

<b>Institution:</b> University of Worcester
<b>Unit of Assessment:</b> 5 Biological Sciences
<p><b>1. Unit context and structure, research and impact strategy</b></p> <p><b>Context and structure</b></p> <p>Following strategic investment in the life sciences over the last assessment period, through development of dedicated research infrastructure and recruitment of excellent researchers and research leaders to its Institute of Science and the Environment and its Pollen and Aerobiology Research Unit, the University submitted to UoA5 for the first time in REF2014. Prior to this, a small number of researchers in the Institute had been included in an “Allied Health Studies” submission in RAE2008. This submission builds on the 2014 submission, demonstrating the maintenance and development of research in this subject area.</p> <p>In 2018, the University went through an academic restructure introducing Colleges and Schools (see REF5a 1.1.4-1.1.5). Staff in the submitting unit are based in the School of Science and the Environment in the College of Life, Health and Environmental Sciences, and are primarily drawn from the Department of Biological Sciences with a small number from the Department of Geography, Archaeology and the Environment (<b>Adams-Groom, Westbury</b>).</p> <p>The University Research Strategy 2014 – 2019 outlined the key role played by Research Groups in operationalising plans and ambitions for excellent research. The strategy outlined 4 Areas of Distinction to recognise areas of existing and potential research excellence. To support the overall delivery of the strategy, the University held a series of events focused on each of the Areas of Distinction. These events were designed to bring researchers together from across the University whose research aligned with the areas with aim of highlighting existing areas of strength, establishing new collaborations, and developing cross- and interdisciplinary responses to problems. The events identified areas of strength and areas for development and led to development of new research groups and collaborations. Two of these Areas of Distinction were ‘Economic, Social and Environmental Sustainability’ and ‘Human Health and Wellbeing’, achievements against which are reflected in this submission. In 2019, to further enhance the vitality and sustainability of the research environment, research groupings within the School of Science and the Environment were reviewed. The review of research groupings provided the opportunity to link established research fields more closely than previously, to encourage contributions from a wider group of staff, to support inter-disciplinary research and to encourage new areas of across College and University research.</p> <p>These groups are:</p> <ul style="list-style-type: none"> <li>• <b>Sustainable Environments Research Group (SERG) (Ashbrook, Hanson, Herbert, Keane, Tör, Westbury, Wheeler):</b> members are committed to developing a vibrant, internationally engaged research group that encourages the exchange of ideas and the development of new research agendas. Research achievements and activities of members reflect this strategic agenda as follows: <b>Ashbrook</b>’s research interests focus on understanding the impacts of habitat and climate change, and species interactions in ecological systems. <b>Hanson</b>’s research focuses on detecting plant pathogens using molecular techniques. She has been working in this area for over 10 years and her previous research has developed diagnostic tests for use in the agricultural industry. Currently she is using next generation sequencing to study fungal ecology in atmospheric samples in order to investigate the impacts of climate change on crop pathogens. <b>Herbert</b> has been working on molecular and cell biology of flowering plant cell, particularly on the plant cell cycle in the tobacco BY-2 cell line. <b>Keane</b> has been generating monoclonal antibodies and developing Lateral Flow Devices (LFDs) for disease diagnostics. <b>Tör</b> has been carrying out fundamental and translational research in the area of food security, specifically on molecular plant-microbe interactions with particular emphasis on the role of circadian regulation in pathogenicity; the role of small</li> </ul>

RNAs in plant-microbe interactions; biological control of fungal and oomycete pathogens; genome editing for generating disease resistant plants and the use of genomics to accelerate plant breeding. **Westbury** works on the management of agro-ecosystems to support biodiversity and therefore the delivery of ecosystem services within agricultural landscapes. Since 2012, Westbury has focussed on approaches to enhance pollination and pest regulation services in apple, cherry and orange orchards with the aim of enabling growers to produce food more sustainably. **Wheeler's** research centres on elucidating the function of a large family of secreted proteins unique to dicotyledonous plants and mosses, some of which involves in the regulation of self-incompatibility.

- **Worcester Biomedical Research Group (WBRG) (Bueno, Cherry, Coles, Martin, Seville):** the group aims to promote multidisciplinary Biomedical Science research at University of Worcester. The WBRG fosters collaborations between University of Worcester (UoW) staff, students, local health organisations & academic institutions. Current research aims to address the major health issues of our time. Building sustainable societies through research into disease prevention, disease treatment and disease diagnostics, lies at the heart of the WBRG research ethos. WBRG aims to achieve this goal through basic and translational Biomedical Research, with particular focus on key themes, including *Cancer (leukaemia)*, *Cardiovascular Disease*, *Neurodegeneration & Infectious Disease*. **Bueno** has been working on the effects of plant polyphenols and essential fatty acid supplementation on cell membrane phospholipid composition in obese rats and in cell models of neural degeneration. **Cherry's** research focuses on understanding how proteins work at the molecular level and on how one can use knowledge of protein structure to tackle disease. Currently, her research focuses into the Hedgehog signalling pathway, specifically focussing on its role in Leukaemia. **Coles'** interests include basic and translational biomedical research in the fields of haemato-oncology, immunology and redox biochemistry; **Martin** focuses on wound management, formulation and assay development of novel antimicrobial agents, and drug delivery systems for the treatment of oropharyngeal and gastrointestinal infections; **Seville's** research interests lie within the drug delivery systems, with particular emphasis on delivery of drugs to the respiratory tract.
- **Pollen and Aerobiology Research Group (PARG) (Adams-Groom)** the group seeks to understand the formation, release, transport, transformation and removal of bioaerosols in the atmosphere and how this affects the general environment. There are three areas of focus within the group: human health and exposure to bioaerosols; plant health, crop diseases and invasive species; atmospheric processes and detection of bioaerosols. The rest of this group are returned to UoA14. **Adams-Groom** has been providing pollen forecasts and exploring the detection and concentrations of allergenic pollen and spores in the atmosphere for over 25 years. After working as a forensic palynologist for 10 years, she has also engaged in studies of pollen in soil in a forensic context. Current research interests include real-time molecular and laser detection of pollen and spores and analysis of pollen in honey.

Research across the College is overseen by a College Director of Research and Knowledge Exchange (Professor Eleanor Bradley) who works closely with the School senior leadership teams and the Research School on areas of research strategy; recruitment and staff development; chairs the College RKE subcommittee which oversees implementation of University RKE strategy; works with Research Group leads and organises College-wide research events.

### **Research and Impact Strategy**

#### *Unit's strategic research objectives during the assessment period*

Over the assessment period, research activities were guided by the central aspiration outlined within the UW Research Strategy 2014-2019: 'To develop excellent research with social, cultural and economic impact' (see REF5a 2.1).

Building on its core strategic objective in the 2014 submission, the unit has sought to build critical mass and infrastructure within its research groups. The Sustainable Environments Research Group and Worcester Biomedical Research Group have developed their own research strategies and approaches to achieve these ambitions and work is underway to align these strategies with the newly approved UW Research Strategy 2020 – 2025.

Strategies for both recognise the cross-disciplinary nature of the research underway and the groups have adopted approaches to encourage the continuation of research across traditional boundaries. To support the important research underway in these areas, the University has invested in essential infrastructure, encompassing well equipped molecular biology laboratories, bioimaging facilities, plant growth rooms and cabinets, proteomics facilities, and high-performance computing (see Section 3).

#### *Impact Strategy*

The unit engages in research from basic to translational to applied. In all cases, its goal is, long and short term, to generate benefits (health, economic, environmental) for identified groups which include, the general public, growers, seed and breeding companies, allergy sufferers, cancer patients. The unit drives impact through close collaboration with users and beneficiaries in the design and delivery of its research and through a dissemination strategy that targets key audiences for the research (including the general public), e.g. through presentation to practitioners, training, media and social media presence, web resources.

The two case studies selected for REF2021 are a direct result of our strategy to pursue and support research that makes a difference. Research on pollen and pollen forecasting carried out by **Adams-Groom** has been helping patients and allergy specialists to understand which types of pollen are, or will be, causing symptoms, and contributing to the need of pharmaceutical companies, epidemiologists, immunologists, weather providers and providers of allergy treatments, all of which plan their activities around the pollen predictions. Its close collaboration with the Met Office and with other organisations providing pollen information to the public has been key to enabling impact.

Similarly, research led by **Westbury** into wildflower interventions, has led to the mandatory adoption of wildflower strips in all new UK Jazz apple orchards. This was due to the discovery that wildflower strips increased biodiversity, an outcome that has potential economic and health benefit for growers and the society through a reduction in the use of insecticides, whilst promoting biodiversity. The research has been developed and delivered working directly with growers and impact has been enabled through a diverse dissemination strategy focused on reaching key stakeholders.

Beyond the case studies: translational science carried out by **Tör** has been actively helping national and international plant breeding companies. Tör has run workshops for growers, and seed and breeding companies in Turkey. This led him to establish an international collaboration with two plant breeding companies (Yüksel Tohum and Multi Tohum) to develop tightly linked molecular markers to disease resistance genes in pepper, tomato and cucumber crops to accelerate marker assisted selection of plant lines that are resistant to economically important fungal and viral pathogens. Recently, in collaboration with Professor Claire Domoney (John Innes Centre, Norwich UK) and Dr Jane Thomas and Dr Tom Wood (NIAB, Cambridge, UK), he has led a BBSRC-Link project on pulse-downy mildew pathosystem that aims to identify new resistance sources to include in breeding programmes; develop molecular markers to enable rapid identification and monitoring pathogen isolates; and use biological control agents to control downy mildew disease. The proposal brings together a comprehensive consortium representing the UK pulse industry, including 8 plant breeding companies - LSPB, Birds Eye, Syngenta, Elsoms, KWS, Limagrain, Senova, and Storm Seeds, a farm management and advice company (Velcourt), PULSES-UK (representative of users of pulse crops in the UK) and two pulse crop expert consultancy companies (IAR-AGRI, and Keith Costello). In addition, the UK pulse levy

organisation (PGRO) fully supports the proposal and the Agriculture and Horticulture Development Board (AHDB) provides direct and in-kind financial support.

The **WBRG** group, in collaboration with the Worcestershire Acute Hospitals NHS Trust, has worked on novel biomarkers in acute coronary syndrome (ACS), which occur when the flow of blood is restricted to the heart muscle. This can lead to the presentation of several clinical manifestations and ultimately myocardial infarction (MI). They are running a clinical trial (OXY\_ACS), to establish new predictive biomarkers for ACS. They have recruited around 130 patients at the point of an MI and follow up sampling at various time-points. They hope to establish new predictive biomarkers for a secondary MI event and currently the investigation is being carried out.

#### *Inter-disciplinary Research*

The University's College Structure was developed as an enabler of interdisciplinary research (REF5a 2.5). College Directors of RKE are tasked with identifying and developing interdisciplinary opportunities across Schools in a College but also between Colleges where appropriate.

This is manifested in the submitting unit through the research groups outlined above. SERG in particular is fundamentally interdisciplinary drawing on staff from across Biological Sciences but also Geography, Environmental Studies and specific topics such as environmental archaeology. WBRG has membership from across the College, notably researchers focused on genetic understanding of bipolar disorder (returned to UoA4) contribute to the group as well as researchers from sport and exercise science (returned to UoA24) focused on exercise physiology.

#### *Open Research*

The University is committed to developing and maintaining an Open Research environment. It fundamentally recognises the value of open access publication to the HE sector, to the public, to the University and its researchers but most vitally to the integrity and value of the research.

All staff are required to upload outputs from research onto WRaP, the University's research repository. The College is provided with monthly reports on Open Access (OA) compliance from a central Open Access Team based in Library Services (see REF5a 2.6). Information about WRaP and OA features in staff induction, training workshops are offered through the staff development programme, and 1-1 support is available on request from the Open Access and Advocacy Support officer. In addition, there is an OA funding scheme to support Gold Open Access which has been utilised by staff in the unit (**Tor, Coles, Bueno**).

The University will look to review and revise its Open Access Policy in 2021 in light of national and international developments, in particular Plan S. The University has recently signed up to the San Francisco Declaration on Research Assessment (DORA) and has established a working group to implement its principles.

#### *Research Integrity*

At University level, the University's Research Integrity & Governance Committee has oversight of policies and procedures to support research integrity and its Chair is the University's Research Integrity Champion. The champion is expected to embed a culture of integrity across University through developing training and support for staff but also raising its profile.

At College level, Research Ethics Panels are responsible for review of all staff and research student projects to ensure they are conducted according to appropriate ethical, legal and professional frameworks, obligations and standards. Panel Chairs and Vice Chairs are experienced researchers whilst panel reviewers are drawn from across the College; lay

reviewers are also recruited to the panel. Training is provided to all reviewers before they engage in the role. There is an annual audit of reviews to ensure the Panels are fulfilling their role.

For those staff and students conducting research in healthcare organisations (e.g colleagues within the WBRG), the NIHR Local Comprehensive Network West Midlands has provided IRAS, governance and Good Clinical Practice for research (GCP) training at the University over the period.

The University's Research Integrity champion works closely with the Chairs of Ethics Panels at College level to ensure a culture of research integrity is embedded in the wider research culture of the College, offering support and guidance to research students and staff and maintaining a high profile for the research integrity agenda.

#### *Future strategic aims*

In 2020, the University produced a new RKE strategy identifying 5 Areas of Challenge (REF5a 2.3). Colleagues are already conducting impactful research in 2 of these areas ('Human Health and Wellbeing' and 'Sustainable Futures') but have the potential to support developments across all 5. To achieve this will require ongoing support for inter-disciplinary research and across-University collaboration.

The unit's research groups will be supported to sustain the excellent research already underway as well as to introduce new developments in key areas:

- **SERG** will support members to develop research within the thematic areas of priority (food security, sustainable livelihoods, sustainable places, rivers science, conservation and management of species and habits), utilising university and College mechanisms of support for research, in addition to focusing bidding activity in these areas. New stakeholder relationships will be pursued (local, regional, national, and international) with a focus on policy makers. Clear routes for KE and research will be identified through a mapping exercise to identify new, and existing, stakeholders.
- **WBRG** aims to increase research capacity by successfully obtaining funding to support research students and early career researchers. The group will also build on existing external collaborations and actively seek new collaborations with research institutes, universities, government agencies, non-government organisations, including industry. This approach will provide defined routes for knowledge exchange and research impact. The success of the strategy will be underpinned by the University research support schemes, whilst becoming increasingly reliant on the acquisition of external funding.
- **PARG** will build on its previous successes influencing policy by maintaining and creating new research collaborations both nationally and internationally.

We will continue to retain and recruit excellent researchers at all career stages. Job descriptions will reflect research underway across the School and will be designed to attract colleagues who can contribute to work across the research groups. A review of plans to support staff on teaching, full academic and research posts will be undertaken at School level, with a focus on aligning staff with research group activities as appropriate. This will include the provision of training for Heads of Department around setting research objectives and workload planning for all academic staff; routine evaluation of research and KE objectives at annual performance reviews; identification of staff for the research mentor and coaching scheme.

Research in new areas, not aligned with existing groups, will be identified through the regular College research update and School bidding reports. This information will enable colleagues to consider joining groups aligned to their areas of research from across the University, as well as the development of new research groupings within the School. Any new research groupings will be required to be aligned to national and international areas of research priority, notably the UKRI. Excellence in research from across the School will be celebrated through all-staff School meetings and College events.

The opening of a new Medical School (anticipated first intake 2022/23) will provide further opportunities for inter-disciplinary research activity between new academic staff in the Medical School, associate staff from clinical practice, colleagues engaged with the WBRG, as well as colleagues working in areas aligned with UoA3 and UoA4.

## 2. People

### **Staffing Strategy and Staff Development**

#### *Recruitment*

The Department of Biological Sciences comprises 19 academic staff, 3 research staff and 3 technical staff. The College Director of RKE is routinely involved in new standard academic appointments, providing input to the post details, outlining specific areas of research experience and expertise (to align with RKE priority areas) as well as interview and selection processes. One member of staff has been promoted to Professor over the period (**Tor**) and here has been an additional professorial appointment as Head of School (**Seville**).

In addition to these senior research leadership appointments, Honorary Professors have been appointed to strengthen regional and international research links. Professor Stephen O'Hickey (Worcester Acute Hospitals NHS Trust) has worked with colleagues submitting to this unit since the last REF period and contributes to teaching on Allergy Management as well as inter-disciplinary research into severe allergy (submitted to UoA4). Professor Yiguo Hong from Hangzhou Normal University has been an Honorary Professor within SSE and collaborates with Tör to carry out research on Plant Health. Professors Tör and Hong established the Worcester-Hangzhou Joint Plant Health Laboratory with an aim to: enable reciprocal research visits; deliver seminars and lectures in the Joint Laboratory at both locations; carry out joint supervision of research MSc and PhD students; develop collaborative research projects for international funding for both Universities; publish co-authored papers in high impact journals; and share ownership of IPRs from joint scientific research projects.

Visiting researchers have supported ongoing international research collaborations. Six visiting researchers have been located in the unit over the period, from Brazil, Turkey and Syria, funded through international researcher mobility schemes such as CAPES and through CARA (Council for At-Risk Academics) scheme. Their time with the university has ranged from 3 months – 2 years and they have supported the research undertaken by **Bueno** and **Tor**. There has been an additional visiting research student from Brazil, also funded by CAPES, who worked for a 12-month period with **Bueno**.

#### *Progression and Succession Planning*

The contribution of senior lecturers to the submission demonstrates the success the School has had in enabling colleagues working across an academic portfolio (teaching and research) to maintain their research activities (see Table 1):

Contract level	% Eligible	% Submitted
F1 (Professor)	9	14
I0 (PL/Head of School)	32	29
J0 (SL)	41	43
K0 (Lecturer /Research Fellow or Assistant)	18	14

*Table 1: Proportion of staff by contract level*

There are opportunities for colleagues to progress their careers at the University. Colleagues (e.g. **Hanson**) have been supported to move from fixed term research contracts to permanent academic positions. Several have also been promoted to Principal Lecturer positions over the period (e.g. **Prankel, Westbury, Wheeler**). Aspiring research leaders are supported

through an annual Research Leadership Programme. There is a Professorial Mentoring scheme available to those senior colleagues preparing their professorial applications. Research outputs are rewarded through the annual University recruitment and promotion scheme.

#### *Staff Development*

To support a thriving and inclusive research culture, the University is committed to developing and maximising the research potential of all staff on standard academic contracts, and at all stages of their careers. All academic staff are required to engage in research, appraisals are instrumental in providing a framework to discuss research income and output writing objectives, but also staff development needs, which might include attendance at relevant courses and workshops for which there is a budget at School level. Staff are also supported to participate in national and international conferences (see Section 4).

University research support schemes have supported the ongoing development of staff within this submitting unit as follows:

- The Research Outputs Facilitation Fund (ROFF) is a College fund awarded to researchers to facilitate the final stage of research projects into publication. Three grants have been awarded including to **Bueno, Hanson, Keane**.
- Supporting Research Excellence Scheme – the scheme provides staff with full or partial remission from teaching and / or other duties for a period of up to two semesters (8 months) to undertake a project with a clear set of outcomes (see REF5a 3.2.3). Staff from the submitting unit have successfully applied for SRES (**Bueno, Coles, Westbury, Wheeler**), all subsequently produced research aligned with this submission.
- The Vacation Research Assistantship Scheme (VRAS) - staff submit a proposal for research to be supported by a student working as a research assistant for up to three months over the Summer period. Within this submitting unit, the scheme has provided early career researchers with support for unfunded research, as well as valuable experience in supporting and developing new researchers. Eight projects from colleagues in this submission were funded, including **Bueno, Cherry, Coles, Hanson, Westbury, Wheeler**.

The Head of School engages in discussions on research aspirations with all new academic staff during their induction period, new colleagues are also encouraged to meet with the College Director of RKE and provided with a mentor as an independent source of advice and information about available University sources of research support. There is a school budget to support staff to undertake external training which is also used to support staff to undertake higher degrees, notably doctoral study. This support includes the route to a PhD by Published and Creative work which is a valuable opportunity for staff joining the university from senior professional and practice positions. One member of staff within this submitting unit has been supported to complete a doctorate via this route over this period (**Adams-Groom**).

An important resource for early career researchers and staff is the Research Development Programme which comprises a series of workshops over each academic year (see REF5a 3.2.4). Workshops are delivered by senior researchers and professional staff at the University but also draw on external presenters and utilises resources offered through Vitae and other professional development organisations. The programme includes a Research Leadership Programme, designed for more experienced research staff, including research group leads and newly appointment Professorial staff. As these are University-wide programmes, they provide the opportunity to meet other research active staff which has encouraged interdisciplinary research.

Staff across the University also come together on a regular basis for the School's Research Seminar Series and the College Research Seminar series. The School seminar series has run throughout this REF period and draws on a scholarly mix of internal and external staff and postgraduate speakers throughout the academic year. The series includes an annual Lovett lecture which is open to members of the public as well as staff from across the University. The COVID-19 pandemic has escalated work to make these seminars more widely available to

internal and external colleagues through recordings and by hosting online. Both seminar series moved online in 2020, attracting higher average attendance numbers, whilst providing the opportunity to make them widely available to relevant external organisations.

Mentoring is also an important aspect of staff development. There is a university wide mentoring and coaching scheme which brings together senior and emerging researchers, according to expertise and experience. There are a range of training and resources available for mentors and mentees engaged with this scheme. Overall, the department is committed to meeting its staff development demands and aims to provide relevant opportunities enabling all to maximise their academic potential.

UW has implemented the *Concordat to Support the Career Development of Researchers* and developed an action plan based on its recommendations, subsequently being given the HR Excellence in Research award in 2016. Key aspects of this plan have been the development of a bespoke training programme for its research staff, the establishment of a research staff forum, and the development of training for principal investigators around the commitments of the Concordat.

### **Research Students**

There has been an increase in research student numbers from 8 students in REF2014 to 12 students in this submission. There has been a more notable increase in the numbers of students supported to study full-time, with 9 currently studying full-time compared to 5 full-time students in 2014. This reflects success in applications to external funding schemes over the period, which has included The Leverhulme Trust and the Turkish Ministry of Education but also the University's ongoing investment in PhD studentships. The University has funded 10 studentships over the assessment period in areas of research priority aligned with this submission. This has included 6 fully funded and 4 co-funded studentships. Three of the co-funded studentships (**Westbury**) have developed ongoing research to consider the role of wildflower strips as a sustainable method of fruit production (for apples, cherries and citrus) and involved partnership with industry, specifically Waitrose plus a specific fruit producer. The fourth co-funded studentship (**Ashbrook**) is co-funded by the Bumblebee Conservation Trust and investigates bumblebee wildflower meadow habitat preferences using multi-scale remote sensing data.

There have been 12 successful doctoral completions over the period, with a number of these students co-supervised with colleagues submitted to UoA14. Amongst those students who have completed in the period, notably one has become Research Fellow in the College of Life and Environmental Sciences, University of Exeter and another is the Technical Manager at Worldwide Fruit.

Recruitment and selection to the PhD programmes is overseen locally by a PhD course leader. Their role is to ensure that only excellent students are accepted onto the doctoral programme and that supervisory teams meet the requirements of our Research Degree Programme regulations. The course leader also works with academic staff, Research Group leads and the College Director of RKE to advertise self-funded PhD opportunities. The course leader also monitors progress, providing advice and support to supervisory teams and students where required, as well as overseeing the School's enhancement plan for its Research Degree Programme.

The University has a well-established graduate school (branded as the Research School) that is responsible for the management of all Research Degree Programmes from recruitment to examination, in partnership with the academic schools (see REF5a 3.3.2- 3.3.3).

The University has expanded the Research School team to reflect the growth in student numbers over the REF period. It provides a dedicated work and social space for students. The Research School team, co-located in the student space, provides advice and guidance for



students on their programmes, and, working closely with other student-facing departments such as the Disability & Dyslexia Service, the student mental health team, careers service, also offers pastoral and wider support. A comprehensive programme of support and guidance has been developed for PGR students and supervisors around mental health and wellbeing.

All students on research degree programmes are required to undertake an associated training programme, run by the Research School (REF5a 3.3.4-3.3.5). The programme has been mapped against Vitae's Researcher Development Framework. The programme offers a suite of modules, short courses and workshops, delivered face-to-face or online, some of which are compulsory for all doctoral students, focused on the following core areas: planning and managing research; academic writing; research methods; data analysis; research integrity and ethics; dissemination, engagement and impact; careers and employability.

The University also supports students to engage with external training where this is specialist and not available through the University's programmes. Students are also able to access training offered through the GuildHE Research network

Beyond the programme, the Research School offers additional development opportunities. Research Students have opportunities to teach and can access modules and workshops to develop their skills in this area, with the opportunity to gain associate or full fellowship of the Higher Education Academy. The University offers research student-specific dissemination opportunities including an annual "Images of Research" exhibition and student-led PGR Conference. The University provides funding opportunities for students to attend and speak at external conference and events and separate funds to support students to develop inter and cross-disciplinary networks, seminar series, conferences and events. The University is a member of the Brilliant Club, a charity focused on improving access to University, which provides opportunities for doctoral students to go into schools and deliver tutorials in their area of expertise. The Research School also provides ad hoc opportunities: for example, in 2019 the lead for the development programme worked with a student team to deliver a University programme for Pint of Science.

Office space for PhD students is provided at the Research School, but there is additional space available for those students who require access to specific on campus facilities (for example, laboratory space). Feedback is sought from doctoral students via the Postgraduate Research Experience Survey (PRES) every 2 years (see REF5a 3.3.6) and feedback has been utilised over this period to encourage doctoral students to feel more embedded within the culture of the College. For example:

- The School and College Research Seminar series encourage participation from doctoral students
- Students have been invited to provide posters at College Research events and work is also displayed within the School
- There is research student representation on the College RKE Subcommittee which ensures the student voice is fed into the development of research strategy at College level
- Doctoral students are provided with opportunities to work with UG students to support the development of student societies (e.g. the UW Biology Society), help with specialist teaching, serve on committees of external organisations, and make significant contributions to STEM outreach and widening participation activities

Supervision at Worcester is always by a team consisting of a DoS (who must be based at the university) and up to two other supervisors. The team must have relevant expertise and collective experience of supervision. Staff with no prior experience of supervision are supported to take on Director of Studies (DoS) roles with the support of a supervisory mentor. Supervisors are therefore selected in relation fit to the project. All supervisory teams must be approved by the University's Research Degrees Board.

The Research School maintains a register of approved supervisors which identifies the expertise and experience of supervisors. The register is reviewed on an annual basis. There are currently 15 approved supervisors from the submitting unit, a significant increase from 8 in 2014.

The Research School provides opportunities for the professional development of experienced and new supervisors through a supervisor development programme. This programme has been in place for some 20 years but was rethought and relaunched in 2018/19. The programme offers a wide range of support for supervisors at various career stages on themes such as: introduction to supervision, supervisory styles, regulations and processes, supervising international students, PGR mental health and wellbeing, supporting student progress. New supervisors must complete the whole programme but more experienced supervisors must also engage with core elements and all supervisors are required to engage in regular refresher training (every 3 years).

Training is complemented by other development opportunities including: supervisor lunches that bring together supervisors to discuss key topics and challenges in supervision; the Share and Inspire series, and external professional development for supervisors provided through the UK Council for Graduate Education (UKCGE).

### ***Equality and diversity***

The University has a fundamental commitment to equality and diversity (REF5a 3.4). It seeks to consider and apply equality and diversity principles in all that it does. Its policies and processes are designed to disadvantage no-one and are subject to ongoing equality impact assessment to ensure this is the case.

The unit's approach flows from this with the Head of School ensuring that the University's principles and policies are fully enacted. Line managers are sure staff are aware of and are supported to engage with, for example, the University's flexible working policy, its parental leave policies, its policies which support carers (such as its Critical Illness Policy) and its staff wellbeing initiatives (see REF5a 3.1.8)

Several staff in the unit have benefitted from the University's flexible working policy (REF5a 3.1.8) with a move to part-time or compressed hours. There is no evidence that this has impacted on research productivity, access to funding or progression. It is notable that both at institutional (REF5a table 2) and unit level, part time staff are as well-represented in the Category A submitted as eligible category.

Staff in the unit have taken parental leave in the assessment period. They have received active support to transition back to work after the leave period, through "keeping-in-touch" days, phased return, mentoring. It is ensured that where a staff member takes parental leave this does not impact on research leadership or supervisory roles. The School has a fair and flexible approach to working, particularly during the current lockdown period in recognition of the challenges of home schooling.

Staff in the unit are committed to equality and diversity. Staff were members of the University's Athena SWAN self-assessment team; the University received its institutional Bronze Award in April 2018 and is committed to making departmental applications in the next 2 years. Staff are also engaged with various staff networks focused on protected characteristics and with the LGBTQ+ Allies scheme.

### **3. Income, infrastructure and facilities**

#### ***Income***

The development of new facilities, infrastructure and research strategy have resulted in an increased research grant income to a total of £1,784,990 over the period. Colleagues have engaged with a diverse range of funders over the period. Examples include:

- **Biotechnology and Biological Sciences Research Council (BBSRC)**  
Three projects have been funded by the BBSRC over the assessment period.
  - New approaches for the early detection of tree health pests and pathogens (2014-18) led by FERA, part of the council's Tree Health and Plant Biosecurity Initiative (£192k)

- Global threats from *Phytophthora* spp. and their mitigation through nursery best practice (2016-19), also part of the Tree Health and Plant Biosecurity Initiative (£45k)
- Pulse-Downy Mildew Pathosystem: Deploying disease resistance, pathogenomics and microbial biocontrol (2020-23), led by Worcester (**Tor**) with academic partners at the John Innes Centre and NIAB, Cambridge (£512k).
- **Agriculture and Horticulture Development Board (AHDB)**  
Four projects were funded by the AHDB over the period, targeted at plant disease and detection. The initial 2 projects included an evaluation of an integrated disease management system to ascribe risk of downy mildew disease on commercial salad and bulb onion crops in the UK; followed by a review of best practice for oomycete root-rot detection and control CP 126. The completion of these led to a further 2 funded pieces to new methods of detection, including the employ of a lateral flow device to detect Gummy Stem Blight and the second tested single and multiple diagnostic devices for early detection of oomycete root.
- **British Council**  
The University received funding for 2 projects in the area of food security (**Tor**). These included an overview of the latest technologies for crop improvement (2014) and an evaluation of current plant health challenges and solutions (2016).
- **Sir Halley Stewart Trust**  
The Trust has funded two projects led by the WBRG (**Coles**); the first looked at the efficacy of novel therapeutics in the treatment of parasitic infections and haematological malignancy. The second focused on the development of point of care testing for detection of *Ureaplasma* infection amongst preterm infants.
- **Institute of Biomedical Sciences**  
Colleagues working within the WBRG have been successful with funding from this professional body, with 4 projects funded over the period. These have included two in the area of antibody development (**Coles**), one which investigated MLF1 as a marker for Treatment of Acute Myeloid Leukaemia (**Cherry**) and one to develop a lateral flow diagnostic device for the diagnosis of *Acanthamoeba* Keratitis (corneal infection).

### **Infrastructure**

The university has invested significantly in research support infrastructure over the REF period (see REF5a 4.1.1) and established robust Pre- and Post-Award processes for externally funded projects (approved in 2018/19 and subject to evaluation and review in 2020/21). These processes scaffold the Research Office support systems set out above and ensure good governance for bids and for projects. Staff within the submitting unit work closely with colleagues based in the Research Office to develop bids for funding, with support available at pre- and post-award. Within the College, there is an RKE facilitator who disseminates information about new opportunities for research funding to colleagues, works closely with Research Group leads to develop a research funding profile (including fingerprinting for Research Professional), provides tailored information about specific opportunities on request and registers information about bids in preparation.

Peer review for draft bids is encouraged for every submission, and mandated for larger value bids, as well as those targeting Research Council and UKRI opportunities. A peer review process is co-ordinated by the College Director of RKE, utilising expert feedback from academic colleagues across the College. It has been recognised that the processes need to incorporate Equality Impact Assessments at various stages of both pre- and post-award. In lieu of this broader development, the University has adopted the BBSRC EIA guidance and template for reviewing research bids. It has also been agreed to undertake a review of bidding over a 5-year period from an equality perspective and this will be completed in 2021. The review will inform the development of support mechanisms for bidding.

Biology researchers are proactively supported by the Information & Learning Services through subject-focused staff. The University opened a new Library (The Hive, which has won 46 awards) jointly with Worcestershire County Council, providing a central location for public engagement as well as ready access to the book stock.

**Facilities**

The University has invested significantly over the last decade in developing and maintaining its research facilities in the biosciences. It has established:

- A fully equipped molecular biology laboratory.
- A well-equipped laboratory for Leukaemia research
- A laboratory dedicated to monoclonal antibody production that is linked to plate readers for conducting ELISAs and generating lateral flow devices.
- A laboratory dedicated to disease diagnostics using immunochemical detection as well as carrying out ordinary plant pathology work. Linked to this are growth cabinets and growth rooms.
- A proteomic laboratory equipped with LC/MS single quadrupole, GC/MS, AKTAPure chromatography system, Crystallography incubator and GavaCyte 2/4 flow cytometer. An environmental test chamber allowing researchers to conduct environmental research at various temperature and humidity.
- In-field facilities including drones for carrying out aerobiological research that allows capturing airborne pollens, fungal spores and particles and a large collection of detectors for bioaerosols.
- A large collection of pollen samples that allow researchers to perform palynology and students to be trained for pollen identification.
- A High-Performance Computing (HPC) facility, which is linked to high speed internet, that helps researchers process and analyse very large data sets and perform complex computational tasks including modelling and next generation sequencing analysis.

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

Staff within the submitting unit have engaged in collaborative research with other universities and research organisations internationally and nationally.

Colleagues have been supported to initiate and sustain links with international academic partners over this period. For example, Dr Allain **Bueno** graduated from the Paulista School of Medicine, Sao Paulo Federal University, Brazil. During his time at the University of Worcester, he has maintained his links with former colleagues and has produced research outputs through this collaboration in the area of experimental biology. Dr Bueno has also been supported to retain his collaborative relationships with the School of Nutrition, Bahia Federal University and, as well as publishing several outputs together over this period, he is currently working with these colleagues to conduct a large clinical study in the area of clinical nutrition, cancer aetiology and survivorship. Other successful international collaborative links include: **Adams-Groom** (University of Madrid; University of Parma, Italy; University of Salamanca; University of Gothenburg, Sweden; University College Dublin; University of Wellington, New Zealand); **Ashbrook** (University College Cork, University of Vienna); **Bueno** (Texas Tech University); **Cherry** (Karolinska Institute); **Coles** (Aarhus University, Denmark); **Martin** (Universiti Kebangsaan Malaysia; University of Douala, Cameroon); **Tor** (Hangzhou Normal University, China; Akdeniz University, Turkey), **Wheeler** (Montana State University).

Colleagues are also supported to collaborate with colleagues from universities across the UK. For example, Dr Steve **Coles** completed 2 post-doctoral associate posts at Cardiff University before taking up his post at the University of Worcester in 2013. Dr Coles has retained close links with Cardiff, working with colleagues in the Darley/Tonks laboratory in order to publish 2 collaborative research outputs over the period to consider immune responses and AML suppression. Dr Coles continues to be mentored by senior colleagues at Cardiff. Other colleagues also have successful national collaborative relationships universities across the UK including: Leicester, Bangor, Aberystwyth (**Adams-Groom**); Wolverhampton (**Martin, Keane**); Liverpool John Moores (**Martin**); Oxford (**Wheeler**); Sussex (**Coles**); Coventry (**Coles**);

Birmingham (**Bueno, Martin, Wheeler**); Leeds Beckett (**Bueno**); Bristol (**Bueno, Coles**); Loughborough (**Coles**); York St John (**Martin**); Cardiff (**Keane**); Exeter (**Adams-Groom, Tor**); Cardiff Metropolitan (**Coles**); Leeds (**Cherry**); Chester (**Prankel**); Francis Crick Institute (**Cherry**).

### ***Contributions to the Research Base***

Colleagues have been invited to give keynote presentations at international conferences including: Plenary Public lecture, Nutritional approaches for the prevention and management of Depression; 21 April 2018 (**Bueno**); SIGS and HIGS: investigation into silencing genes in the obligate downy mildew pathogen. International Molecular Plant Protection Congress Adana TURKEY - April 10-13, 2019 (**Tor**). Molecular plant-microbe interactions: systems for defence and strategies for attack. Plant Health Meeting, February, Antalya, Turkey, 2016 (**Tor**).

Staff within the submitting unit are engaged in a range of activities which make wider contributions to the research base economy and society. These include:

- Membership of external committees, societies and associations including the Association of Nutrition (Bueno), The Encephalitis Society (Bueno); Academic of Pharmaceutical Sciences Board of Directors (Martin), Treasurer of the British Society for Plant Pathology (Tor); Malvern Hills Trust – Wildlife Expert Panel (Westbury); Royal Pharmaceutical Society of Great Britain (Seville); Academy of Pharmaceutical Sciences of Great British (Seville), International Society for Aerosols in MEDicine Member, UKI Controlled Release Society (Seville).
- Reviewers to grant committees: Pool member for BBSRC Grant Committee, 2016-2019 (Tor), Core member for BBSRC Grant Committee (Tor), Assessor of Innovate UK grants (Tor)
- Membership of Editorial Boards / Editors e.g. Journal of Physiology and Biochemistry (Bueno); Cancer and Oncology (Coles); Frontiers in Plant-Microbe Interactions (Tor), Journal of Environment and Agricultural Studies (Tor); Journal of Agriculture and Sustainability (Tor; Westbury); Advances in Agriculture (Westbury); The Scientific World Journal (Westbury); Research and Reviews in Drug Delivery (Seville).
- Reviewers for journals, publishers etc including Aerobiologia; Journal of Nutritional Biochemistry; Chemical Nutrition; European Journal of Clinical Nutrition; International Journal of Clinical Practice; Neurochemical Research; Journal of Pharmaceutical Science; Powder Technology; Functional Genomics; Molecular Plant Pathology; Plant and Soil; Sustainability; Journal for Nature Conservation; Oxford University Press; Routledge;

### ***Contributions to Economy and Society***

Colleagues have engaged members of the public with their research over the period with a range of public engagement activities including:

- **Adams-Groom:** Pollen forecasting to the Media. U3A, Science Seminar, Gloucester, July 2016. Analysis of the pollen content of commercial honey. Worcestershire Beekeepers annual meeting, Worcester, February 2015 and April 2016.
- **Cherry:** Programme at Worcester Sixth Form “Proteins and Drug Design; The devil is in the detail”; 2019; Impetus Programme at Christopher Whitehead School “Developing novel anti-viral and anti-cancer agents”, 2019.
- **Coles:** Pint of Science Festival, Worcester, 2019: Future Treatments for Leukaemia: Immune checkpoints point the way forward; Science Week Worcester Hive Micro-science Festival, 2018: AML Immune Checkpoints: CD200 & PD-1 crosstalk; The Worcester Infirmary Museum, 2016: Natural Born Killers: the immune cell vs cancer.
- **Westbury:** Public event at the Hive for British Science Week “Ecology Forum” March 2019; Public lecture at the Hive “Gardening for wildlife” March 2017

Colleagues have also acted in an expert capacity in the following roles:

- Scientific Advisor of the Food Standards agency. Scientific Advisor, Registered Specialist. May 2019 to present (**Bueno**)

- Trustee of the British Society for Plant Pathology. 2017 – Present (**Tor**)
- Wildlife Expert Panel for Malvern Hills Trust. 2012 – Present (**Westbury**)