Institution: University of Nottingham

Unit of Assessment: 5 REDACTED FOR PUBLICATION

a. Overview

Research in the School of Life Sciences (SoLS) is managed under a number of natural, subject-based themes within the biomedical sciences. These reflect not only our major strengths in research but also the disciplines in which we have critical mass and which we aim to consolidate further. The largely non-hierarchical structure is a major feature underpinning our research strategy. Although each member of academic staff has a recognisable home and like-minded colleagues, the structure we have devised is both dynamic and fluid. Without major budget-based divisions, it encourages collaboration, fosters multidisciplinary activity and provides no barriers to the emergence of new disciplines. Most importantly, it enables the efficient and effective management of staff and resources to pursue and promote excellence. Our research is delivered via ten major groups: Cell & Developmental Biology, Ecology & Evolution, Genome Biology, Human Genetics, Infection & Immunity, Metabolic & Molecular Physiology, Molecular Microbiology, Neuroscience, Pharmacology and Predatory Microbes, Parasites & Pathogens, all of which have produced notable achievements during the REF period including:

- Multiple ground-breaking publications in leading international journals with 38 papers in Science, Nature and Cell family journals.
- Establishment of the MRC-Arthritis Research UK Centre for Musculoskeletal Ageing Research at the University of Nottingham (UoN), joint with Birmingham.
- £227 million collaborative research funding portfolio, with £128 million to PIs in SoLS and income to Nottingham of £54 million.
- Formation of the ARUK Centre for Pain Research at the University of Nottingham.
- 1000 graduate students, of which 550 are PhDs and including a £5.6 million BBSRC Doctoral Training Partnership and five EU Marie Curie Training Network awards totalling £13.4m.
- ARUK Centre for Sport, Exercise and Osteoarthritis (led by the Nottingham and Oxford).
- Programme lead and major participant in two of the six networks, which comprise the BBSRC Sustainable Bioenergy Centres (BSBEC).

b. Research strategy

i) Strategic aims and recent history

SoLS is a vibrant, forward-looking research outfit that provides the main focus for biological and biomedical research at the University of Nottingham. It was established following two major reviews of the Faculty of Medicine and Health Sciences (FMHS) which together recommended a consolidation of existing structures into a single large School, consistent with a general trend to larger structures inside the Higher Education sector over recent years, bringing basic biomedical sciences at Nottingham under unified management for the first time. An initial advisory review in 2009, chaired by Professor Sir John Savill, brought forward recommendations to strengthen the research infrastructure and provide new opportunities for high-quality translational research. Following a further executive review in 2011, major organisational changes were implemented and the School of Life Sciences (SoLS) was established on the 1st August 2013. It comprises elements of four former schools each of which had an independent research strategy for most of the current REF period. However, unifying themes derived from the university's over-arching strategy were common to all four schools and this has provided the platform for our research achievements. The first three aims of the university research strategy exemplify this shared approach;

1. To recruit, develop and retain exceptional individuals with outstanding research credentials.
2. To continue to develop a world-class environment and infrastructure.
3. To deliver the highest international quality transformational and translational research.

The essential ethos underlying our research philosophy is reflected in the BBSRC statement "Excellent research and excellent people are cornerstones of our strategy." We encourage our staff to generate and test their best ideas using responsive mode funding, which provides the necessary and "vital agility to respond to emerging areas". This approach is counterbalanced by an awareness of Research Council and major charity priority areas to generate impact across a broad range of biomedical and biological science. Thus, the majority of the grants obtained by members of SoLS are driven by individual or collective curiosity. We have also recorded significant

success for research objectives aligned to key strategic priorities of the research councils and major charities. The MRC/ARUK Centre for Musculoskeletal Ageing Research is a key example of this. Others include funding from EPSRC synthetic biology, BBSRC strategic LoLa in Industrial Biotechnology and Bioenergy (IBB), MRC Stratified Medicine, MRC DPFS and Wellcome Trust Seeding Drug Discovery. International grants have also been secured from the Gates Foundation, Human Frontiers Science Programme and National Institutes of Health in addition to substantial EU funding. We think it important that research active staff hold research grants, even though we accept a significant proportion of our grant income will come from a few larger successes.

ii) Research groupings, activities and achievements during the assessment period

The research focus, strategy and groupings in SoLS are drawn from the strongest elements of the four former schools. Our approach, based on individual research excellence, multidisciplinarity and international collaboration, has been highly successful, delivering many notable research achievements, some of which are described below.

1. **Cell & Developmental Biology** incorporates important basic and applied research areas, which have received consistent funding from BBSRC, EPSRC, MRC, and others totalling £10.5m. Three members of the group investigate the origin, specification and role of various stem cell types. Recent achievements include: identification of a novel mechanism for the determination of primordial germ cells (Johnson), the observation that lyl1 is required for blood vessel maturation and haematopoietic stem cell survival (Sablitzky) and identification of the roles of BMP, Delta/Notch and Hey2, and their epistatic relationships in haematopoietic stem cells (Gering). Layfield, has shown that mutations in sequestosome 1 (SQSTM1/p62) are commonly found in Paget's disease and Shaw has unravelled transcriptional mechanisms relevant to cancer, development and cognition. Vinkemeier has shown that β-arrestin1 is dispensable for STAT1 dephosphorylation and the termination of IFNγ signaling. Newly appointed group members have been particularly successful. Georgiou, a CRUK Career Establishment Fellow, has shown apical polarity proteins cooperate with Rho-GTPases to control cell morphology. Wheatley has demonstrated Plk1 kinase is essential for accurate chromosome alignment and cell proliferation, and Friel has shown that the kinesin-13 MCAK has an atypical ATP turnover cycle, tailored to its function as a microtubule depolymerase. The Cell & Developmental Biology group best exemplifies our flexible and responsive approach to interdisciplinary opportunities. Collaboration between members of SoLS (led by O'Shea) and colleagues in engineering has been promoted by co-locating engineers and biologists to form a genuinely interdisciplinary outfit, the Institute for Biophysics, Imaging and Optical science (iBIOS) directed at major biological and biomedical problems that benefit from £20m of active funding including substantial MRC and EPSRC awards.

2. Researchers in **Ecology & Evolution** have made important contributions in genetics and conservation. They are supported by funding from the BBSRC, NERC, the Wellcome Trust, the Leverhulme Trust, and other sources. Grants involving members of the group total approximately £20m. Gilbert's lab has made fundamental discoveries in the application of mathematical modelling to the conservation ecology of endangered species. Crittenden has shown that lichens have a key role as indicators of nitrogen pollution and Reader demonstrated that experimental infection of female mice with a protozoan parasite leads to a greater resistance to the parasite in their offspring. Goodacre has shown the impacts of endosymbionts on sex ratios in spiders, and the triggering of host dispersal by Rickettsial bacteria and Chapman demonstrated that boldness influences the migratory propensity of fresh water fish. Other substantial discoveries include the elucidation by Hanotte of the genetic origins of cattle and chickens and the basis of pathogen resistance in these animals, the demonstration by MacColl of how parasites influence the selective forces acting on sticklebacks and the identification by Brookfield of genetic variation for DEET insensitivity in *Aedes aegypti* mosquitoes with colleagues at Rothamsted.

3. Members of **Genome Biology** conduct fundamental research in genome dynamics and DNA repair, exploiting bacterial, archaeal and eukaryotic models to unravel the mechanisms that secure faithful transmission of the genome from one generation to the next. Pioneering studies from the Allers, Bolt, Lloyd and Nieduszynski laboratories have revealed how a complex arsenal of protein-DNA and protein-protein interactions ensure that genome transmission is achieved with high fidelity. The paradigms established have paved the way towards an understanding of genome stability disorders in humans. Recent collaborative and groundbreaking studies, published in

Nature, Molecular Cell and other leading journals, shed new light on the nature and exploitation of replication origins, and revealed how DNA translocases and helicases act to prevent re-replication of already replicated DNA and to limit conflicts between DNA replication and transcription. The finding by Allers and Nieduszynski that efficient cellular growth is possible without any canonical origin for controlling the initiation of DNA replication is a particularly significant discovery. Brown exploits genomic variants of fission yeast to investigate centromeres and speciation and Chalmers discovered an auto-regulatory mechanism that allows a selfish transposon to replicate in harmony with a eukaryotic host. He also collaborated on studies revealing how RNA molecules provide thermosensors that contribute to immune evasion by meningococci. Research in the Genome Biology group has been funded by grants from the MRC, BBSRC, Royal Society and Wellcome Trust to a total value of £7.8m including two MRC Programme grants (Lloyd), a Royal Society University Research Fellowship (Allers) and a BBSRC David Phillips Fellowship (Nieduszynski).

4. **Human Genetics** covers research into gene copy number variation in Crohn's disease and psoriasis (Armour), myotonic dystrophy and congenital heart disease (Brook), as well as dystroglycanopathy and facioscapulohumeral muscular dystrophy (Hewitt). Group members also study chronic obstructive pulmonary disease (Kalsheker and Chappell), and Alzheimer's disease (AD) (Morgan), which has led to the discovery of over 20 new genes involved in AD, in collaboration with several consortia. Time magazine rated the work of Morgan and collaborators as one of the major scientific breakthroughs of 2009. Knight has recently joined the group with a research focus on bioinformatic analysis of AD phenotypes. Significant progress has been achieved with six Nature-family papers resulting from research funded by grants worth £5.5m from MRC, BBSRC, Wellcome Trust, Alzheimer's Research UK, and the British Heart Foundation. Other large collaborative grants include a £6 million NIHR Biomedical Research Unit award and a €5.7 million EU-FP7 award for studies of pre-eclampsia (both involving Kalsheker). Armour & Brook have both held Leverhulme Research Leave Fellowships during the REF period.

5. **Infection & Immunity** focuses on the pathogenesis of infectious diseases and the associated human immune response, to identify better treatments and vaccines. They are developing novel analytical methods and tissue models for autoimmune diseases. The Ghaemmaghami lab, has made substantial progress investigating the molecular basis of allergic sensitisation using immunocompetent models of human tissues and Tighe has identified novel treatments for Tumour necrosis factor receptor-associated periodic syndrome (TRAPS). The virus research group has defined the natural history of HCV infection through co-ordination of the Trent HCV cohort and HCV Research UK (Irving), which underpin the STOP-HCV MRC stratified medicine programme. Research by Ball and Tarr has led to the development of novel antibody-based vaccines and therapies against HIV. Sewell, with colleagues in the School of Medicine and collaborators from other world-leading cancer centres, have delivered a world first; translating their research on human autoimmune responses to cancers into a diagnostic test for early detection of lung cancer that is in clinical use (improving patient outcomes) in the UK, USA and other countries worldwide. Awards involving members of the group exceed £27m from various bodies including Asthma UK, BBSRC, EU, MRC, MRF, NIHR and industry for individual and collaborative research.

6. **Metabolic & Molecular Physiology** is at the forefront of integrated *in vivo* metabolic research, particularly in relation to skeletal muscle in ageing, physical activity and health. This is exemplified by the group's central role in establishing the MRC-Arthritis Research UK Centre for Musculoskeletal Ageing Research (in collaboration with Birmingham University) and the Arthritis Research UK Centre for Sport, Exercise and Osteoarthritis led by Nottingham and Oxford. A state of the art Mass Spectrometry core facility has been established to enhance invasive human studies and complement the innovative assessment of intermediary metabolism and molecular biology approaches. Significant progress has been achieved in key areas such as: nutritional metabolism; obesity, diabetes and insulin resistance and muscle protein and mass modulation by blood flow, inactivity, hypoxia, and physical activity with respect to ageing, health and chronic disease. Long-standing and new interactions with industry have flourished (with Ajinomoto, Novartis and Mars), and collaborative clinical translational research networks have been successfully developed locally, across the UK (MRC-Association of British Pharmaceutical Industry consortium in COPD) and internationally (EUFP7 projects MetaPredict, PlanHab, Preview). Members of the group are involved in collaborative research awards worth £38m, of which £11m comes to the group.

7. **Molecular Bacteriology & Mycology** incorporates fundamental and applied research programmes on the biology and genetics of pathogenic and industrially important bacteria and fungi. Ground-breaking research achievements include development in the Minton/Winzer lab of a patented genetic toolkit for *Clostridum* species. This includes ClosTron, a transposon mutagenesis system for *C. difficile* and Allele-Couple Exchange (ACE), which facilitates insertion of DNA of any size or complexity into any *Clostridium* or bacterial genome. New materials with resistance to bacterial attachment were discovered and demonstrated to have *in vivo* efficacy to improve medical device performance (Williams, Atkinson). New insights into sophisticated Quorum Sensing (QS) networks, virulence and biofilm development in *P. aeruginosa* and *Yersinia* have been obtained by Williams, Camara, Heeb and Atkinson. Other break-throughs include the demonstration that QS is a cooperative social behaviour *in vitro,* that can be manipulated by cheats *in vivo,* and exploited for therapeutic benefit (Diggle); identification of the human non-integrin laminin receptor as a common target for meningitis-causing pathogens (Ala'Aldeen): and the discovery of novel signalling mechanisms involving the TolB protein (James). Members of the fungi section have made outstanding progress. Avery, working with *Saccharomyces cerevisiae*, has identified novel modes of action of major antimalarial drugs. Archer has developed a predictive model that will underpin future approaches for much-needed improvement to fungal enzyme functionality. The discovery of sexual reproductive cycles in *Aspergillus fumigatus* and *Penicillium chrysogenum* by Dyer provides important insight into the evolution and spread of resistance to antifungal drugs. Members of the group have published six papers in Nature family journals and participated in awards worth more than £40m with £22m to SoLS, including two BBSRC Sustainable Bioenergy Centres (BSBEC), three 5 year MRC programme grants and 8 fellowships (from the BBSRC, MRC, NERC, Wellcome Trust, Royal Society and industry). In addition Minton, Camara and Williams were co-investigators in two collaborative NIHR-funded Biomedical Research Units (Respiratory Medicine and Digestive Diseases) at Nottingham worth £14.5m.

8. **Neuroscience** has employed molecular and integrated [text removed from publication] approaches to discover novel therapeutic targets and to achieve the substantial potential identified in RAE2008; "*The combination of advanced* [text removed from publication] *research methods currently in use, was thought to provide this institution with the opportunity to develop further strength in physiological systems research within the UK."* For example, Chapman, Fone and Ebling have made important discoveries [text removed from publication], including; fundamental mechanistic studies of arthritis pain (Chapman), recognition of dopamine D_3 and 5-HT_6 receptor importance in cognitive deficits (Fone) and establishing the role of FGF21 in regulating adiposity (Ebling). Other research highlights comprise landmark discoveries on the mechanisms of axon- and neuro-degeneration, including: identification and characterisation of the novel neuroprotective factor Wld^S (Conforti), demonstration of the importance of glycogen in Schwann cells to the maintenance of myelinated axon conduction during aglycemia (Brown) and identification of the critical role of microRNA-9 in the control of local translation and the regulation of axonal extension and branching (Dajas-Bailador). Pardon has shown [text removed from publication] that regular physical and mental exercise slows down the progression of AD. The recently established £2.5m Arthritis Research UK Pain Centre, with Chapman as Deputy Director and pre-clinical lead, provides an important platform for future research. New appointments have enjoyed considerable grant success including: Hathway (BBSRC, Arthritis Research UK, and Pfizer Neucentis), Bellamy (BBSRC and Leverhulme Trust), Conforti (EU and CHDI foundation) and Dajas-Bailador (MRC). Significant industrial funding has also been obtained from amongst others; Shire, Hoffmann-La Roche, Eli Lilly and Pfizer, demonstrating the success of our approach and importance of the work to drug development. Total grant awards to group members exceed £10.8m.

9. **Pharmacology** covers research into membrane proteins including G protein-coupled receptors (GPCRs; Hill, Briddon, Baker, Holliday, Gardiner), VEGF tyrosine kinase receptors (Woolard), ATP-binding cassette drug transporters (Kerr), intracellular signalling (Hill, Briddon, Baker, Holliday) and trafficking (Hume). Significant progress has been made in all areas funded by a research grant portfolio worth £26m from MRC, BBSRC, Wellcome Trust, EU and others. A major feature of current work has been the development of drug discovery projects in collaboration with medicinal chemists from the School of Pharmacy, which has identified a lead compound (highly selective β1-adrenoceptor antagonist) to treat patients with concomitant cardiovascular and respiratory disease, funded by a Wellcome Trust Seeding Drug Discovery Award (Baker, Hill). Five

patents have been filed and development work is in progress to take the lead compound into Phase I/IIa studies in man. Members of the group are directors of UoN Spin-Out companies (CellAura Technologies Ltd, Hill; Nottingham Drug Discovery, Hill, Baker, Woolard). Hill and Briddon developed novel approaches to study GPCRs at the single cell and membrane microdomain level. Baker has provided the first antagonist- and agonist-bound crystal structures of the β1-adrenoceptor in collaboration with the Laboratory of Molecular Biology (Cambridge). Other discoveries include: development of widely applicable high content imaging methodologies for GPCR intracellular signalling (Holliday), defining the pharmacology of the plant auxin importer AUX1 (Kerr) and determining the role of small GTPase of the Rab family in organelle transport (Hume). Prestigious fellowships were held by three members of the group; Holliday (RCUK Fellow), Woolard (Wellcome Trust Advanced Training Fellowship) and Baker (Wellcome Trust Clinician Scientist).

10. **Predatory Microbes, Parasites & Pathogens** combines traditional parasitology with molecular biology to understand disease processes and develop novel approaches to therapy. For example, Wickstead characterised molecules involved in parasite antigenic variation and reconstructed the evolutionary history of key cellular components in both *Plasmodium* and *Trypanosoma*. Tewari has analysed signalling pathways that regulate malaria parasite development, providing novel drug targets for therapeutic intervention. Other discoveries include the first functional data linking genetic variants in Crohn's disease to the anti-bacterial autophagic response (Huett) and insight into the structure and biological relevance of immunodominant *Schistosoma mansoni* egg antigens (Doenhoff). Gadelha has uncovered, the architecture of surface membrane and cytoskeleton structures critical for parasitism and created a validated proteome for the cell surface of African trypanosomes, suggesting a new avenue for therapeutic intervention against sleeping sickness. Sockett has shown mechanistically how predatory *Bdellovibrio* bacteria attack bacterial pathogens of animals and crops, and Bradley's work led to the discovery that macroparasites, including blood sucking ectoparasites and helminths, are able to affect innate immune responses. Total awards for the group, from BBSRC, EU, MRC, NERC and the Wellcome Trust exceed £6m. Wickstead holds a BBSRC New Investigator Award.

iii) Research plans and capacity building over the next five years

SoLS is committed to promoting an active and vital research culture that informs and illuminates key areas of basic biology and biomedicine. This is a pre-requisite to translate research for the pharmaceutical, biotechnology and food/agricultural industries, to improve human health and wellbeing, and to improve our understanding of human impact on biodiversity and the environment. Recruiting, nurturing and maintaining high quality staff is crucial. Our professors take responsibility for the research mentorship of 3 or 4 non-professorial academic staff. Colleagues are encouraged to attend internal workshops and seminars to present their research, test their ideas and stimulate interactions. Funds are available to promote attendance of international and national scientific meetings, facilitate dialogue at various levels and assimilate the latest research findings from others. SoLS currently spends around £500k per annum on travel and subsistence for conference attendance by academics, postdocs and PhD students. Support for early career researchers is essential and we intend to maintain this level of investment. All academic staff members are urged to follow their primary interests and trust their instincts, forging collaborations and interdisciplinary groupings, locally or globally, whenever appropriate or opportune. They are also encouraged to publish research in leading international journals, and are guided to do so. Quality as opposed to quantity is the prevailing aim. To achieve their research goals, staff need support. The primary source of research funding for most members of SoLS over the next few years will remain responsive mode, benefitting from the broad range of interests and creativity of staff, though we will remain attentive to new research opportunities as they arise. Three areas of current strength: the MRC/ARUK Centre for Musculoskeletal Ageing Research, the ARUK Centre for Pain Research and the Industrial Biotechnology Initiative have matured over recent years and we see their continued development as central to our research strategy. Furthermore, we see other specific subjects (Synthetic Biology, Bioinformatics and Drug Discovery, including novel antimicrobials) as important areas for future growth, which recognize internal strengths that align with national and international priorities and initiatives. To develop these areas in SoLS we intend to pursue an interdisciplinary approach modelled on the successful collaboration between Biology and Engineering described above for iBIOS, which benefits from the co-alignment of research

strategies in other schools at the UoN. For example, we are developing our Drug Discovery Initiative (DDI) jointly with Pharmacy, our Bioinformatics with ADAC (Advanced Data Analysis Centre) and our Synthetic Biology in collaboration with the schools of Chemistry and Biosciences. These areas will be progressed for the most part by parallel appointments to accelerate the formation of critical mass and in some cases via joint appointments. Significant and substantial investments have already taken place to establish these initiatives, which we expect to come to fruition over the next 5 years. For example, the DDI has benefitted from £500k over 4 years and the UoN has committed £1m over 3 years to support the activities of ADAC. We intend to continue our current strategy of making primarily lectureship level appointments, exploiting the excellent developmental and mentorship mechanisms already established to 'grow' our own staff, but we may also make more senior level appointments if we identify suitable individuals with a strong strategic match to our research priorities. Based on current staff numbers and age distribution, SoLS is likely to have a staff turn-over of around 4 academics per year for the foreseeable future. This provides an opportunity to develop and grow new areas of research, which, underpinned by a strong teaching department, allows continuity and sustainability. The size of the SoLS staff base means that we are not tied to make appointments for teaching replacement and our approach to recruitment will be research-led, with an emphasis on the areas described above.

c. People

Establishing and maintaining a highly talented and motivated academic staff and nurturing ambition, are key to research success and its sustainability, and therefore rightly dominate our research strategy. We see every academic appointment as an opportunity to recruit the most gifted of investigators. Compatibility with existing strengths and interests, coupled with due consideration of RCUK and UoN Research and Knowledge Transfer Priority Areas, guides our decisions.

ia) Staffing strategy

SoLS currently comprises 136 academic appointments (36 Professors, 11 Readers, 29 Associate Professors, 41 Lecturers and 17 Research Fellows); 96 research leaders (91 FTE) are included in this submission. Retirement and departures (10 Professors, 2 Readers and 7 Associate Professors) triggered a planned expansion of early career researchers, with the appointment of 22 new Lecturers, 15 recruited externally. Together with 36 promotions, we have succeeded in our aim to maintain a healthy balance of staff across all career stages, while expanding capacity and developing future research leaders in strategically important areas. We will continue this approach.

Clinical researchers play a crucial role in several of our research groups, providing translational bench-to-bedside capability, therapeutic context, and access to specialist clinical facilities and equipment. The clinician researchers within SoLS are fundamental to the success of many of our projects. For example, Sewell (Immunology), plays a key role in the translation of research on human autoimmune responses into diagnostic screening tests for early detection of solid tumours. Baker (Respiratory Medicine) guides drug discovery activities within the Pharmacology group, and Ala'Aldeen (Microbiology), Irving (Virology), and Turner (Bacteriology) provide expertise for epidemiological studies and support for vaccine development trials, and Williams in the Metabolic and Molecular Physiology group provides expertise and governance for human studies requiring invasive techniques (e.g. tissue biopsies, arterial/venous cannulation and infusions). We consider it important to retain these clinical skills within SoLS to benefit translational projects.

SoLS delivers extensive support to facilitate research. Eleven experimental officers and 96 technicians provide specialist facilities and resources (anatomy, histology, imaging, proteomics, sequencing and [text removed from publication]), direct laboratory support and routine lab management. Of the support staff, 90 are core-funded, which limits staff turnover and improves the development and retention of key skills. 15 administrators deal with grant finances, contract management and infrastructure development. Senior technical and admin colleagues deal with infrastructure maintenance in conjunction with the university Estates department. Funding from the UoN and the Wellcome Trust has supported key staff, particularly to bridge individuals for career purposes and retain essential skills. Since 2008 SoLS has received around £430k in 'Value in People' (VIP) awards from the Wellcome Trust. Because this scheme no longer operates, SoLS has established an equivalent £120k per annum fund to support career development.

ib) Staff career development

The UoN has recently been awarded the European Commission's 'HR Excellence in Research' badge in recognition of its commitment to both supporting research staff and implementing the Concordat encouraging career development of researchers. We are fully committed to providing equal opportunities for staff and students, with freedom from discrimination. The UoN Strategic Plan (2010-2015) sets clear goals to increase numbers of ethnic minority staff and female senior staff. All UoN staff participate in training for equality and diversity. Our commitment is exemplified by the University Women in Science, Engineering and Technology (WinSET) group, the recognition of SoLS as a Science, Technology, Engineering, Mathematics and Medicine (STEMM) school, and our efforts to secure a school Athena Swan Silver award in 2014, following submission of a bid in 2013, to match the current UoN institutional silver award.

Our return includes 15 new Lecturers and 2 independent Research Fellows as early career researchers. The UoN supports young staff via competitive Early Career Research and Knowledge Transfer awards, Nottingham Advance Research (NAR) Fellowships and Anne McLaren (AM) Fellowships. NARs are targeted at exceptional postdoctoral researchers and provide 3 years of independent funding alongside participation in a mentoring and career advice scheme. The AM Fellowship is targeted at excellent women scientists and engineers. From 2013, both schemes will provide an established academic post at the end of three years. Our unit has hosted 2 NAR and 4 AM fellows since 2008. In addition we have supported 10 early career clinicians to advance their laboratory research skills, funded by EU, MRC, Wellcome Trust and other sources.

Early career researchers benefit from personal academic advisors providing grant mentorship, and time-management and career advice. They are strongly encouraged to focus on establishing their research; they have minimal teaching loads and no administrative responsibilities in the first two years. Grant proposals at all stages of career development undergo formal scientific and financial review prior to submission. Multi- and inter-disciplinary networking at the UoN is encouraged via the award of cross-school PhD studentships and pump-priming initiatives. All staff are encouraged to take advantage of training opportunities available at School, Faculty and Institutional levels. Balancing workloads is a School priority. The UoN launched a new workload framework in 2013 to guarantee equitable and transparent allocation of work, promote fair working practices and improve working culture and staff satisfaction. It operates an annual merit-based promotions cycle open to all R&T staff. Promotion opportunities recognise individual career profiles, achievement in research and scholarship, and contributions to teaching and academic service. Staff progress is underpinned by an annual performance review process evaluating achievements, setting goals, assessing workloads and identifying training/mentoring requirements. The UoN Staff Education and Development Unit offers a broad portfolio of courses covering research leadership, management and career progression. The UoN also operates a research leave scheme and Schools provide opportunities and funding to relieve staff of teaching and administrative duties for up to six months. This year (2013) UoN launched the Nottingham Research Leaders Programme to support and advance senior academics in strategic leadership and development through individual mentoring and training in large grant management, developing networks and collaborations. International networking is strongly encouraged for all academic staff and supported with funds to attend conferences and/or to visit existing or potential collaborators. This is reflected in the £500k per annum spent by SoLS on travel. The UoN is committed to global outreach and embeds its internationalisation programme into research developments. Its award-winning campuses in China and Malaysia encourage staff mobility and foster research links.

ii) Research student training and integration

SoLS benefits from a £5.7m BBSRC Doctoral Training Partnership award, which provides 30 studentships per annum with four year training programmes. The school has also been supported by five EU Marie Curie Training Network awards over the past six years, providing PhD and early career training for 94 PGRs and PDRAs, of which 15 trained in Nottingham. The total value of the awards is £13.4m across the five networks, with £2.9million to SoLS. Since 2008 we have received 95 studentships from the MRC, BBSRC, EPSRC and NERC, of which 20 were CASE studentships. PGR (PhD and MRes) enrolment in SoLS has been consistently greater than 100, each year since 2009. The number of PhD starters has risen steadily; from 70 (61.5 FTE) in 2008 to 85 (73.2 FTE) in 2012. Nearly all PhD students are co-supervised by two academics and more than a quarter of

these involve a supervisor from outside SoLS, which reflects the multidisciplinary nature of the research training. PGRs receive generic training, currently selected from ~80 courses covering all aspects of biology and researcher development. PGR have access to all research facilities and receive training in the use of state-of-the-art equipment wherever appropriate to their research. They work alongside postdoctoral RAs and interact freely with senior members of staff. Postgraduate Tutors provide overarching support, formally monitoring progress and attendance at taught courses and disbursing School travel awards to facilitate PGR attendance at major conferences. PGRs and PDRAs in SoLS run their own research seminars at which they present and discuss their own work. Seminars with external speakers are organised separately and attendance at these is compulsory for PGRs. Research groups also run journal clubs allowing students to present and discuss topical papers regularly with academic staff and postdoctoral research fellows.

The UoN Graduate School provides generic administrative support and has established Graduate Centres that facilitate interdisciplinary networking and collaboration through provision of social areas with access to study space, wireless internet and seminar rooms. They also host dedicated researcher development activities, training courses, careers sessions and seminars. Staff organise opportunities to discuss issues related to career and professional development.

PGR students are issued with a laptop and have access to high quality PCs and computer support for all aspects of research, data mining and electronic journals for literature searching, across all the biological, biomedical and clinical sciences. Extensive electronic journal access is available and the George Green Science and Greenfield Medical libraries carry hard copies of the major international journals. The Graduate School provides research travel prizes to enable postgraduates to attend conferences with SoLS having provided an additional £300k since 2008 to support PGR conference attendance.

d. Income, infrastructure and facilities

Income

Over the REF period 90% of researchers in this return held research grants and of the rest, the majority were new staff still establishing their laboratories and formulating applications. Our total funding portfolio exceeded £227m, including £128m to PIs in SoLS and an overall income of £54m. Collaborative awards exceeded £2.2m per academic. The total number of awards surpassed 550, with almost half having a six figure value or greater. As the funding model for research councils has moved towards fewer, larger awards, one of the important challenges over the period has been to develop interdisciplinary (including multi-site) research proposals. Successful collaborative bids include: £11.5m for ARUK Centre of Excellence for Sports Injury and Osteoarthritis Prevention, €20m for an EU IMI Kinetics for Drug Discovery consortium, £4.5m for an MRC stratified Medicine Award, two Wellcome Trust Awards (£2.8m and £1.3m), an ARUK Pain Centre Programme (£2.5m) and an MRC-ARUK Centre Programme to build infrastructure in musculoskeletal aging research (£2.5m) held jointly with Birmingham. We also benefitted from multiple other grants of more than £1m including three BBSRC Biofuels awards and a strategic LOLA award totalling £8.8m; £1.9m Medical Research Foundation Award, three MRC awards totalling £5m; £1.7m from the Food Standards Agency and two BHF programme grants for £2.3m. Funding has been secured from a variety of sources: UK Research Councils (50%), UK Charities (23%), EU (13%), UK Government (2%), UK Industrial Partners (5%), and others overseas (7%).

Infrastructure, Facilities and Equipment

SoLS boasts state-of-the-art research infrastructure, core facilities and equipment within the Queen's Medical Centre (QMC), the Life Sciences building and the new Centre for Biomolecular Sciences (CBS) on the main University Park campus, and the Graduate Entry Medicine building (GEM) at the Royal Derby Hospital. These enable all aspects of contemporary biological and biomedical research to be conducted by members of SoLS and their research students. CBS, opened in 2007 at a cost of £40m fully equipped, provides a modern research environment for members of SoLS, promoting interdisciplinary research with groups from several other schools including Chemistry, Medicine and Pharmacy. The CBS building provides level 2 and 3 containment facilities and high-tech liquid and gas fermentation labs. The university has invested £9m for other groups in SoLS since 2008 through a rolling programme of building improvements.

SoLS possesses extensive state-of-the-art facilities for invasive human physiology-based investigations at the University of Nottingham Medical Schools in Derby and Nottingham. These include clinical experimentation wards, metabolism laboratories and volunteer screening rooms in addition to exercise training gymnasia. Dedicated facilities exist for measurement of body composition (DXA), muscle function, exercise tolerance, *in vivo* haemodynamics and cardio-respiratory function. There is also access to world-leading whole-body magnetic resonance facilities for human imaging and spectroscopy. These sites house a unique mass spectrometry core including two GC-C-combustion isotope ratio mass spectrometers and a GC-pyrolysis-IRMS for deuterium, with unrivalled in-house stable isotope tracer expertise. Facilities and skills exist for biochemical (intermediary metabolism), mitochondrial (luminometric determination of mitochondrial ATP production rates) and molecular biological analyses, including in-house facilities for low-density gene array card analysis.

Liquid handling robotics for tissue culture, high-content imaging and fluorescence confocal microscopy provide opportunities for cell-based drug screening within SoLS. Our laboratories are equipped with Molecular Devices Ultra and Micro fluorescence imaging plate readers, PerkinElmer Envision, BMG-Labtech PheraStar and FlexStation fluorescence plate readers, and a Tecan Freedom Evo automated liquid handling robot within a BigNeat tissue culture cabinet. In addition, the Advanced Microscopy Unit supports time-lapse microscopy, and preparation techniques for tissues, cells, materials and tissue engineered constructs, with software for quantitative image reconstruction, tracking and analysis. We have one of the most extensive confocal imaging facilities in the UK, which includes a Zeiss LSM 510, Zeiss LSM Confocor 2, Zeiss LSM Confocal 3 multi-photon, Zeiss LSM 710, Zeiss Exciter, Zeiss TIRF and a DeltaVision Elite. This equipment provides the capability for all forms of confocal microscopy including TIRF, FCS, FLIM, FRAP and FRET. Following a recent BBSRC award (£800k) the facility will incorporate super-resolution structured illumination microscopy (SIM) and single molecule localization techniques (PALM & dSTORM) combined with a 32-channel GaAsP detector confocal microscope.

Our nucleic acid sequencing facility, DeepSeq, offers state-of-the-art high-throughput DNA and RNA sequencing technology including whole genome and transcriptome sequencing, and a variety of other sequencing and bioinformatic capabilities. Sequencing platforms include: Life Technologies 5500xl, Roche 454 FLX Titanium and the Illumina MiSeq. The Post-Genomics Technology Facility (PGTF) offers facilities and expertise for transcriptomic and genomic research, including custom in-house microarray printing, QC and automated hybridization. It also provides laser capture microdissection for transcriptome analysis and bacterial genome comparisons.

Within the Proteomics Laboratory SoLS provides core technologies of 2D gel separation, protein mapping by mass spectrometry and database mining. The laboratory is fully equipped with gel imaging and software analysis tools and the ability to perform protein spot excision from gels, processing and tryptic digestion to peptides. It also houses three tandem MS-MS instruments and two MS analysers offering complementary capabilities for ionisation, resolution, mass-accuracy and ion-counting with triple-quadrupole, time-of-flight and hybrid-Q-TOF platforms.

SoLS provides researchers with the tools for cell sorting including the use of a Beckman Coulter FC500 Flow Cytometer, a MoFlo XDP Single Laser FACS Machine and a Beckton Dickinson FACSCanto II 2 Laser 6 Colour Analyser/Work Station. Electron microscopy equipment in SoLS includes an FEI Tecnai 12 Biotwin Transmission Electron Microscope (TEM) with up to 120kV and x300k magnification. It has high contrast lenses and auto-montaging software and is currently being upgraded for cryo-TEM and tomography software. It is accompanied by a Leica EM UC6/FC6 cryo-ultramicrotome for preparation of frozen EM sections. The Unit shares access to a Jeol JEM1010 TEM and a Jeol JSM840 Scanning Electron Microscope (SEM) with the NHS.

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The School has 117 tissue culture safety cabinets, 100 chemical fume cabinets, 19 cold rooms, and 3 warm rooms to support our research activities.

Shared and Collaborative use of Research Infrastructure

In addition to the state-of-the-art equipment available within SoLS, the UoN has adopted a cross-HEI shared approach to maximise access to a wide range of analytical equipment available across all departments via UNICAS, University of Nottingham Interdisciplinary Centre for Analytical

Science. The analytical equipment is divided into 8 sections according to the techniques employed: Mass spectrometry, microscopy/imaging, magnetic resonance imaging, nuclear magnetic resonance spectroscopy, thermal analysis, infrared and Raman spectroscopy and a miscellaneous section which includes techniques such as X-ray photoelectron spectroscopy, X-ray CT, ICP-MS and others. Thus, members of SoLS have access to MRI, fMRI, LC-MS/MS and NMR. There has also been sustained institutional investment over recent years in High Performance Computing (HPC). Most recently, a £1.2m equipment refresh delivered a 2600-computer core facility with a peak performance of 46 TFlops, which was launched in January 2013. This provides essential e-infrastructure for researchers using molecular modelling and computational approaches in the life sciences. UoN is also a key partner in the EPSRC-funded MidPlus regional HPC centre. UoN operates a Kit-Catalogue, which is an open source web-based system that helps to catalogue, record and locate equipment. It contains a wealth of information on each item including its specification, custodian, handbook, access requirements, usage data and photos. The Kit-Catalogue enables university staff and research students to find specialist equipment and facilities they need, with details of who to contact. Interdisciplinary research that has arisen through these shared facilities includes collaboration with the schools of Pharmacy to develop fluorescent ligands for GPCRs, and to understand drug structure-activity relationships; Chemistry to investigate rainforest chemistry; Mathematics to model GPCRs and calcium signalling in neuroscience; as well as other collaborations with Engineering and Physics.

In 2011 the UoN and the University of Birmingham announced a new partnership enabling them to jointly award degrees and share academic staff. The universities work closely together in a number of key areas including research initiatives, developing the student experience, business engagement activities and internationalisation (e.g. development of 20 full-fee PhD scholarships annually for Brazilian students; a visiting Fellows programme and a £480k joint research investment fund with the São Paulo Research Foundation). The collaboration enables each partner to share best practice, diversify income while strengthening research and teaching, and improve management and administration. The MRC-Arthritis Research UK Centre for musculoskeletal Ageing Research is an example of excellent interaction between the two institutions.

Members of SoLS have well-established collaborations with pharmaceutical companies that have resulted in benefits-in-kind, such as several donations of equipment and consumables to groups within the school (e.g. following the closure of the nearby AstraZeneca R&D site at Loughborough).

Policy and Practice in Relation to Research Governance

Research governance for SoLS follows procedures outlined in the university's Code of Research Conduct and Research Ethics, which describes the standards and context that research staff and students must adhere to. The Code provides a clear governance framework for research conduct and promotes the highest standards of research integrity ensuring that academic staff have the freedom within the law to question and test received wisdom and develop new ideas and responses. It is based on a range of accepted sources including the UK Research Integrity, the Declaration of Helsinki and guidance from Research Councils based in the UK and abroad. The university's central research committees (the Research and Knowledge Transfer Board (RKTB) and the University Research Ethics Committee (UREC)) maintain and annually review the Code so that it reflects current research policy and responds to changes in the broader research landscape.

e. Collaboration and contribution to the discipline or research base

i) Collaborative research

Members of SoLS have established more than 800 collaborations, including national and international alliances with commercial, industrial, academic and public sector partners. The extent of collaboration is apparent from our publication record and research grant achievements. Virtually all of the 370 papers listed in REF2 involve collaboration of some kind, with more than 50% including international partners drawn from the rest of Europe (100), USA and Canada (98), Asia (32), Australia and New Zealand (20), Africa (11) and South America (7). Our portfolio of collaborative awards exceeds £227m. Of 500+ grant successes, 41% involve collaborators in the UK, 23% in the rest of Europe, 12.5% in USA and Canada, 5.7% in Asia and the Far East, 1.8% in Australia and New Zealand, 1.4% in Africa and 0.6% in South America. Members of SoLS have collaborated with numerous prestigious institutions worldwide and these include amongst others:

- USA: The Universities of Berkeley, California at San Diego, Cornell, Harvard, Pittsburgh, Rockefeller, Stanford and Yale, Massachusetts Institute of Technology, and research establishments including the Human Genome Sequence Center (Houston), St Jude Children's Research Hospital (Memphis), the Scripps Research Institute (La Jolla), the Broad Institute (Cambridge) and National Institutes of Health (Bethesda).
- Europe: Universities and research institutions in 19 countries including amongst others the Karolinska Institute (Stockholm) in Sweden, the Max Planck Institute of Molecular Cell Biology and Genetics (Dresden), Leibniz Institut fur Molekulare Pharmakologie (Berlin) Technische Universitat München, University of Cologne, University Medical Centre Freiburg and the University of Bonn in Germany, Sanquin Institute (Amsterdam) and Leiden University in The Netherlands; Medical University of Vienna and Medical University Innsbruck in Austria; in France the Institute Pasteur de Lille, Université Montpellier, Institute Curie (Paris), Centre National de la Recherche Scientifique (Paris), Institute de Génomique Fonctionelle (Montpellier) and Institute de Fer à Moulin (Paris) in France; Instituto de Biomedicina de Sevilla and Universidad Complutense de Madrid in Spain, Novartis Institute for Biomedical Research, University of Bern and University of Lausanne in Switzerland; University of Antwerp and the Nuclear Research Center in Belgium; University of Copenhagen in Denmark and the European Chemicals Agency (Helsinki) in Finland;
- Rest of the World: University of Sydney, Victor Chang Cardiac Research Institute, Queensland University of Technology, University of Western Australia and Monash University, Australia; Institute of Animal Science, and First affiliated Hospital Sun Yat-sen University Guangzhou, China; Tel Aviv University, Israel; Research Institute of Environmental Medicine, and Centre for Emerging Infectious Diseases, Japan; International Livestock Research Institute, Kenya; and University of Malaya.
- UK: Universities of Aberystwyth, Aberdeen, Birmingham, Cambridge, Dundee, Edinburgh, Imperial College London, Kings College London, Leicester, Manchester, Oxford, University College London, and specialist research establishments: London School of Hygiene and Tropical Medicine, MRC-Laboratory for Molecular Biology, Roslin Institute, Rothamstead Research, Sanger Institute Liverpool School of Tropical Medicine, Cambridge Institute for Medical Research (CIMR), and the Wolfson Centre for Inherited Neuromuscular Disease.

Collaboration with industrial partners is a strongpoint. 55 members of SoLS are actively engaged in collaborative research with industrial partners derived from several business sectors including:

- Pharmaceuticals (AstraZeneca, Conatus, Eli-Lilly, Epix, Forest Labs, GSK, Heptares, Hoffmann La Roche, Merck, Novartis, NovoNordisk, Pfizer, Pharmnovo, Proximagen, Servier, Shire)
- Diagnostics and devices (Advanced Medical Solutions, GE Healthcare, LGC, Vision Biotech)
- Food and nutrition (Abbott, Adisseo, Ajinomoto, DSM Food Specialties, Mars, Roal, Unilever)
- Agrochemicals (Syngenta, Novozymes)
- Energy/biofuels (TMO Renewables, Green Biologics, LanzaTech)
- Biochemicals (Alzchem, Ascent/Abcam, CellAura, Evonik, Invista, Lanxess, Promega)
- Biotechnology (Agilent, Azotic, Kirkstall, Oxford Nanopore, Zyoxel).

Collaboration with the NHS is important to members of SoLS with approximately one fifth of researchers involved in active partnerships. Nationally these include centres such as St Georges London, Institute of Mental Health and the Oxford Clinical Trials unit, in addition to University Hospitals of Birmingham, Leicester and Bristol. Locally, members of SoLS collaborate with clinical research colleagues within the Nottingham University Hospitals Trust and are also involved with the East Midlands Strategic Health Authority. Others participate in multi-centre clinical trials (e.g. DAFNE, REVEAL, SABATO, THRIVE).

ii) Peer review of grant applications and research publications

Contribution to the peer review process by academic staff is significant and extensive. Numerous members of SoLS have served on grant review panels for UK research councils including BBSRC, MRC and NERC, as well as for HEFCE, the European Research Council (ERC), the Wellcome Trust and other major charities. Since 2008 SoLS staff on BBSRC panels include: Brookfield, Ebling, Greenhaff and Narici on Committee A, Sockett on Committee B, Ghaemmaghami and O'Shea on Committee C and Bonev on Committee D. Prior to committee reorganisation members of SoLS served on the BBSRC Engineering and Biological Systems committee and the Genes and

Developmental Biology panel. Colleagues have also contributed to the BBSRC Strategic Longer and Larger Grants committee and the Tools and the Resources Development Fund. Sewell and Hill have occupied senior positions on MRC committees. In 2011 Sewell completed a seven-year term as a Member of the governing MRC Council and remains a National Grant Panel Member, and Hill Chairs the MRC Molecular and Cellular Medicine Board. Ala'Aldeen has been a member of the MRC Infection and Immunity Board. Brook and Hill have contributed to cross-council activity, the former as a member of the DTI/BBSRC/MRC Applied Genomics Programme and the latter on the Cross Research Council Chemical Biology Network Panel and RCUK Cross Council Optical Microscopy Panel. Brookfield, Davison and MacColl have served on various NERC panels including; the Standard Grants Panel, the Small Grants Panel and the Fellowship Panel as well as contributing to the NERC Peer Review College. Significant contributions have also been made to peer review for major charities with SoLS representation on funding committees for Alzheimer's Research UK (Morgan), Muscular Dystrophy Campaign (Hewitt) and the Wellcome Trust (Hewitt and Sockett). Support for European funding agencies has also been provided in several areas. Tewari has served on the European Research Council Advanced Grant Panel for Infection and Immunity, and Szewczyk and Narici on the European Space Agency Life Science Peer Review Board. Members of SoLS (Archer, Avery, Ball, Brook, Constantin-Teodosiu, Hewitt, Macdonald and Szewczyk) have also served on government-led research committees in Denmark, Finland, Germany, Italy, Latvia, the Netherlands, Qatar, Spain and the USA. With the exception of three early career researchers all members of our return have reviewed grants for major funding bodies.

Nearly half of our researchers also contribute to journals as editorial board members and around 20% are journal editors including Editors in Chief, Associate Editors and Guest Editors for a diverse range of journals including; the American Journal of Physiology, British Journal of Pharmacology, Ecological Entomology, Heredity, International Journal of Obesity, Journal of General Virology, Journal of Insect Science, Journal of Medical Microbiology, Journal of Natural and Environmental Sciences, Journal of Neuroendocrinology, Nutrition and Diabetes, Plasmid and Psychopharmacology, amongst others. All members of SoLS have reviewed papers for esteemed journals since 2008.

iii) Fellowships and awards as indicators of research excellence

Two Fellows of the Royal Society (Clarke and Lloyd) have been active researchers within SoLS during the REF period. Lloyd has continued to lead a group and is included in this submission. Clarke was awarded the Darwin Medal, one of the Royal Society's most prestigious awards, for his contributions to evolutionary biology. Other members of the unit have held prestigious fellowships and research awards during the assessment period. These include: Allers and Diggle (Royal Society University Research Fellowships), Atherton (American Physiological Society International New Investigator Fellowship), Bellamy and Nieduszynski (BBSRC David Phillips Fellowships), Fone (Fellow of the British Pharmacological Society), Georgiou (Cancer Research UK Career Establishment Award), MacColl (NERC early career Fellowship) and Macdonald (Fellow of the International Union of Nutritional Sciences). Three members of the school: Armour, Brook and Sockett have been awarded Leverhulme Trust Research Leave Fellowships since 2008. Honours and awards for research excellence include: Baker (British Pharmacology Society Novartis Prize; Medical Research Society Respiratory Prize), Briddon and Holliday (Bill Bowman Travelling Lectureships), Camara (Guest Professor, University of Jiangsu, China), Hill (Raine Visiting Professor, University of Western Australia), Chapman (British Pharmacological Society Novartis Prize), Di Stefano (Marie-Curie Fellowship), Crittenden (Elected Honorary Member of the British Lichen Society), Davison (Furusato Award of the Japan Society for the Promotion of Science), Diggle (Society of General Microbiology Fleming Prize), Ebling (Mortyn Jones Lecturer, British Society for Neuroendocrinology), James (Society for Applied Microbiology Communications Award), Medway (Sir Terry Pratchett Fellowship) and Pardon (British Association of Psychopharmacology preclinical award).

iv) Indicators of wider influence or contributions to the discipline or research base

All members of SoLS have made substantial and significant contributions to the wider discipline and research base over the past few years. They have advised more than 35 public bodies in the UK and abroad including: the Advisory Committee on Dangerous Pathogens, the Commonwealth Scholarships Commission, the Danish Council for Strategic Research, the Department of Health,

the European College of Sport Science, European Molecular Biology Organisation, the Health Protection Agency, the Ministry of Defence, the National Institute for Health and Clinical Excellence, INSERM (France), Israel Science Foundation, Japanese Space Agency, RAE 2008, the Roslin Institute, Swiss National Science Foundation, the Technology Strategy Board, UK Space Agency and the US Environmental Protection Agency. Irving chairs of the Department of Health Expert Advisory Group on Hepatitis. Two colleagues held advisory roles to governments; Turner as Advisor to the Parliamentary and Health Service Ombudsman and Ala'Aldeen who was appointed Minister of Higher Education and Scientific Research for the Kurdistan Regional Government. Members of SoLS have also served on the committees of 18 learned societies and charities, examples of which include: British Mycological Society, British Society for Human Genetics, Physiological Society, Royal College of Pathologists and Society for General Microbiology. Five colleagues have held positions as senior officers including three Presidents: Bradley (British Society for Parasitology), Crittenden (International Association for Lichenology) and Narici (European College of Sport Science); one Vice-President; Brookfield (Genetics Society) and one Chairman; Ebling (British Society for Neuroendocrinology).

Further evidence of the contribution of SoLS members to the research base is demonstrated by their involvement at national and international conferences and at other universities. All of our staff have delivered talks at conferences or seminars to university departments as invited speakers (averaging more than 6 presentations each). Furthermore, 40% have chaired conference sessions and 10% have organised meetings.

The wider influence of members of SoLS is also evidenced by their strategic advisory roles and consultancies for multiple industrial partners. For example, Archer serves on the Scientific Advisory Board for the Kluyver Centre for Genomics of Industrial Microorganisms in The Netherlands, Atherton advises Abbott Nutrition and MacDonald is a member of the advisory council of Mars Scientific and the Public Policy Advisory Board of Coca Cola International. In addition more than one quarter of SoLS serve as consultants for a range of companies such as 3M Healthcare, AstraZeneca, Bio-Rad, Delta Biotechnology, DuPont, GSK, Glycoform, Jansen-Cilag, Esteve, Mars, Merck, Nike, Novartis, NovoNordisk, Oxford Nanopore, Pepsico, Pfizer, Proctor and Gamble and the Waltham Centre for Pet Nutrition.

Thus, the re-configuration of biological and biomedical sciences at the UoN brings together leading researchers within a new 'School of Life Sciences' that provides a coherent, vibrant and forward-looking environment for world-changing research. The many accomplishments we have documented since 2008, coupled with the high quality infrastructure and cutting edge facilities we have established, demonstrates that we have built an outstanding platform, from which talented individuals can continue to deliver the highest level of international quality research, scholarship and impact.