

Institution: University of Kent
Unit of Assessment: 5: Biological Sciences
<p>1. Unit context and structure, research and impact strategy</p> <p>Comprising the research activity within the School of Biosciences at Kent, this submission reflects a Research and Innovation Strategy initiated in 2014 to deliver top-quality research with broad appeal and significant end-user engagement. The key tenets of this strategy included:</p> <ul style="list-style-type: none"> • A drive to generate high levels of research income per staff member, with an emphasis on research council funding and industrial buy-in. • A radical programme of staff recruitment and retention over the REF period, tackling strategic issues, strengthening research areas, and addressing Athena SWAN priorities such as gender balance. • Targeting of research outputs based on fundamental molecular genetics, molecular biology, and biochemistry, to journals with the broadest appeal. • The planning and development of new research and teaching hub building, and a programme of high-quality laboratory refurbishment in existing space. • A strong commitment to further development of our historically strong engagement with industry stakeholders; this resulted in significant industrial funding and numerous projects with industry buy-in. • An enhanced commitment to the 'bench to bedside' ethos, resulting in many research groups contributing directly to end-user engagement in the medical profession and to patient care. • All the above towards the goal of greater collaboration and research capability, which resulted in a significant increase in staff numbers, PhD awards, high-quality laboratory space, outputs, and income since REF2014. <p>Our core mission is the pursuit of new knowledge in the molecular life sciences, and its application for useful purposes, thereby fulfilling the criteria of Research Excellence and High Impact. Our research covers three areas of core strengths, namely: Applied Molecular Biotechnology (AMB); Infectious Disease (ID); and Genomic and Cellular Dynamics (GCD). An intentional focus on themes, rather than a rigid group structure, enables our staff to participate in more than one research area, thereby encouraging collaboration and cross-disciplinary endeavour. Moreover, cogent (often multidisciplinary) groups with common interests consisting of multiple academics are encouraged where appropriate.</p> <p>The Applied Molecular Biotechnology (AMB) theme is characterised by significant industrial buy-in and end-user engagement in that it targets the application of fundamental research findings to biotechnological solutions. AMB's activities range from: a) Industrial Biotechnology, with a focus on the production of biopharmaceuticals (a longstanding area of success for the School (Robinson, C.; Smales; see impact case study); b) the design and improvement of new Synthetic Biology products (Lawrence, Moore, Warren); and c) molecular diagnostics for fertility issues relevant to human health and agriculture (Griffin, O'Connor; see impact case study). Members of the theme have consistent and outstanding successes in accessing industrially oriented funding streams, including KTP, Innovate UK, Catalyst, GCRF, Industry Fellowships, and others (see section 3 for details). Consequently, this theme accounts for most of the School's income, from research councils, industry, and the majority of the post-doctoral researchers and PhD students. Multiple advisory roles with diverse companies originate from this group, and help to maintain a strong network with end users. For example, Garrett advised on drug discovery to Kinsensus, Azeria Therapeutics, Centauri Therapeutics, and Sierra Oncology; Ortega Roldan on NMR-based metabolomics and protein interaction studies to AlgaeCytes and Charles River; Moore on cell-free system applications to Oxford Biotrans; and von der Haar on efficient recombinant gene design to UCB, ZuvaSyntha, and Phenotypeca Ltd. In collaborative terms, AMB leads the Centre for Industrial Biotechnology, which draws in support from the Kent Business School, the Faculty of</p>

Social Sciences (now the Division of Natural Sciences), and the School of Engineering and Digital Arts.

The **Infectious Disease (ID)** theme encompasses the fundamental study of a range of infectious agents, including bacteria, viruses, protozoans, fungi, and prions, with numerous examples of biomedical applications. This ranges from studies into nitric oxide metabolism in *E. coli* (Shepherd), evolutionary studies on microbial parasites (Tsaousis), aspects of the biology of fungal pathogens (Buscaino, Gourlay, Hall), and studies on viral evolution (Michaelis, Wass), antimicrobials (Kad), and fungal prions (Xue, Tuite). While focusing principally on fundamental research, this group has also increasingly connected to stakeholders in the human and animal health fields, resulting, for example, in one of our impact case studies (on preventing fungal colonisation of voice prostheses in cancer patients with laryngectomies; Gourlay), in an Interreg2Seas-funded project on the prevalence of *Cryptosporidium* in European Dairy Cows (Tsaousis), and in collaborative work on clinical sample analyses with our regional East Kent Hospital Universities Foundation Trust, EKHUFT (Shepherd, Tsaousis). There are two cogent, cross-disciplinary groups with more than one academic identity within this theme: the Kent Fungal Group (Tuite, Buscaino, Ezcurra, Gourlay, Hall, Mulvihill, Von Der Haar, Tullet, Xue), which brings groups researching the fundamental biology, pathogenicity, and biotechnological applications of fungal model organisms into collaboration with the Schools of Computing, Engineering, and Physics; and RAPID (ResistAnce Pathogenicity and Infectious Diseases) (Shepherd, Wass, Tsaousis, Tuite, Gourlay, Buscaino, Michaelis, Robinson, G.), which also draws in support from Kent Health, Pharmacy, and Computing.

The **Genomic and Cellular Dynamics (GCD)** theme centres around a number of pathways and diseases where genomic processes and/or cellular architecture are crucial. It combines fundamental research with biomedical application in the areas of cancer, infertility, heart disease, deafness, blindness, Parkinson's and autoimmune diseases. This includes chromosome evolution in microbes, birds, and mammals (Buscaino, Ellis, Farre, Griffin) genome function during reproduction (Ellis, Griffin), (mal)functioning of genomic processes and cellular signalling in cancer (Fenton, Garrett, Kad, Michaelis, Wass), studies of processes that lead to organismal ageing (Ezcurra, Korzelius, Tullet), and generation, sensing, and control of mechanical forces in the living cell (Geeves, Goult, Gourlay, Kad, Mulvihill). As for ID, much of the fundamental research in GCD translates to human health, and members of the group increasingly engage with clinical practitioners. This is evidenced, for example, by the co-supervision of doctoral students (Garrett with the Maidstone and Tunbridge Wells NHS Trust), collaborations with the local East Kent NHS Trust (Shepherd, Tsaousis), Guy's and St Thomas' (Wass), as well as collaborations with world-leading fertility clinics – London Women's Clinic, CARE fertility (Nottingham), Zouves Fertility (San Francisco), CCRM (Colorado), Andrology Solutions (London) – and with diagnostic laboratories (Igenomix, Cooper Surgical) (see also impact case study). Two cogent, cross-disciplinary groups, plus one Centre, identify within this theme, namely Mechanics and Dynamics of Cells and Proteins (MaDCaP) (Geeves, Goult, Gourlay, Kad, Mulvihill), and Evolution, Reproduction and Genome Organization (ERGO) (Griffin, Ellis, Farre, Fenton, Wass), forming part of the Centre for Interdisciplinary Studies for Reproduction (CISoR), which engages with the Schools of Law, Social Policy, Psychology, Philosophy, Anthropology and Conservation, History, and Physical Sciences.

A key facet of our Research and Innovation Strategy has been in the area of staff recruitment over the last six years. This has shaped an interactive, well-rounded, and well-functioning research environment. Around half (14 of the current 28.8 FTE) were appointed during this REF period, providing a rare opportunity to employ strategically into developing areas. These included: Synthetic Biology (Lawrence and Moore complementing existing research in the Warren lab); Cancer Research (where Fenton and Garrett complemented the activities of Michaelis and Wass); and Evolution, Reproduction and Genome Organization (where Ellis, Farre, and O'Connor formed this new group with Griffin). The Infectious Disease theme was joined by Hall and Mulligan, and a new activity in Ageing Research was established through the recruitment of Ezcurra, Korzelius, and Tullet. Finally, Goult, Kad, Mulligan, and Ortega-Roldan strengthened existing capabilities in Biochemistry and Structural Biology.

Supported by our mentoring and staff development mechanisms (see section 2), our newly recruited staff have been highly successful in producing funded grant applications, and have published their work in leading journals, including *Nature*, *Nature*-associated journals such as *Nature Communications* and *Nature Protocols*, *eLife*, *Cell Reports*, *Current Biology*, and *PNAS*. Their contribution to research excellence in the School is thus significant and highly valued.

2. People

Summary of Research-Active Staff and Students

Over the current REF period, 11.2 FTE on Education and Research (E&R) contracts left the School through retirement (5.6), through taking up positions elsewhere (4.6), and through transfer to non-research contracts (1). This was balanced by the recruitment of 14 new E&R members of staff, growing the School to its current size of 28.8 Category A staff. At the time of writing, this includes 7 FTE at Lecturer level, 8 FTE at Senior Lecturer level, 5 FTE at Reader level, and 7.8 FTE at the Professor level. The School houses 3 full-time Research Fellows, and 4 full-time facility managers who support our research staff by maintaining and running essential large items of equipment. Moreover, 7 academic staff on Education, Scholarship and Professional Practice (ES&P) contracts are not directly involved in research, but provide essential support for the School's research by delivering a large share of the teaching duties. Addressing issues of gender imbalance from our last submission (where only one female member of staff was submitted), 7 of our current Category A submitted staff are female (all newly recruited in this period), and we aim to approach a gender equal ratio by the next submission.

Most of our hands-on research activities are carried out by postdoctoral and technical staff, as well as research students, and the School currently houses 35 Postdoctoral Research Assistants, 15 Technical Staff, 88 Doctoral students, and 25 students undertaking MSc by Research degrees.

Leadership and Governance

The University is currently transitioning from a Faculty-based structure (19 Schools and 3 Centres housed in 3 Faculties) to one based on six multi-subject Divisions. The transition process took place in 2020 and culminated in the formal launch of the Divisions in November 2020. Throughout the REF period, our School was part of the Faculty of Sciences, reporting on research matters through the Dean and Associate Dean for Research to the University's Executive Group. The School's activities were directed by the Head of School and a Senior Management Team consisting of School Directors of Research, Graduates Studies, Learning and Teaching and Student Experience, as well as a School Administration Manager and a Science Support Manager. The directors involved staff in governance matters via a devolved committee structure, where committees relevant to research matters included the Research and Innovation Committee, Graduate Studies Committee, Facilities Committee, and Athena SWAN Committee. These met termly to report on relevant matters, to discuss issues within their remit, and, where appropriate, to approve of policies related to such issues. All these subject committees reported to an Academic Committee consisting of all academics, as well as representatives for postdoctoral research assistants, research students, and administrative staff. As a School, we exchanged examples of good practice and other information with other Schools in the Faculty through a Faculty Research Committee, and with the wider University through a Directors of Research Network that met termly. Specific Research Student Matters were governed by the Graduate School (now the Graduate and Researcher College), via a Faculty Associate Dean for Graduate Studies.

The new Divisional structure is intended to facilitate more direct communication routes between the centre and the University's academics, and to increasingly encourage interdisciplinary research. The School of Biosciences joined the Division of Natural Sciences, together with the Schools of Physical Sciences and Sports and Exercise Sciences, and with the Medway School of Pharmacy and the Kent and Medway Medical School as affiliates. Division-level committees led by Divisional Directors will continue the activities of previously School-led committees, and we are

currently working towards an effective sub-structure in the Division that is conducive to both efficient communication and for promoting interdisciplinary research.

Staff Development

We are fully committed to supporting staff at all levels to develop their research profiles, through a portfolio of measures that are integrated into a wider culture of support and mentoring. All our staff are appraised under the University's 'Reflect, Plan, Develop' (RPD) framework, which for research-active staff includes discussion of annual Individual Research Plans, documenting both successes and challenges to date, and detailing plans for development.

One central element of RPD discussions is the need for appropriate levels of research income. Although the University sets research income targets for Schools, the School decided not simply to pass these on to individuals. Instead, our aim is to enable individuals to attract research support to a level commensurate with the particular research problems on which they work. The high levels of research income of the School overall (see the section on income below) provides a framework and system of mentorship to encourage funding success among recently appointed colleagues.

Both the University and the School offer a number of tools to support research staff specifically in their quest to attract research funding. The University's Grant Factory (organised by the Graduate and Researcher College) is targeted primarily at postdoctoral researchers and early career academics, and provides training in various generic as well as funder-specific aspects of grant writing. The School offers events targeted to discipline-specific funders, including mock-panel meetings where early career researchers can gain experience of the decision-making dynamics on grant panels. The extensive presence of our more senior staff on actual funding panels (see the section below on our contribution to the research base) is a valuable asset in making these mock panels a realistic and valuable exercise. During this REF period, we also revised our formal procedures and clarified criteria for applying for study leave (modified from the pre-existing University policy on study leave). This has since been taken up by typically 2-3 members of academic staff per year with a demonstrably positive influence on both grant applications and outputs.

An array of additional training opportunities that promote career development is available to our researchers. A number of our staff participated in national leadership training schemes such as AURORA (4 participants from the School during this REF period), or in Kent's Leadership for Areas of Significant Responsibility (LASR) scheme (3 participants). During this REF period, the University established a scheme enabling postdoctoral workers to apply for independent summer studentships. This enables them to gain experience with grant writing, to establish small independent projects that are worked on by undergraduate summer placement students, and thereby also to gain valuable independent supervisory experience.

Research Students

Research students are one of the central pillars supporting our research. They are essential for developing research projects to a point where they are suitable for grant applications, and frequently also contribute directly to our highest-quality papers. Around a quarter of our submitted outputs are co-authored by PhD students.

During this REF period, the School has trained and graduated on average 20 Research MSc and 15 PhD students per year. While our MSc student cohort is almost entirely self-funded, most PhD students are externally funded, with a smaller number of (mostly international) self-funded doctoral students. Despite the cessation of BBSRC-funded studentships awarded to individual research departments in 2011, we succeeded in maintaining doctoral student intakes at very high levels, given the size of our unit. We were very successful in attracting CASE Studentships, notably in 2015, when six academics from the School were awarded seven CASE studentships (6 x BBSRC, 1 x MRC). Since the decision by BBSRC to cease open CASE competitions in 2016, we maintained PhD student numbers through a mixture of University-funded Graduate Teaching

Assistantships, direct industrial funding, the Global Challenges Doctoral Centre (established from GCRF-related QR funding), charity funding, and philanthropic donations (1 Rogerson and 2 Stolz studentships annually). With the award in 2019 of BBSRC DTP3 funding to SoCoBio (a Doctoral Training Partnership between Kent, Southampton, Sussex, Portsmouth, and East Malling Research), we look forward to continuing the successful provision of high-quality postgraduate training.

Research students typically receive training in subject-specific skills in the School, and training in transferable skills through the rich offerings of the Graduate and Researcher College's Researcher Development Programme. Some transferable skills training is also provided by the School, and in particular the training provided to those students contributing to our undergraduate teaching was mentioned in two consecutive rounds of accreditation of our UG programmes by the Royal Society of Biology as sector best practice. All research students are expected to participate in an annual Research Student Symposium in which they present their work as posters (MSc and second-year PhD students) or oral presentations (third-year PhD students) to the School, and which attracts both internally and externally funded prizes (the latter including the Lonza Prize for best oral presentation; and the Knowles Prize for best work with an applied aspect). The Research Student Symposium always ends with a presentation by an invited speaker chosen for their standing in the field and for a track record in inspiring future generations of scientists.

As part of our preparations for the SoCoBio DTP, we established a coordinated training structure that makes both subject-specific and transferable skills training opportunities from Kent, Southampton, Sussex, and Portsmouth available to all students associated with the DTP. This will further enhance training opportunities.

Equality, Diversity, and Inclusion

All Biosciences staff have equal opportunities to make contributions to our research activities, and to support them to succeed in their research ambitions is a central goal of the School. Consequently, we have made strong commitments to improving our EDI position during this REF period. Many of these improvements have been linked to our Athena SWAN Bronze status, which was first awarded in 2014, successfully renewed in 2019, and as a result of which we have developed an action plan with the aim of achieving Silver status in the next REF period. Among changes that have directly improved our practice in this area are the provision of dedicated EDI training courses for all staff, as well as Unconscious Bias Awareness training for all decision-makers; for example, members of interview panels and the Senior Leadership Team. Moreover, since the Athena SWAN award, we initiated regular surveys of our staff to capture diversity better, and to highlight areas in need of further improvement. We are currently establishing surveys specifically to follow the impact of Covid-19-related restrictions throughout 2020 on individual researchers, and this will inform how Covid-19 research mitigation funds made available by the University will be spent.

The School has particularly improved its position with respect to female staff members. As mentioned, 7 of the 28.8 FTE academic staff submitted to this REF exercise are female (compared to only one in REF 2014), and female staff now constitute one-quarter of our academic staff base, including three at Lecturer, two at Senior Lecturer, one at Reader, and one at Professor level. In this REF period, the success rate in promotion applications of female staff have exceeded that of male staff, leading to an improved balance in representation of staff across seniority levels.

In order to enable early career members of academic staff to consolidate their research groups successfully at a time when they are also likely to start families, the School funds temporary laboratory manager positions for research group leaders going on parental leave. This is aimed at protecting the continuation of research activities during the period of absence of the PI. It was taken up by two staff members (Buscaino, Tullet) during the REF period, both of whom were able to start their academic careers very successfully with excellent papers, repeated grant successes, and promotions to Senior Lecturer.

3. Income, infrastructure and facilities

Income

Our research is supported by competitive levels of external income from a wide range of funders, including Government, charities, and industry. The total external research and innovation funding awarded to the School of Biosciences during the REF period amounted to £26.1 million, or an average of over £125k per research-active FTE per annum. Our most important individual grant funder was BBSRC (accounting for £10.5 million in grant awards during the REF period). The remaining funding was awarded by 36 distinct funders, of which the European Commission, MRC, and Wellcome Trust awarded between £1 million and £2 million each, and the Leverhulme Trust, Innovate UK, and Royal Society awarded between £0.5 million and 1 million each.

During the REF period, external support for our research broke new ground in several ways. We received some of the largest awards ever made to the University, with notable successes including the UKRI Strength in Places-funded consortium Growing Kent & Medway to strengthen the competitiveness of Britain's horticulture, food and drink industries (£3.1 million to Kent; Robinson, C., Buscaino), a GCRF award on enhancing the capacity for biopharmaceuticals and vaccine production in South-East Asia (£2.2 million to Kent; Robinson C., Smales), a BBSRC sLola on the Industrial exploitation of bacterial microcompartments (£1.4 million to Kent; PI Warren), and a directly industrially funded collaboration with Lonza (£609k to Kent; Smales). We also attracted awards for the first time from a number of new funders, including Cancer Research UK (3 awards, £437k), the Gordon and Betty Moore Foundation (2 awards, £382k), the Human Frontiers Science Program (1 award, £239k), and the Bill and Melinda Gates Foundation (1 award, £81k).

A particular hallmark of the School is the broad distribution of research funding across its staff base, with three-quarters of our staff acting as PI on at least one successful three-year grant or externally funded three-year studentship during the REF period. More than one-third of our staff acted as PIs on multiple three-year grants. Activities under the Applied Molecular Biotechnology (AMB) banner were at the forefront of our successful grant writing efforts, with both the Infectious Disease (ID) and the Genomic and Cellular Dynamics (GCD) themes also contributing substantially.

As already shown, the School has a strong industrial component to its funding, and this is a major driver of the high impact our science achieves. Aside from directly industrially funded projects (£978k), we were particularly successful in our participation in the industrially co-funded, BBSRC-led Networks in industrial Biotechnology and Bioenergy. Two of the 13 first-round NiBBs that ran from 2014 to 2019 were co-led from the School (BioProNET, Smales; Metals in Biology, Warren), and our academics successfully bid for proof-of-concept grant or business interaction voucher funding awarded through four distinct NiBBs. While the NiBB awards were relatively small in monetary value (typically £5k-100k), they drove the development of important, innovative research activities that frequently lead to larger grant applications, as well as constituting first points of contact with industrial partners for many of our early career researchers. As such these activities form one end of a successful pipeline of industrial activities, at the other end of which we held successful BBSRC LINK awards (Smales with ICB and with Lonza Biologics; Warren with DuPont; Mulvihill with Fujifilm Diosynth; Griffin with JSR Genetics, Topigs Norsvin, and ActivfET), UKRI Industrial Biotechnology Catalyst (Robinson, C., Smales), Knowledge Transfer Partnerships (Griffin, twice with the London Women's Clinic and once with Oxford Gene Technology; Smales with Lonza), Innovate UK grants (Griffin with Paragon and Boviteq; Smales with Lonza), Apex (Kad), fielded three Royal Society Industry Fellows (Mulvihill, Smales, Warren; in addition, von der Haar was awarded a Royal Society Short Industry Fellowship), generated licensing income of £167k, and generated a number of new patents (Warren, Smales, Robinson, C.). The enterprise activity CytoScreen Solutions (Griffin, O'Connor – see impact case study; turnover around £100k per annum, providing support for one Research Fellow (O'Connor) as well as a 0.6FTE technician and one PhD student.

In summary, all aspects of the School's research are supported by appropriate and competitive levels of funding that we generate from a broad array of funders.

Infrastructure and Facilities

The School of Biosciences is physically located in three buildings. The University regularly invests funds to ensure appropriate upkeep of the building infrastructure, and to adapt labs and offices to changing requirements. During the REF period, this included general building refurbishment at a cost of £3.6 million, as well as construction of the Freedman Science Student Hub, which contains new staff offices and enabled us to convert previously used student space into additional lab space (total cost £1.7 million). Together, these measures have provided some very welcome relief on space pressures in the School, and have enabled us to increase the number of research groups compared to the previous REF.

We maintain a number of central facilities in house that support our research. These are targeted to provide cutting-edge equipment most beneficial to ongoing research in the School, with interactions with external users a secondary consideration in deciding which kind of equipment to provide. All facilities are run by experienced managers responsible for planning experiments and training new users.

The Biomolecular Science Facility houses mass spectrometers (Waters Synapt G2Si, Bruker micrOTOF-Q, and Agilent single quad GC-MS) for protein and metabolomics work, as well as general equipment for chromatography, fluorimetry, and circular dichroism. Our Image Analysis Facility houses a Zeiss LSM 880 Elyra confocal microscope with Airyscan and PALM/STORM Super Resolution capabilities, a spinning disk confocal microscope, and a Jeol 1230 120kV Transmission Electron Microscope equipped with a new Gatan One View 16mp camera with automatic drift correction. A Leica EM UC7 ultramicrotome is available for sample preparation for the EM. This facility also houses a Bruker Multimode Atomic Force Microscope, which is maintained by our Chemical Biology research group (Xue). The Wellcome Trust Protein NMR Facility houses a 600 MHz five-channel Bruker Avance III spectrometer equipped with a cryoprobe, which can observe a wide range of biologically relevant nuclei at high sensitivity. The instrument is also equipped with a 24-place automated sample changer.

In addition to these long-established facilities, this REF period saw investment in an extended central computing facility supporting our bioinformatics groups, as well as other groups' analyses of deep sequencing data (£85k). Two successful BBSRC ALERT bids led by the School enabled us to establish innovative facilities that serve the wider UK Science base by providing access to cutting-edge equipment not otherwise accessible to UK academics. A successful 18ALERT bid by Robinson, C. (250k) funded a Sartorius Ambr250 pilot-scale Parallel Bioreactor Facility, enabling academics and industrial end users to explore how experimental biopharmaceutical constructs behave under industrially relevant expression conditions. At the time of acquisition, this system was one of only two such instruments housed in academic institutions in the UK. The following year, a successful 19ALERT bid led by Kad with co-applicants from Sussex and Nottingham (750k) funded acquisition of a Lumicks C-Trap instrument for advanced single molecule studies, which is being housed in the Kent National Optical Trapping (KNOT) Facility.

Equipment in our facilities, as well as larger equipment in research labs, is maintained through both external grants and internal investment. Overall, investment in equipment totalled £1.5 million from central University funds, with notable items including new high-end mass spectrometry equipment (£428k) and a significant upgrade of our microscopy capabilities with the acquisition of the Zeiss Elyra instrument (£411k); £1.0 million from direct investment of School funds, with notable items including microscopy lenses and cameras (£140k); and £1.0 million from Research Grants, mostly for more specialised equipment housed in individual research groups.

Use of our in-house facilities is complemented by excellent levels of access to national facilities, as well as facilities at collaborating institutions. This includes time on the National NMR facility and Synchrotron time at the Crick Institute, where the School applies for annual allocations, and at the

Central Laser Facility at Harwell, where members of the School were awarded time and consumables to conduct FLIM/FRET & SIM experiments (Gourlay, Mulvihill). Lastly, a number of our academics use the extensive Sequencing facilities (including Illumina and Nanopore instruments) at East Malling Research, a local collaborating institution that is also a member of our SoCoBio DTP.

4. Collaboration and contribution to the research base, economy and society

National and International Collaborations

With its clear vision of developing basic scientific discovery into genuinely impactful outcomes, Biosciences at Kent is naturally outward-facing, and engages with an extensive range of collaborators and stakeholders. This includes national collaborations based on jointly held grants (BBSRC, Wellcome Trust, MRC, EPSRC, Leverhulme) with Oxford, Cambridge, Bristol, Warwick, Manchester, Queen Mary, Durham, Newcastle, UCL, Southampton, Leicester, and Aberdeen; and international collaborations, with more than half of our publications featuring co-authors from other countries, selected examples including the University of Innsbruck, ITQB (Lisbon), University of Cork, University of Georgia, University of Colorado, Max Planck Institute for Plant Breeding Research (Cologne), Whitehead Institute (Boston), BOKU (Vienna), the Czech Academy of Sciences, SAHMRI (Adelaide), Sharjah (UAE) and the University of Alberta (Canada).

Interdisciplinary Collaborations

Our interdisciplinary collaborations are evidenced by joint grants and publications with Computing (Tullet, von der Haar, Wass), Chemistry (Garrett, Kad, Smales), Physical Sciences (Griffin, Michaelis, Robinson, G., Wass) and Engineering (Gourlay, Michaelis, von der Haar, Wass), and extensive collaboration with end users such as industry and medical professionals (outlined in detail in section 1 above). Several academics from the School are collaborating members of large international research networks, including the Avian Phylogenomics Project (Griffin, Farre, Zhang, et al., 2014, *Science* 346:1311), the wwPDB/CCDC/D3R Ligand Validation Workshop (Brown, Adams, et al., 2016, *Structure* 24:502), the Critical Assessment of Functional Annotation (CAFA) network (Wass, Zhou, et al., 2019, *Genome Biology* 20:244), and the Moore Foundation's Marine Microbiology Initiative (Tsaousis, von der Haar, Faktorova, et al., 2020, *Nature Methods*).

These extensive examples illustrate our success in encouraging and fostering collaborations across the University and the wider research base, with the aims of addressing significant global challenges and maximising impact at the interface between Biosciences and other disciplines. It is this approach that has supported several successful GCRF applications that focus on challenges in developing countries, with the production of Biotherapeutics and Vaccines in Thailand (Robinson, C., Smales), the provision of key nutrients in India (Warren), and the development of natural compounds for the treatment of cancer in Vietnam (Garrett).

Our staff also have strong representation, and make significant contributions, elsewhere in the research base. Over the REF period, the School fielded a panel chair (Brown), three core members (Buscaino, Mulvihill, Tuite), and six pool members (or specific calls) on BBSRC panels (Goult, Kad, Robinson, G., von der Haar, Warren, Wass), and was represented on numerous other research funding panels nationally: MRC (Garrett), EPSRC (Kad, Warren), NERC, CRUK (Garrett), Breast Cancer Now (Garrett), Wellcome Trust (Gourlay, Michaelis), Leverhulme Trust, British Council (Goult), Newton Fund (Goult), MSCA (EU) (Tsaousis), Biotechnology Research Council (India) (Smales).

Shaping Policy

We have contributed to shaping policy through membership on various advisory panels, including the BBSRC Skills and Careers Advisory Panel (von der Haar) and the EPSRC Life Science Interface Advisory Panel (Kad). Ezcurra was a member of a panel giving evidence to the House of Lords Science and Technology Committee on Healthy Ageing. Garrett co-chaired the CRUK

New Agents Committee and was a member of the CRUK Small Molecule Expert Review Panel. She currently acts as advisor to the CRUK Therapeutic Discovery Laboratories and the CRUK Lung Cancer Centre of Excellence, and contributes strongly to shaping the future of cancer drug development in the UK.

Leading Roles in Learned Societies

A number of our staff take leading roles in learned societies, including: Griffin, who is President of the International Chromosome and Genome Society, Treasurer of the Preimplantation Genetic Diagnosis International Society (2013-18), and on the board of the British Andrology Society (2016-19); Tsaousis, who is Vice-President of the UK Protistology Society and Chair-elect of the Eukaryotic Division of the Microbiology Society; Tuite, who was Chair-elect and then Chair of the Scientific Conferences Committee of the Microbiology Society; Garrett, who served as General Secretary of the British Association of Cancer Research; Mulligan, who is Councillor to the International Transmembrane Transport Society; and Hargreaves, who is a panel member of the Genes panel of the Biochemical Society.

Conferences, Workshops, and Training Courses

During the REF period, Biosciences staff organised or co-organised a large number of national and international conferences, workshops, and training courses. One of the flagship events in this respect is the EMBO Practical Course, 'The application of kinetic methods to dynamic biological systems', which has been held in Canterbury bi-annually until 2017 and was organised by Geeves. Beyond this, members of the School also contributed to other summer schools (e.g. the 2015 FEBS/EMBO course on 'Mitochondria in life, death and disease', Gourlay), and were involved in the organisation of numerous conferences:

- Conferences on Oxygen Binding and Sensing Proteins, Hamburg (2016) and Sheffield (2014); session chair: Shepherd.
- Gordon Research Conference on the Chemistry and Biology of Tetrapyrroles, Newport, Rhode Island, 2014; chair: Warren, also adviser for these meetings in 2016 and 2018 and session chair in 2020.
- British Association for Cancer Research Conference, 'Response and Resistance in Cancer Therapy', 2018 and 2020 (postponed to 2021); organisers: Michaelis, Wass, Garrett, Fenton.
- British Association for Cancer Research Conference, 'Advances in Cancer Drug Discovery', Cambridge, 2014; organiser: Garrett.
- Genes and Cancer Meeting, Cambridge, 2015; organiser: Garrett.
- Annual National Cancer Research Institute (NCRI) conference, Liverpool, 2016; co-organiser: Garrett, also for the same conference in Glasgow 2018.
- Alpbach Workshops on Muscle Myosin and Motility, Alpbach, Austria, 2016 and 2019; organiser: Geeves.
- European Muscle Conference, Canterbury, 2019; organiser: Geeves (also on the organising committee for this conference in 2015, 2016, and 2017).
- Pig Breeders Round Table, Canterbury, 2015, 2017, 2019; chair: Griffin.
- 13th Preimplantation Genetic Diagnosis International Society Conference, 2014; chair: Griffin.
- 20th International Chromosome Conference, Canterbury, 2014; chair: Griffin, also co-chair for the 22nd International Chromosome Conference in Prague, 2018.
- XXII meeting of the International Society for Evolutionary Protistology, Cyprus, 2018; organiser: Tsaousis.
- Microbiological Society British Yeast Group Meeting, Canterbury 2017; organisers: Buscaino, Gourlay, Hsu, Tuite, von der Haar.

Public Engagement

Biosciences staff are actively engaged in public engagement. The School, led by Tuite and assisted by many other of its staff, was the principal academic partner for the Wellcome Trust-funded Myelin Basic Protein Project (MBP²). This project received widespread acclaim for the way in which it engaged secondary-school students in real research, was the forerunner to the National Authentic Biology programme, which engaged schools and universities across the UK in collaborative projects (including further Kent partnerships between Geeves and the Archbishop's School, Canterbury, and between Warren and Roger Manwood School, Sandwich), and eventually culminated in the formation of the Institute for Research in Schools.

Other flagship activities include sustained public engagement throughout the period through documentaries that received UK-wide airing (Griffin, 'IVF – the Science of making babies' and 'Love my genome'), and through widely read contributions to *The Conversation* (Ellis, Griffin, 'The Y chromosome is disappearing', >2 million reads; Griffin, O'Connor, 'Jurassic Spark: Can we really resurrect a dinosaur?', >95,000 reads and reprinted in *Scientific American*). Numerous other presentations in Café Scientifique, Pint of Science, and talks to the general public were delivered by staff members, including the *Nature Blogs* and *Science Magazine* (AAAS) webinars. Griffin has recently been awarded a British Film Institute grant (£275,00) to make a series of six documentaries on genomics, aimed at 14-18-year-olds.