

Institution: Canterbury Christ Church University

Unit of Assessment: 5 - Biological Sciences

1. Unit context and structure, research and impact strategy

1.1 Structure of the unit and context

This Biological Sciences Unit of Assessment (UoA) submission is made by academic staff from the Section of Natural and Applied Sciences, one of four Sections organised around disciplines in the School of Psychology and Life Sciences, which sits in the newly formed Faculty of Science, Engineering and Social Sciences (see REF5a). This Faculty contains over half of all the active researchers in Canterbury Christ Church University (CCCU) and as such, is seen as a major driving force of research. Formed in 2020, the School of Psychology and Life Sciences derived most of its staff, including those in the Section of Natural and Applied Sciences, from the School of Human and Life Sciences. This submission therefore covers staff who have been part of the same unit, the Section of Natural and Applied Sciences, for the entire REF period and who are now part of the large and highly research-active School of Psychology and Life Sciences.

In REF2014, the Section's staff were returned to UoA 6: Agriculture, Veterinary and Food Science, with this submission focussed on the work of the Ecology Research Group, a grouping with research priorities in biodiversity and plant science. Progress within the 2009-2013 period and the success of the REF2014 submission led to significant growth in staffing of the Section during 2013-2016, with the Section's staff numbers increasing from 11.5FTE to 19.5FTE. This growth in the vitality of the Section's research led to a strategic review in 2015, and to the formation of a new Biomolecular Research Group, with research priorities in reproduction, cancer biology and stress responses. In recognition of the growth and diversification of the Section, the decision was also made in 2015 to work towards a REF2021 submission to Biological Sciences (UoA 5) as this more accurately reflected staff expertise. This submission therefore builds on the foundation of the UoA 6 REF2014 submission, whilst representing a substantially larger group of staff with a broader set of research interests.

1.2 Achievement of strategic aims for research and impact

The 2015 review of the research, knowledge exchange (KE) and consultancy activity of the Section identified aims for the newly created Biomolecular Research Group, and otherwise confirmed the aims outlined in the REF2014 submission. Work within the REF2021 period has achieved these aims. Specifically, the UoA has:

- Successfully expanded the number of both academic staff ([aim 1a](#)) and of post-graduate research (PGR) students ([aim 1b](#)). This is evidenced by the 50% increase in staff submitted to the REF (13 in REF2014, 20 in REF2021), and the 70% increase in PhD completions within the REF period (7 in REF2014, 12 in REF2021). These increases are the result of strategic appointments designed to strengthen key research areas (see section 2), an increase in external funding (see below and section 3) and in CCCU investment in research facilities and infrastructure (see section 3.2). This growth has also been supported by key promotions within the UoA (see section 2).
- Increased external income ([aim 2](#)). Here, work to mentor and support staff in order to improve the quality and quantity of research bids, and to increase funded collaborations with external stakeholders has delivered a more than 560% increase in income within the REF2021 period (£113,225 in REF2014 compared with £634,288 in REF2021) (see section 3).
- Delivered the major goals of the two research groups by increasing the quality and quantity of research outputs and by increasing both internal and external collaboration ([aim 3](#)). In this REF period, staff produced more outputs, with these evidencing greater collaboration (see section 4) and being assessed, by both internal and external review, as being of a higher quality. Central to this success were enhanced processes to support research, to develop staff, and to both support and incentivise collaboration (see section 2).

Key to the delivery of all of these aims was work undertaken to support the UoA's early career researchers (ECRs) in establishing their research programmes. This was a critical need as 7 of the 10 staff submitted to REF2014 were ECRs (see sections 1.3 and 2.2). This REF cycle has therefore seen the majority of the UoA's staff establishing themselves and their research, with key successes being the dramatically increased external income, and the greatly increased numbers of PhD students (see section 3). The REF2014 strategy also emphasised the importance of enhancing research impact. Success here was achieved by continuing the UoA's strategy, as formalised in the REF2014 submission and agreed in the 2015 strategic review, of delivering impact by building understanding of the specific needs of beneficiaries and stakeholders, and then by addressing those needs via coordinated and sustained research activity. Specifically, this approach to impact involved: (i) targeting research towards impactful questions; (ii) maximising stakeholder ownership of the projects; and (iii) developing virtuous impact circles through strong relationships with users. This approach is exemplified by the submitted impact case studies, where the key partners have been engaged throughout the life of the work, and is also seen more broadly in the other work of the UoA (see sections 3.3 and 4.1).

This REF period has also seen the approval, design and construction of a substantial new £65m STEM building, the Verena Holmes building, that houses CCCU's specialist laboratory facilities. This development results from the University's Strategic Framework 2015-2022 that signals a greater investment in research, particularly in STEM subjects, and has led to a £150m Estates Master Plan that seeks to transform the campus into a truly modern site for teaching and research. The Verena Holmes building therefore represents an £8-9m investment in laboratories for the biological sciences, doubling the UoA's research laboratory space (section 3.2). Within the Verena Holmes building, the Section will be located alongside the new Kent and Medway Medical School, other lab-based disciplines from within the School, and the University's new School of Engineering, Technology and Design. This development therefore represents a key part of our future strategy (see section 1.3).

1.3 Future strategic aims and goals

The creation of the School of Psychology and Life Sciences, together with the University's investment in STEM, represents a future strategic aim to enhance the interdisciplinary, applied and impactful nature of our research. As a more mature unit, and with a more established staff complement (70% of the Section's staff were returned as ECRs in REF2014, compared to 10% in REF2021), the next phase of the UoA's development is to support these, now established, researchers to become leaders in their respective fields and to fully develop their international reputation. This will require the translation of the science that has been undertaken in this REF cycle, and by recently completed PhD studies, into further peer reviewed publications and grant applications. In turn, this will translate into increased amounts of external funding, which will increase the size of research groups by supporting additional PhD students and post-doctoral researchers.

Central to this strategy is the maturation of the research mentorship programme (see section 2.2), as the benefits from this, in terms of outputs and outcomes, are not yet visible. Within this context, the UoA has identified three strategic aims for the period 2020-2025. These are to 1) enhance the quality and impact of the UoA's work in the research priority areas of the Ecology Research Group and the Biomolecular Research Group, and 2) expand the reach of our research by increasing interdisciplinary collaboration. In combination, these will deliver our broader aim of 3) building the academic standing of the UoA.

In order to achieve this set of interlinked aims, we will:

- Continue support for the research priorities of the UoA's research groups as a means to set specific developmental pathways for individual's research programmes, and to define the future capital equipment and infrastructure needs of the UoA;
- Prioritise and support existing relationships with external beneficiaries and stakeholders to develop long term and impactful research programmes and leverage impact from completed and ongoing work;

Unit-level environment template (REF5b)

- Develop new interdisciplinary relationships and extend existing ones from the colocation in the new Verena Holmes building with Kent and Medway Medical School, Engineering, Sports Science and Psychology;
- Support academic staff at all career stages in the development and delivery of personal research plans with short and long-term goals that capture all aspects of the research process.

The UoA is also committed to ensuring that our science is as widely accessible as possible, seeing this as a critical way to increase the reach and impact of our work. This commitment is evidenced by our 100% compliance with the open access requirements of the REF. In addition to this, and going significantly beyond the University's commitment to green open access (see REF5a), nearly 60% (28/49) of our submitted outputs (REF2) were published via gold open access routes, and therefore were available to everyone from the point of publication. The UoA also promotes and encourages the use of preprint options to allow earlier access to research outputs and the archiving and deposition of data in ways that promote use and re-use. UoA staff have also played key roles in discussions at an institutional level to allow the *ResearchSpace* repository system to host datasets as well as outputs. Continuation, and extension, of this commitment is seen as a core part of ensuring the widest possible access to both papers and data in the future.

The combined effects of delivering against these aims is expected to produce additional synergistic benefits for the UoA's environment. For example, increases in funding and support to develop staff will allow more research to be undertaken and will further increase opportunities for more impactful studies. In turn, this is expected to continue to improve output quality by increasing the significance of the work, with the ultimate aim of producing more outputs that make more influential contributions to the discipline, and hence that allow further support to be sought.

2. People

2.1 Staffing strategy

The overall staffing strategy of the School of Psychology and Life Sciences has three aims, these being: firstly, to recruit staff, particularly ECRs, to available posts strategically, such that they bring specific expertise and skill sets, that they can work with one of the research priorities of the UoA (see below) and to promote staffing stability (see below and section 2.2); secondly, to develop and promote staff internally (sections 2.2 and 2.3); and thirdly, to increase staff time for research (see below and section 2.3). This strategy mirrors that seen in the former School of Human and Life Sciences during the majority of the REF2021 period and, in combination, these goals aim to provide a supportive and collaborative research and enterprise environment where staff can flourish and develop their research careers.

Since the 2014-15 review, the Section's staff appointments have been strategically designed to strengthen key research priority areas within the UoA. For example, the appointment of **Syed** (2014) supported plant science, of **K Harvey** (2014) supported reproduction, of **Trim** (2014) and **Wilson** (2015) supported cancer cell biology, and of **Stastna** (2018) supported stress responses. Other appointments have been targeted to bring in additional key skills. For example, **Rahman** was appointed in 2019 to complement **Leslie's** bioinformatic skills and **Ahmed** was appointed in 2019 to bring additional skills in industrial biotechnology, and to support our strategy for delivering impact. This growth in staffing has resulted in 20 staff being returned in this REF, compared to 13 (10 from the Section) in REF2014 (delivering [aim 1a](#) from section 1.2), increasing UoA vitality and building critical mass in the key research priority areas of the unit. The success of building strong priority areas is also evidenced by the increased submission and success rates of collaborative ventures, with most grants and industry-funded projects in the REF period involving multiple UoA staff. Although many research outputs from projects funded during the 2014-21 period are not yet visible, more than 15% of the outputs returned to this REF also have multiple authors from within UoA. In contrast, no staff returned outputs with co-authors from CCCU to REF2014.

Key to the promotion of staff stability is that all academic staff within the Section are employed on permanent (open-ended) contracts that include both research and teaching responsibilities, *i.e.*, no academic staff are employed on either fixed-term contracts or in teaching only roles. All academic staff are also independent researchers, having both identified research time within their workload (this varied between 20 and 40% of staff time across the REF period), and the expectation that they will produce REF submissible outputs. Formalised in 2019 as part of CCCU's code of practice for the selection of staff to be submitted to the REF (see REF5a), this criteria for REF submission, that staff have significant responsibility for independent research mirrors the expectation used within the Section since 2008. This is therefore an inclusive and supportive strategy that is reflected by the fact that 83% of Section's staff were returned to REF2014 (10 of the 12 biological sciences staff in the Section) and 100% of staff being returned in this submission (20 of the 20 biological sciences staff within the Section). This career stability gives staff the time and intellectual space in which to develop their careers (delivering aim 3 from section 1.2).

The growth in staff numbers has been supported by key promotions within the UoA, by targeted support for staff, and by strategic efforts to mentor all members of the Section. Within the REF period, key promotions have seen **S Harvey** promoted to Professor in 2018, and **K Harvey** and **Syed** promoted to Reader in 2020. This period has also seen systematic investment in internally-funded PhDs (17 started in this REF period), and work to develop externally-funded PhDs (6 started in this REF period, with 4 funded directly by industry and 2 from grant income) (delivering aim 1b from section 1.2). Critically for staff development (section 2.2), the growth in PhD numbers has been strategically directed to support the UoA's ECRs in establishing their research, with significant effort put into the development of these PhD students (section 2.3). This means that the majority of academic staff within UoA (90%) are, or have been, first supervisors of PhD students. This growth in the number of staff and PGR students has been supported by investment in research facilities and infrastructure (section 3.2).

2.2 Staff development

In line with CCCU policy (see REF5a) the UoA provides support for career development across the entire range of academic grades. Key to this development of staff is the research mentorship programme. This was established in former School of Human and Life Sciences during the REF period, formalising approaches to mentoring staff that had developed and been implemented independently in the different UoAs from this School. With the formation of the new School of Psychology and Life Sciences, and the larger resource base this offers, the programme has now been further extended. An example of this approach is the use in annual appraisals of individual research plans that cover both short- and long-term research planning and that were initially developed and implemented in the biological sciences during the REF2014 period. This approach was subsequently adapted and used by other units in the University and is now a formalised part of the School's research mentorship programme, with the review of these research plans guiding the allocation of internal research funding and allowing support for individuals to develop and work towards long-term plans. This formalised programme within the School therefore integrates the formal appraisal process and a range of informal mentoring and support opportunities. As such, the research mentorship programme represents an ongoing and supportive dialogue that considers short- and long-term goals, explicitly covering plans for income generation to support work, output production, and how the impact of completed, ongoing and planned work can be maximised. This provides a formal way for staff to discuss, and ultimately agree, both their short-term goals and their long-term plans, and for them to be supported in their career progression.

Staff at all levels also have the opportunity to discuss their research and knowledge exchange plans with the School Director of Research and Knowledge Exchange Environment and the relevant UoA Coordinator, and to have a suitable research mentor within or external to the University. This dual support – formal via the appraisal process, and informal via the mentoring and discussion options available – ensures that staff at all levels have access to support for all stages of their research careers. Outcomes across these processes are also collated to provide

a profile of the team and to monitor progress, allowing collective needs to be identified. The mentorship programme also formalises processes for improving output quality by using internal pre-submission review of funding bids and of papers. This integrates with the University's processes for developing funding applications (see REF5a) and primarily seeks to improve the originality and significance of research (via the review of funding applications), and the rigour and reproducibility of resulting publications (via the review of both funding applications and papers).

During the early part of this REF period, much of the work to support staff development within the Section was focussed on ECRs. All ECRs are given a 20% reduction in teaching load for their first two years in post (this time being additional to that already allocated for research), are supported with start-up funding, are prioritised for supervision of internally-funded PhDs, and are mentored to work alongside more experienced colleagues. As the REF period has progressed, and as the UoA's ECRs have started to establish their research at CCCU, the focus has broadened to ensure continued support. Here, a key element is the role of the research mentorship programme (see above) in developing a plan for promotion and career progression. As part of this, staff are encouraged and supported to engage with the training opportunities provided directly, or supported by, CCCU's Department of Human Resources and Organisational Development. Within the REF period this has involved: supporting an early career researcher in attending CCCU's SPARC (Supporting Progression in Academic Research Careers) programme (**Stastna**); supporting multiple more senior staff (**K Harvey**, **Mylona** and **Trim**) to attend Aurora leadership training (Advance HE's leadership development initiative for women and those who identify as women); and supporting senior staff (**Forsyth**, **C Harvey** and **S Harvey**) in attending internal training in Leadership and Management, and in Coaching and Mentorship. The success of this approach is shown by the subsequent appointment of the staff involved to more senior roles within the University. For example, **K Harvey** was appointed Faculty Athena SWAN Champion, **C Harvey** was appointed School Director of Learning and Teaching Environment, **Trim** took on a leading role in the management of the Section's teaching, and **Forsyth** was promoted to Director of the Section. Success is also evidenced by the promotion within this REF period of three people from Lecturer to Senior Lecturer (**K Harvey**, **Mylona** and **Rintoul**), two people from Senior Lecturer to Reader (**K Harvey** and **Syed**), and one person from Reader to Professor (**S Harvey**). Staff have also been supported in taking secondments either in industry or in other parts of the University (see section 4.1), with such secondments being seen as important for the promotion of collaboration and research impact and for the career development of the individual.

2.3 Support mechanisms for, and training and supervision of PGR students

The REF period has seen a considerable expansion in PhD student numbers within the UoA, with 17 starting in this REF period and 12 completing (in comparison to 7 completions in REF2014). This has been delivered both by innovative use of internal resources to allow increased numbers of funded places and importantly by securing a diverse range of externally funded PhD positions. For example, over the REF period 4 PhD students have been funded directly by industry and 2 from grant income, with 4 more on projects with a significant in-kind contribution from industry. For internally-funded studentships, most within the REF period have been part-time (and hence have supported students who were not expected to complete in this REF period) and have been combined with part-time University Instructor roles. These teaching-support roles not only allow the student to gain experience of teaching, but have also, across the REF period, made a significant amount of staff time available for research. For example, covering elements of laboratory practical demonstration with University Instructors has, across the REF period, reduced staff teaching by approximately 9,000 hours.

A key element of the development of staff (2.1) has been work undertaken to ensure that PhD student supervision involves all staff. As a result of this, 90% of academic staff within UoA either are now, or have been, first supervisors, a figure notably higher than that seen in the REF2014 submission where only 3 staff were first supervisors. This growth in supervisory capacity has meant that support has also needed to be provided for first-time supervisors in order that they develop the skills necessary to support, train and supervise their PGR students. This has been

achieved by support of supervisory panels, which contain suitably experienced supervisors, assisting both first-time supervisors and the PGR student, with additional support provided by the University's Graduate College.

Training for PGR students is via the Researcher Development Programme, organised by the Graduate College. This programme includes both science specific skills training and wider training, structured according to the Vitae Researcher Development Framework, to prepare students for both academic and non-academic careers. Staff from the UoA now deliver sessions on the Researcher Development Programme, providing PGR students with access to expertise of staff beyond their supervisory panel. Support for PGR students also includes a School PhD Forum where PhD students and developing researchers will present developing work, *i.e.*, before conferences or to gain opinions on data before paper development. The research seminar series both within the Section, where subject-specific speakers present to staff, PGR students and undergraduates, and more widely within the School, where a broader range of topics are covered, also assists in fostering a supportive and intellectually challenging environment for PGR students.

2.4 Equality and diversity

The UoA is fundamentally committed to equality and diversity. This is evidenced by: the balanced sex ratio of academic staff in the UoA (50:50); that all staff within the Section have significant responsibility for independent research and are submitted to this REF; the ongoing support of the research of all staff; and by the representation of female staff in senior roles within the Section (4 of the 7 such roles are held by female staff). Beyond this, UoA staff have been central to the University's broader equality and diversity initiatives. For example, the unit's REF2014 Environment template committed to securing Athena SWAN accreditation, the first such commitment made by the University. **S Harvey** and **Bertolo** then served as key members of the five-person Athena SWAN implementation working group that led to the commitment by CCCU to join the Charter. **K Harvey** was then part of the team that produced the successful institutional application for an Athena SWAN Bronze award and then became the Athena SWAN Champion for the Faculty of Social and Applied Sciences, driving the development of School Athena SWAN award applications. The former School of Human and Life Sciences, in which the Section sat at the time, was then the first School in CCCU to achieve a Bronze School Athena SWAN award, with **K Harvey** and **S Harvey** leading on the application. The School of Psychology and Life Sciences is now positioned to be the first School within CCCU to apply for a Silver award (application due in 2022), with **K Harvey** serving as Co-Chair of the Athena SWAN self-assessment team (with the Head of School as the other Co-Chair) and **S Harvey** a member of the team.

The School's mentorship programme (see section 2.2) also provides an increased ability to monitor equality, diversity and inclusion considerations. This therefore delivers against a specific action in former School of Human and Life Sciences' Athena SWAN Bronze award and is part of the wider body of equality, diversity and inclusion work underpinning the School of Psychology and Life Sciences' planned application for an Athena SWAN Silver award. In relation to the REF, and in all other situations where staff outputs are considered, the UoA is also committed to the responsible use of metrics and to the assessment of research on its own merits. The UoA Coordinator for this submission is also a personal signatory of the San Francisco Declaration on Research Assessment. These commitments extend to all appointment (short-listing) decisions and to appraisal discussions.

3. Income, infrastructure and facilities

3.1 Income

The UoA's research activity is supported and funded by a range of commercial, public, private and charitable organisations, and is also supported directly by CCCU. Increasing external income, and the amount of research activity supported by such income, was a key aim for the REF period. This aim was achieved, with noteworthy successes including major funding from the Leverhulme Trust (3 research grants awarded, including the first such award made to CCCU),

the European Union (as the UK academic lead) and from multiple industry partners. These successes were delivered as a result of the UoA's support for staff (section 2.1 and 2.2) and for industry partners, with this support provided in accordance with the UoA's strategy of stakeholder and beneficiary engagement (see section 4).

Research income during the REF2021 period totalled £634,288, a 560% increase from REF2014 (£113,225). This represents a step change in funding levels and has been driven by more UoA staff securing more grants, and by the size of these being, on average, much larger. Importantly, the number of UoA staff securing external funding has also increased, with the internal peer review of grant applications and active support for collaborative bids (section 2.2) supporting many of these ECRs to secure their first funding. Specific successes within the REF2021 period have been: the award of three Leverhulme Trust research grants (to **Ahmed**, to **S Harvey/Byrne** and to **Syed**) that supported post-doctoral researchers and PhD students; success as the UK academic lead on an Interreg 2 Seas European Union project (**Rintoul**); and multiple large industry funded projects awarded (funding obtained by **K Harvey/S Harvey**, **S Harvey/K Harvey**, and by **Leslie**), with these projects covering staff time, consumables and supporting PhD students (with fee income for these students not appearing as research income). Smaller grants and projects have also been awarded from funders such as the Royal Society, Natural England and Kent Cancer Trust (**Buckley**, **Burman**, **C Harvey**, **Mylona** and **Trim**). In conjunction, this means that: the majority of staff within the UoA have received external funding within the REF period (delivering aim 2 from section 1); many staff have had continuous externally derived funding for much of the REF period; and that significant income is already secured for the post-REF2021 period as many grants and contracts extend beyond 2020. Beyond this directly funded work, the REF period has also seen a greatly increased level of income-in-kind deriving from industrial collaborations (principally derived from the work of **Byrne**, **K Harvey**, **S Harvey**, **Leslie**, **Mylona**, **Trim** and **Wilson**, and estimated at a value of more than £520k). Importantly, the smaller grants and the income-in-kind are seen as routes to greater future growth as staff graduate from smaller to larger grants, with support from colleagues with experience of the latter. This also means that new staff appointed within the UoA will be coming into an environment where the expectation of securing external funding is an embedded part of the culture.

The UoA has also benefited from strategic investment by the University. Distributed to Faculties via a single Research and Enterprise Support Funding (RESF) stream, which integrates quality related (QR), Higher Education Innovation Fund and institutional PhD bursary funding (see REF5a). Over the REF period, this has meant that income derived from the UoA's submission to REF2014 has been used strategically to support staff and post-graduate students within the UoA. Distributed via the UoA, the majority of this income has been used within each year to support direct costs of staff research (e.g., consumables, equipment and travel), with remaining funds used to provide bursaries for PhD students within the UoA. This therefore serves the critical purpose of supporting infrastructure and preliminary studies that underpin applications for external funding. The success of this approach is clear as the great majority of successful bids, and hence the majority of the income reported here, are linked to such preliminary internal support. Across the REF2021 period support distributed in this way has totalled £416,947. This represents the majority of the QR income coming to CCCU as a consequence of the UoA's submission to REF2014, *i.e.*, across this REF period the bulk of QR income has not been used to directly support academic staff salaries. As staff within the UoA have established their research (see section 2.1 and 2.2 for discussion of how the UoA's strategy has facilitated this) the focus of this will change and a greater proportion of RESF funding will be used to support staff time. QR funding for direct costs will however remain available, particularly for the support of ECRs and for pilot studies.

Overall, the greatly increased funding available within the UoA has been important in increasing the quality of research undertaken, by allowing access to more consumables and equipment, and hence allowing more significant studies to be undertaken. This improved support has also allowed the quantity of research outputs produced to be increased by supporting both post-doctoral positions and PhD students.

3.2 Infrastructure and facilities

Additional to the funding discussed above, within this REF period CCCU has provided significant support to develop and upgrade the UoA's research infrastructure.

This support has included 1) the establishment in 2015 of the Life Sciences Industry Liaison Lab, a strategic development to facilitate industrial collaborations, that was formally opened in March 2016, and 2) the design and construction of the Verena Holmes building, the £65m home to the University's specialist facilities that opened in January 2021. Both of these infrastructure developments are part of the University's £150m Estates Master Plan with planning for these developments starting in 2014.

The establishment of the Life Sciences Industry Liaison Lab involved significant investment within the REF period in the rental and refit of laboratory facilities at Discovery Park, in the Enterprise Zone based at the former Pfizer site in Sandwich, one of Europe's leading science and technology parks. The establishment of the Liaison Lab proceeded in parallel with planning for the Verena Holmes building, with the Liaison Lab being a more externally focussed and impact-orientated space, aiming to drive collaborative research and KE between the University and the biotechnology related industries at Discovery Park. To date, the Liaison Lab has successfully extended existing collaborations and has built new links, leveraging a significant amount of income (more than £267k can be linked to Liaison Lab activity to date) and income-in-kind (more than £500k to date). The success of this initiative is also demonstrated by the use of the Liaison Lab as a model for the University's EDGE Hub initiative (REF5a), which has attracted significant external funding supporting both the development of the Verena Holmes building, and our expanding network of industry hubs across Kent and Medway.

Planning and design of the Verena Holmes building was started in 2016. Discussion of the UoA's research needs and strategies, as defined in REF2014 and subsequently modified, at Research and KE meetings at School, Faculty and University levels, fed into this planning process during 2016. Early parts of these discussions also involved key external stakeholders such as Discovery Park. Specific discussions between the Section (represented by the UoA Coordinator and the Section Director), the University's Master Planning team and the project architects were then initiated in April 2016 and continued during 2017 and 2018. At this stage, the research needs of the UoA, specifically in terms of space required for planned growth in researchers and in postgraduate students, was used to define the plan for the parts of the building to be occupied by the Section. This resulted in a doubling of the UoA's research laboratory space.

Beyond these major infrastructure developments, the University has provided more than £240k in internal support for capital equipment purchases in the REF period. This included: £50k for cell culture and analysis equipment and £60k for fluorescence microscopy in 2015; £40k for incubators and constant temperature facilities in 2016; £70k for gas chromatography–mass spectrometry in 2017; and £20k for embryo culture equipment in 2018. These developments allowed access to tools and approaches that previously would have had to be sourced externally, allowing increasingly sophisticated work to be undertaken at CCCU. The UoA has also benefited from improved research support within the School that has been delivered via the appointment of additional non-academic staff to support research activity. Specifically, this involved the appointment of additional technical staff in all three UoAs within the School, and by the creation of School-wide administrative roles to monitor research budgets and support purchasing. The UoA directly benefited from this, as it allowed the creation of two research technician posts to support research across the UoA.

3.3 Support for research impact

Within the UoA, the two research groupings, by design, seek to deliver different types of impact. With a focus on biodiversity and on plant pathogens, much of the work of the Ecology Research Group's aims to deliver impact on the environment. In contrast, the Biomolecular Research Group, with its focus on health and its closer links to industry, is focussed more on health and welfare and on income generation. These different approaches can be seen in the case studies

submitted in REF3 and in the details of other work by the groups provided above and mean that elements of how the groups seek to deliver impact, and in how they are supported in this differ.

In line with the University's impact strategy, both groups work towards, and are supported in delivering, deep local and regional impact. For the Biomolecular Research Group, this support is seen most obviously by the establishment of the Liaison Lab at the Discovery Park Enterprise Zone (see above). Here, support has been targeted on collaborative work with industry and the UoA has supported this via funding for PhD students, and by providing staff time and consumables. Such collaboration is exemplified in the Venom case study where UoA staff have worked closely with the SME Venomtech Ltd. for a number of years. This research has delivered significant value for Venomtech Ltd., providing critical local and regional impact.

More generally, the approach is also seen in other developing case studies such as that arising from work with Genea Biomedx, an international company with a branch at Discovery Park. This project links the work of two CCCU staff (**K Harvey** and **S Harvey**) and is designed to meet specific industry challenges and has now been expanded to cover work that links the needs of Genea Biomedx with those of JSR Genetics Ltd. and Topigs Norsvin, leading national and international swine genetics companies. Initially supported by a CCCU-funded PhD student, with in-kind support from Genea Biomedx and JSR Genetics Ltd., this research area has now secured external funding from Genea Biomedx and from Topigs Norsvin and is laying the foundational groundwork for future national and international impact via improved manufacturing processes, both from research and development changes at Genea Biomedx, and from international changes in pig production and stock breeding at JSR Genetics Ltd. and Topigs Norsvin.

Although differing in detail, the same strategy is seen in the work of the Ecology Research Group. For this group, local and regional impact is delivered via close and long-standing collaborations with stakeholders such as Kent Wildlife Trust and Natural England. These links are then used to leverage relationships and projects that allow the delivery of national and international impact. For example, significant early parts of the underpinning research for the pheromone case study reported here were conducted locally by **Burman**, with the impact then deriving from the extension of this work nationally and internationally. This strategy is also seen in the way that **Rintoul's** Interreg 2 Seas European Union project links a local partner, Kent Wildlife Trust, into a collaborative project with 12 additional partners from across Belgium and the Netherlands. Similar to some other elements of the UoA's research, significant elements of the work of the Ecology Research Group is 'far from market' (e.g., **Syed's** work on alternative splicing), and therefore it is to be expected that, even as this work matures, it will still be some time before impact is realised.

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

4.1 Collaborations, networks and partnerships

Members of the UoA collaborate with a wide range of external organisations and communities. This is shown in the outputs returned in REF2, with 88% of outputs with authors from outside CCCU and 76% resulting from international collaborations. Collectively, and excluding papers with 15 or more authors, these submitted outputs include external co-authors from 69 different organisations. Importantly, 16% of these collaborations are with co-authors at non-University institutions, evidencing the UoA's commitment to working collaboratively with stakeholders. In combination, this demonstrates the UoA's strong and productive, links to academic and non-academic external organisations, with some of these spanning the entire REF period. An example of this is **Bertolo's** collaboration with the Bioscope research group, based at the Universidade Nova de Lisboa in Portugal. This research focussed on functionalised gold nanoparticles, that have potential applications as drug delivery agents in cancer treatment. This collaboration has resulted in three research papers and one review article over the REF period. Similarly, **S Harvey** and **Stastna's** long standing collaboration with the Laboratory of Nematology at Wageningen University and Research (WUR, Netherlands) is evidenced by the presence of WUR staff as co-authors on five of the outputs submitted here.

Beyond collaborations where outputs are currently visible, there are ongoing funded collaborations with many other external organisations that are expected to produce outputs in the next REF cycle. For example: **Rintoul's** Interreg 2 Seas project links academic and research institutions such as the Flemish Institute for Technological Research, University College Ghent, Delphy BV and Avans University Applied Science with government bodies such as Province of West Flanders, non-profit organisations like Kent Wildlife Trust and Pro Natura, and companies including Vanheede Landfill Solutions NV, Millvision BV and InneC CVBA; **Buckley** has been collaborating on two projects with the Rivers Trust; **Ahmed** and **Burman** are collaborating with Algaecytes Ltd. on algal carbon capture; **C Harvey** has been working with researchers at NBAF Sheffield on NERC funded work looking at the population genetics of the shining ramshorn snail; and **K Harvey** and **S Harvey's** are working with Genea Biomedx, JSR Genetics Ltd. and Topigs Norsvin.

Active collaborative work is also evidenced by the joint supervision by UoA staff of PhD students based at other Universities. For example: **Vega** is currently supervising a student at University of Greenwich on a project of looking at the molecular ecology of African giant pouched rats (*Cricetomys*); **Ahmed** is supervising a student at the Birla Institute of Technology and Science (India) on a project investigating the relationship between rheology and microstructure of Biofilm; **Wilson** supervised two PhD students at the University of Liverpool in this REF period; and **S Harvey** is currently a member of the supervisory panel for a student at WUR that is looking at thermal stress responses and supervised a student who completed a joint PhD at CCCU and WUR in 2019 (with the student completing theses for, and obtaining awards from, both institutions).

The UoA also supports staff to work on secondments to both academic and non-academic partners, seeing this as a critical way to build relationships with collaborators and research users. During the early part of the REF period, this support was seen with the three-year secondment of **Burman** to a 0.4FTE research project coordinator role at Thanet Earth, Britain's leading glasshouse complex. More recently, **Mylona** has been seconded to a 0.5FTE role managing CCCU's Stem Cell and Advanced Bio-Engineering Laboratory (SCRABEL) since 2019. Part of the University's Institute of Medical Sciences and based at the Medway campus, SCRABEL focuses on regenerative medicine and musculoskeletal tissue engineering, with research driven by collaboration with clinicians and performed by SCRABEL staff. Although outputs and outcomes from this work are not yet visible, such work is generating proof-of-principle data for grant applications and validating the Biomolecular Research Group's model for academic/clinician collaboration that will form a key part of this research group's approach to collaborative interdisciplinary work in the new building.

This wide engagement with both academic and non-academic partners is a key part of the responsive and applied nature of the work undertaken by the UoA. Such non-academic and academic links are supported and fostered as they deepen and broaden the range of expertise available to the UoA and extend opportunities for use of infrastructure, equipment and resources. These links therefore serve multiple purposes, specifically to strengthen the UoA's research and teaching activity, and the links between, and integration of, these activities. Staff also work closely with other Schools and research centres within CCCU. For example, UoA staff have collaborated with colleagues in the Faculty of Arts, Humanities and Education in work to promote STEM uptake, and with colleagues in the Business School to facilitate KE activity. Strategic initiatives designed to increase internal collaboration within the UoA and with staff in other parts of the University have also increased research quality, principally by increasing the scope of the work undertaken. Only limited outputs from such internal interdisciplinary work have been published to date, but this strategy has resulted in **S Harvey** publishing on placebo effects with staff from Sport, Exercise and Rehabilitation Science (this included collaboration on an international consensus statement on the application of the Placebo Effect in Sport that was published in a leading Sports Science journal in 2018). More recent extensions of this have included a large multidisciplinary application linking the UoA with Sport Scientists and Psychologists that would support the establishment of a Research Institute for Placebo Effect

Research. The UoA also continued its support for interdisciplinary work undertaken with external partners and the continued success of this is seen by the submission of outputs here from **Bertolo** and **McIntosh** that link across to chemistry and physics, respectively.

4.2 Relationships with key research users, beneficiaries or audiences

Key to research within the UoA is the strategic development of collaborative research projects with stakeholders, with projects developed in response to user-defined needs that are then further supported by the targeting of fundamental level research. Within this REF period, investment in facilities and infrastructure, and in staff development have also been crucial (see section 3.2). The Section has also greatly benefited from work undertaken to foster a collegiate research community and to improve collaboration (see section 2.2). This approach means that a wide range of non-academic user groups benefit from the work of the UoA. In recent years these have included government agencies (e.g., Canterbury City Council, Environment Agency and Natural England), charities (e.g., the Aspinall Foundation, and Kent Wildlife Trust), and commercial companies (e.g., Algaecytes Ltd., BCP Ltd., Genea Biomedx, JSR Genetics Ltd., Topigs Norsvin and Venomtech Ltd.). In most cases, as per our strategy for developing impact, user groups are involved directly at each stage in the process and hence activity is specifically directed to meet the users' needs. Importantly, these relationships represent some of the most significant achievements of the UoA's research groups during the REF period. For example, a key success for the Ecology Research Group was the completion of a major project on the conservation and reintroduction of the Shining Ramshorn snail by **C Harvey** and **Buckley** that was linked to, and supported by, Natural England. Similarly, for the Biomolecular Research Group, the most significant achievement within the REF period is the establishment of the Life Sciences Industry Liaison Lab (see section 3.2 for details), the first of the University's industry hubs where research is embedded with local industry partners.

Key to the development of these relationships is the flexibility of UoA staff and the focus on adding value for the external partner. In some cases, this involves funded work (see above for examples of such projects), but also involves work that is either not currently funded, work that serves to broaden our relationship with that partner, or projects that are not designed to produce academic publications but that provide some other benefit. Examples of such interactions include: **Vega's** work with the Aspinall Foundation on the conservation genetics of endangered western lowland gorillas, and with the Sussex Peregrine Study on the population genetics of peregrine falcons on the south coast – both projects that have been internally supported and that will generate both outputs and future grant applications; **Bloemink's** collaborative work with Algaecytes Ltd. on the effect of EPA-ethyl esters, isolated from algae, on sarcopenia, which serves to extend our existing relationship with this company (via **Ahmed** and **Burman**) and seeks to generate both outputs and future grant applications; **Wilson's** work with Anton Paar that has generated application notes for their Nanoparticle tracking system validating its use in novel applications; and **Buckley's** long standing consultancy work with Kent Wildlife Trust, the Environment Agency and with Natural England. In combination, relationships such as these ensure that the UoA's work delivers substantial benefit to our partners.

4.3 Wider activities and contributions to the research base, economy and society

UoA members have served and sustained the discipline as members of a wide variety of subject associations and learned societies, through peer-review activity (including reviewing both national and international grant applications, and by acting as reviewers for a wide range of journals), and through engagement in institutional consultancies at a number of universities in the UK and abroad. Members of the UoA have also served as external examiners of PhD theses within the REF period internationally at institutions such as Erasmus University Medical Centre (Netherlands), La Trobe University (Australia), Mario Negri Institute (Italy), University of Porto (Portugal), and WUR (Netherlands), and nationally at institutions such as King's College London, the University of Santiago de Compostela (Spain), the University of Kent and the University of Oxford.

Another key part of our strategy is to provide and develop opportunities to bring multiple stakeholders together. For example, external stakeholders are routinely invited to speak as part

of the research seminar series. Established in 2012, the UoA also developed the HortAg Forum to provide an annual meeting for agricultural stakeholders in the region. With an initial remit that included research and KE, this forum eventually broadened its scope to target education within the plant sciences. As such this the HortAg Forum, in association with Rural PLC (Kent), has organised plant sciences public engagement activities involving local schools, colleges and the farming community. Further to this, the UoA has also hosted a number of important international and national conferences, meetings and events, with illustrative examples being the three international conferences organised by staff from the ERG that ran at CCCU in this REF period. UoA staff were also critical to the organisation of the 2019 spring meeting of the Primate Society of Great Britain meeting that ran at the Powell-Cotton Museum and at CCCU.