSK, Advion Biosciences, Genosis, Organoteknica, Ferring Research, Scottish and Newcastle, Thermo Fisher Scientific. Agencies include the Health Protection Agency, Defence, Science and Technical Laboratory and British Antarctic Survey. In addition, we attract a significant number of overseas students funded by the EU (Marie-Curie ITN scheme), the Darwin Trust, Commonwealth Scholarship Commission and Government agencies in the EU, Asia, Middle East and South America. Since 2008 we have

increased our annual recruitment of overseas DRs from ~25 to 45 in 2012/13.

Effective and sustainable doctoral research training: The University Graduate School (UGS) offers a diverse programme of developmental workshops and events of which Biosciences DRs make extensive use. The programme is mapped against the VITAE Researcher Development Framework (RDF). All new Biosciences DRs are required to undergo a Development Needs Analysis (DNA) linked to the RDF. In 2011-12, 38 Biosciences DRs engaged in UGS workshops and resources in core skill areas covering topics such as academic writing, presentation skills, project and time management. DRs also have access to online resources such as Doctoral Researcher Essentials (an induction package for DRs in the first six months of a PhD) and development toolkits aimed at specific groups such as part time researchers. In 2011-12 our DRs accessed 130 online courses or resources. Partners from Employability provide development opportunities for DRs in enterprise, consultancy and leadership skills. For instance, Talent Pool, a comprehensive consultancy programme for postgraduate and postdoctoral researchers, trains DRs to become professional consultants, entrepreneurs and intrapreneurs who are then supported to deliver projects for public/private organisations or create their own enterprises. It is a prime example of training which stimulates and facilitates exchanges between academia and business, industry or public and third sector bodies. As a result participating UoB DRs are able to provide a service and engage in open dialogue with the public and local communities. The Centre for Learning and Academic Development provides advanced DR training in teaching skills. DR development activities are supported through School and College Postgraduate Development Funding. This is closely aligned to the RDF domains and the Research Development Statement is used by the Graduate School Management Board and Colleges as a strategic guide to prioritize DR skills development areas. BBSRC and NERC funded DRs receive direct support (up to £3000) to attend and present their work at conferences and to gain specialist training through secondment to other UK or International laboratories. The School matches this support for other DRs and also funds membership to a learned society.

Evidence of a strong and integrated research student culture: DRs are an essential part of the School's research culture and are represented at all levels of the School, College and University. Our DRs organise an annual **DR Research Symposium** which provides an opportunity to showcase their research to the UoB research community. Since 2012 the School has also provided financial support for a new annual scheme that allows a group of DRs to organize a **DR-led symposium** with invited external speakers. DRs are involved in a wide range of outreach activities eg. "meet the scientist" events at Birmingham's Thinktank science museum and school visits.

d. Income, infrastructure and facilities

Research Funding Strategy: Since 2008 we have secured around £35 million in funding, most (~50% is via the four natural science based Research Councils with large facility support from STFC. In addition, charities such as Leukaemia and Lymphoma Research, the British Heart Foundation and Cancer Research UK, and trusts such as the Wellcome Trust and Leverhulme Trust are also important sponsors of our research (~25%). Consortium-based and collaborative based projects are increasingly an integral part of Biosciences funding strategy. We have had particular success in EU FP7 and Marie-Curie ITN programmes, where we coordinate 5 projects with a total value of ~ €15 million and are partners in 5 others. The UoB component of these awards now account for ~10% of our research income. Other notable collaborative programmes include current involvement in the Synthetic Biology Integrated Knowledge Centre application and a Wellcome Trust Programme grant (with Oxford). Most recently, a joint Biosciences/Geography, Earth and Environmental Sciences project, made possible by a £15 million philanthropic donation, has been announced aimed at establishing a world-leading Institute of Forestry.

Research Infrastructure, Facilities and Specialized Technologies: Biosciences provides high quality, modern facilities and core technical support and has an on-going commitment to further develop research infrastructure through a variety of routes (see below) including strategic alliances (see earlier). In addition to the general research facilities, the School provides access to a wide range of specialized facilities (Table 1). These include both in-house facilities together with those in other Colleges within the University and supplemented by cooperative links with other Institutions. Each facility is overseen by an expert academic director who is charged with delivering sustainability and shaping future development. Facility directors are supported by a dedicated team

of staff who provide services based around the equipment, promote the use of the facilities, provide training and manage cost recovery. Research grants provide an important route to upgrading existing research equipment and securing new cutting-edge equipment. This is supported by UoB for items costing >£10k, through a Research Technology Coordination Group which approves the 50% contribution required on Research Council grant applications for costs over this threshold. To extend the range of equipment that is available to UoB academics, since 2008 the University has responded to the Wakeham report by creating a searchable assets register and equipment sharing collaborative with a group of Midlands Universities (Birmingham, Leicester, Loughborough, Nottingham, Warwick). A summary of specialized technology platforms and facilities within Biosciences and key facilities accessible cross-campus are shown in Table 1.

Table 1. Specialized Research Technology and Facilities	
a. Technology Platforms	
i. Functional Genomics, Proteomics and Metabolomics	
Director: Viant + 3 support staff	DNA sequencing, genotyping, microarrays, RNA quantification and quality assessment, proteomics and cell sorting
ii. Advanced mass spectrometry	
Director: Cooper + 2 Experimental Officers	FT-ICR, Orbitrap and triple quad instruments provide proteomic and metabolomic services and method development
iii. Birmingham Advanced Light Microscopy (BALM)	
Director: Rappoport + 1 Experimental Officer	Nikon A1R confocal/TIRF microscope, 2 Leica confocal microscopes, Zeiss TCS microscope, 8 Nikon/Olympus epi-fluorescence microscopes
iv. Birmingham Biomolecular Characterisation Facility	
Director: Dafforn + 1 support staff (0.2 FTE)	Analytical ultracentrifugation, FT-infra red, circular dichroism and linear dichroism spectroscopy, dynamic light scattering, and isothermal titration calorimetry
v. Macromolecular X-ray Diffraction	
Director: Futterer + 1 support staff (0.1 FTE)	X-ray crystallography is supported through access to X-ray diffractometer, crystal imager and liquid handling robot for setting up small volume crystallisation trials
vi. Birmingham Drug Discovery Facility (BDDF),	
Director: Alderwick	Includes biochemical and cellular screening platforms to allow libraries of compounds to be tested against a variety of assays.
b. Specialized Facilities	
i. Horticulture: a >100m^2 GM facility with computer controlled environment. Additional capacity for non-GM growth is sourced through the on-campus Winterbourne Gardens. Supported by 2 trained support staff; ii. Microbiology: containment category BSL-2 laboratory (upgrade to BSL-3 under-way); iii. Aquatic model organism growth facility; iv. Drosophila facility. v. Centre for Systems Biology (Director: Heath). A 128 processor cluster. Supported by a systems administrator (0.25 FTE); vi. Chaddesley Woods nature reserve; vii. Aquatic Mesocosm facility	
c. Additional UoB technology/facilities utilized by Biosciences academics	
i. The Henry Wellcome Biomolecular NMR Unit 900MHz, 800MHz, 600MHz and 2x 500MHz instruments; ii. Centre for Electron Microscopy: transmission and scanning microscopes; Atomic Force Microscopy; iii. The Birmingham Medical Support Unit; iv. Birmingham-BGI Environment & Health Centre	

Policy and practice in relation to research governance: Biosciences is guided by and adheres to the RCUK Policy and Guidelines on Governance of Good Research Conduct (revised Feb2013). This is implemented through College and School Research Committees with input from the School Safety Committee. Oversight of Health and Safety for research is provided by the **School Safety Committee**, chaired by School's Safety Officer. The School has a H&S Handbook and checklist to assist individuals in evaluating matters of H&S (chemical, biological/microbiological, GM, radiation) in relation to their work, and taking appropriate steps to offset and minimise risks. The completed forms are evaluated by the School Safety Committee, and are a compulsory requirement for all projects. All new project work requires completion of an UoB ethical review prior to initiation.

e. Collaboration or contribution to the discipline or research base

Academics in Biosciences are active contributors to the wider research base locally, in the UK and Internationally. Academic citizenship is encouraged at the School, College and University level and is a component of the PDR. The examples presented, whilst not an exhaustive list, are selected to provide an illustration of the range of activities:

***Committee members for UK and European grant funding agencies*:** BBSRC (deputy chair committees A, B, D); NERC; MRC (advisory board); Wellcome Trust Investigator Award Scheme (expert review group); CRUK. International Grant review committees: Natural Science Foundation of China; DFG (Schwerpunkt programmes); European Synchrotron Radiation Source, Science Academy of Finland; Agencia Nacional de Evaluacion y Prospectiva, Spain; ESF; Leukaemia and Lymphoma Research (Prof Bunce is Director of Research).

Editorial work: Includes: BMC Genomics; Ecological Genetics and Physiology; Plant Physiology; Journal of Experimental Botany; Journal of Sexual Plant Reproduction; Molecular Microbiology; FEMS Microbiology; PLoS One; PLoS Genetics; Journal of Biotechnology; Neuron Glia Biology.

Activities in learned societies: Colleagues make a significant contribution to the scientific community through extensive roles in learned societies such as: Biochemical Society (Vice-Chair and Chair-Designate; Membership Secretary; Council Member); Society for General Microbiology (Treasurer elect); Society for Experimental Biology (Council Member, Chair Education and Public Affairs committee; Plant committee); International Association of Sexual Plant Reproduction (Secretary General); Genetics Society (Regional Organizer); International Metabolomics Society (Director); GARNET (Steering Group).

Conference presentations and organization: Recognition of Biosciences research is reflected in the fact that many (28) staff have presented keynote lectures or been invited to participate in plenary sessions. Some examples of conference organization/co-organization include Gordon Research Conference (2013) Ecological and Evolutionary Genomics; 9th European Meiosis Conference EMBO workshop (2009); 21st Int. Congress of Sexual Plant Reproduction (2010).

Fellowships and Awards: Recent examples include: Lister prize (May, 2010); Colworth Medal (May, 2013); Royal Society Wolfson Research Merit Award (Colbourne; Besra); US Environmental Protection Agency Scientific Achievement award (Viant, 2010); The Biochemical Society award (Besra, 2008); EMBO Young Investigator (Lovering, 2013); UoB Founders award (Besra, Viant); Fellow of the College of Medical Sciences (Besra). Individual Fellowships: Tomlinson, British Heart Foundation; Bhatt, Loman, MRC; Sanchez-Moran, BBSRC David Phillips; Dafforn, Murray BBSRC enterprise Fellowships; Grainger, Cooper, Wellcome Trust; Brogna, Royal Society.

Effective academic collaboration: Members of Biosciences have extensive and productive links with Institutions in the UK and overseas. This is evidenced by a substantial record of publications, with ~60% of the REF outputs involving external collaborators. Examples include Oxford, Cambridge, Harvard, Purdue, Cornell, Davis, Duke, Shanghai Fudan/Jiao Tong, Adelaide RIKEN Japan, Singapore, Indian Institute of Science, Bangalore etc. Collaboration is also promoted through participation in UK, EU and overseas network projects and consortia (eg Daphnia Genomics Consortium, eMICE;FlyBASE; BBSRC LOLA; see section b for details of EU projects).

Extent of collaboration/integration with NHS R&D, Industry and Government agencies: As detailed in the Impact template Biosciences has strong ties with a variety of external agencies and companies, these have involved ~50% of colleagues since 2008. Work in IMI and and MCB has links with the NHS (eg Bunce impact case study; the NIHR Trauma Centre's MiSeq is run within the School's Genomics Facility); Infectious Disease Centre, Texas USA and a range of companies (eg UCB Celltech, GSK, Astra Zeneca, Daiichi-Sankyo, Hamilton Robotics etc). Research in BEC involves the recent link with the Beijing Genomics Institute to form the Joint BGI-Birmingham Environment and Health Centre (Colbourne - Co-Director), Thermo Fisher Scientific and Beckman Coulter Inc. Research on conservation of genetic diversity of crop wild-relative and environmental risk assessment of non-native biological control agents have involved close interactions with UK and International government agencies (Bale and Maxted Impact Case Studies). These include: DEFRA, European Plant Protection Organisation, United Nations Food and Agriculture Organization. Activity in the area of Food Security has led to links with various plant breeding companies (KWS, Sesvanderhave, Limagrain, PBL etc), Environmental microbiology (United Utilities). Staff are also increasingly committed to research commercialisation with the formation of three spin-out companies since 2008 (Dafforn, Thomas and Macaskie).