Institution: University of Abertay Dundee

Unit of Assessment: 5

a. Overview

Abertay University is a compact institution, comprising approximately 200 academic staff and 5,500 students. This concentration enables us to work effectively across departmental and discipline boundaries to create an innovative and sustainable environment for research. Our approach to research is defined in our University Strategic Plans and expresses our ambition to be a centre of excellence for inter-disciplinary research, innovating practical solutions for business, society and government. This Unit is coupled to the wider context of a University-level strategy of development of a small number of focused, inter-disciplinary groups:

- **SIMBIOS** (Scottish Informatics, Mathematics, Biology and Statistics Centre), which focuses on understanding the organisation and integrated, complex behaviour of environmental and biological systems;
- **WhiteSpace**, a cross-University research group integrating computer arts, computer science, psychology, sociology, biological and environmental sciences (integrated with our UK Centre for Excellence in Computer Games Education);
- **CCSB** (Centre for Cancer Systems Biology), a partnership among Abertay, St Andrews and Edinburgh Universities to use mathematical modelling of complex systems and interactive visualisation. Part of CCSB is the Centre for Molecular and Cellular Biosensor Research (**CMCBR**) focused on development of molecular and cellular biosensors for research in molecular, cell and systems biology with strong pathways to the biopharmaceutical industry;
- **FIA** (Food Innovation @Abertay), a practical research and innovation support service for the food and drink industry, offering tailored and creative solutions to business challenges.

This UoA5 submission (13.6 FTE researchers (4 Professors, 1 Reader, 2 Senior Lecturers, 4 Lecturers, 1 Teaching Fellow, 2 Early Career Researchers)) draws on expertise from across the University and constitutes a core **Cancer Systems Biology** group (6), a **Food & Drink Bioscience** group (3), and associated **individual experts** in nanotechnology, microbiology, physiology, genetics and bioethics (5). The interconnected mappings between UoA5 groups and University groups (above) are as follows:

- **Cancer Systems Biology**, interoperation of theoreticians and experimentalists and aligned to SIMBIOS, WhiteSpace and CCSB, the latter leading to two Impact Case Studies;
- **Food & Drink Bioscience,** part of a nascent group of mainly early career academics, aligned to FIA, SIMBIOS and WhiteSpace, with emerging research, knowledge exchange and impact;
- The **individual expertise** cited above is situated within the School of Science, Engineering & Technology and is rooted firmly to a professional body accredited teaching portfolio.

These activities have impacted directly on our portfolio for REF2014, have allowed us to consolidate existing groups, form new academic and industrial partners, and have influenced our pattern of teaching provision to promote research and knowledge exchange (RKE)–teaching links that are essential in our operating context. Interactions among these University and UoA5 groups have delivered innovative solutions and UoA5 impact case studies. This has given us confidence to adopt a new 5-year Research Strategy, R-LINCS (see b), that integrates activities into a single Abertay-wide RKE initiative to build depth and stimulate new developments and partnerships.

b. Research strategy

University context: The University is committed in its Strategic Plans to maintaining our world-leading role in aspects of environmental sciences (modelling, simulation & visualization), developing our nascent groups in inclusive technologies for sustainability, well-being and security, and growing research activity, income, impact and demand driven KE, based on subject-focused and inter-disciplinary research themes that align with our teaching activities and government priorities. Discipline expertise from a range of subject areas is integrated and used to support discovery, innovation and translational research across traditional disciplinary boundaries. Researchers have engaged fully with Scottish research pools SAGES (Scottish Alliance for Geoscience, Environment and Society), SIPR (Scottish Institute for Policing Research), and SICSA (Scottish Informatics and Computer Science Alliance) to maximise development, particularly for early career researchers. This strategy has been successful, leading to the re-submission of successful RAE2008 units together with three new submissions (UoA5; UoA23; UoA26).

Unit specific approach: This, our first Biological Sciences submission represents a progression of the remit of SIMBIOS, a centre for systems biology approaches, linking micro-scale processes to macro-scale, emergent patterns. SIMBIOS initially developed critical mass and an internationally leading role in bio-physical modelling of the soil-microbe complex (RAE2008 Unit 17). Unit strategic objectives stated that we would: build strength at the physical-life-science interface; invest in strategic partnerships; invest in world-class infrastructure aligned with our research strength; and optimise dissemination and KTPs. All objectives have been met in the Biological Sciences context as follows:

The SIMBIOS inter-disciplinary ethos founded on a tight coupling of discipline expertise, experimental systems and theoretical modelling has required integration of biology, epidemiology and ecology with computational, statistical and mathematical modelling. This interoperation provides augmented, reciprocal benefit and has driven the development of innovative systems approaches which have been transferred, applied, adapted and specialized across disciplines, in particular for this UoA to cancer biology and now emerging in our Food & Drink Bioscience. Core SIMBIOS research strengths and WhiteSpace interactive visualization expertise, provide a focus and framework of support and opportunity to a wider biological science community. This unit is concerned with two main areas: (i) understanding mechanisms of disease progression and management; and (ii) food and drink bioscience. It combines the work of 14 researchers (13.6FTE) with expertise in nanotechnology, microbiology, molecular and cell biology, medical biotechnology, computational and data modelling, bioethics and food & drink bioscience. This is a strategic consolidation of focus and growth (6 new staff) since 2008, with 9 staff returned for the first-time and 5 staff returned from other RAE2008 units. Each researcher has developed their own research programme, and contributes to a joint inter-disciplinary research strategy and focus. For example, biologists and computational modellers formed the CCSB to link drug action at the cell-scale to tumour response at the scale of human tissue. Focused areas are led by Professors in Medical Biotechnology, Systems Biology and Zymology, who foster interaction.

Our guiding philosophy links quality research to end users in response to national and international priorities and initiatives, for example: **Cancer Systems Biology** work with University of Edinburgh Breakthrough Breast Cancer at the Western General Hospital and St Andrews Medical School, and the Universities of York and Kent, on the characterization of cell signaling network dynamics in response to therapeutic interventions and oncological mutations and link network dynamics to patient profiles and gene transcription; tumour morphology characterization (based on CT thresholding work in SIMBIOS) linked to tumour grading; development of a multi-scale modelling and simulation framework linking cell signalling behaviour to tumour morphology; have demonstrated GNB3 protein mutations linked to diseases (IP patent no. S86306); designed, developed and commercialized new instrumentation used in biopharmaceutical research and industry with Norton Scientific Inc. (Impact CS1); and developed with clinical testing a new drug therapy with Cyclacel Pharmaceuticals Inc. (Impact CS2). **Food & Drink Bioscience** researchers have; established Knowledge Transfer Partnerships (KTP) with major companies (eg. Diageo), industrial sponsorship of PhDs (eg. Lallemand Inc, Agrico UK), developed interactive software for sensory analysis (jointly licensing with an SME), partnerships in Scottish Government/ EU funded consortia such as the Scottish Biofuel Programme (next generation biofuel from renewable resources), a recently approved Industrial Biotechnology Innovation Centre (innovation for product development and manufacturing processes), are the University hub for Scotland Food & Drink Skills Academy (recommends and develops training and education across Scotland for the industry), are a lead partner University for Interface Food & Drink (driving sector KE in Scotland), and through FIA have supported >140 Scottish Food & Drink SMEs to innovate.

University Research Strategy for the next 5 years: We have established R-LINCS (Research-Led Innovation Nodes for Contemporary Society), driven by a University-wide Research Executive that manages internal research funds and drives external fund-raising activity to support innovative solutions to societal problems through 4 cross-Abertay themes: Environment, Security, Society and Creative Industries. These themes recognize our major income and output streams. R-LINCS provides the following resources to the research community:

- Single, pan-University research leadership to drive our discipline strengths and inter-disciplinary research agenda, propose strategic research-focused appointments and to mentor early-career researchers and foster external collaborations, including with industry;
- Intra- and inter-theme support for research (funded doctoral studentships) housed in a single

Graduate School, which offers a coherent, University-wide integrated training programme (e.g. research methods, writing & presenting skills, entrepreneurship); the single Graduate School will inculcate inter-disciplinary working in our next generation of researchers, will drive new research areas, and add value to disciplines through cross-fertilisation;
- The Graduate School will also encompass all taught PGT and so stimulate R-T links;
- Funding for proof-of-concept RKE projects, staff training and open-access publication;
- Facilitation with public engagement channels including our STEM outreach activities, the Dundee Science Centre, the Dundee Science Festival, Tayside Space School, Dare to be Digital, British Science Association, our local Café Science and public exhibition spaces.

UoA5 is well served by this strategy due to its industry partnerships and broad inter-disciplinary research base. We will help drive the Environment theme (e.g. health & food; sustainability), will advance technologies through the Creative Industries theme (highly interactive modelling & visualization tools for complex systems; industry & market), integrate with the Society theme (sustainable living; nutrition & health) and engage with an expanded Security theme (big data, data mining, network analysis & food security).

Our UoA5 objectives for the next 5 years: UoA5 will build on success in leveraging research excellence and funding through integrating our discipline strengths, application of interactive technologies and industrial partnerships. The **Cancer Systems Biology** group will use a mix of external funding (e.g. £1M Trust funding secured to date; £0.6M of SICSA staff funding with significant match funding from Abertay) and R-LINCS support, to continue on our trajectory and secure new external funding through collaborative networks. We will:
- Continue development of a novel highly interactive visualisation tool based on 3D games technology (linking with creative industries and digital media group UoA15) that places complex signalling models in the hands of biologists through interactive graphics, to allow for comparisons of cell response to two different drug regimens. This will be a significant contribution to the field of cancer systems biology (patent filed PCT/GB2013/052708);
- Develop a new range of biomarkers for tissue samples, founded on spatial statistics and tested on patient samples (colorectal cancer) and prognoses from Western General Hospital;
- Further implement our multi-scale modelling framework able to link cellular signalling to tumour morphology through next generation massively parallel hardware platforms, concurrent programming and interactive visualization.
- Further develop our collaborations with the biopharmaceutical industry building on our expertise in drug discovery and development of novel screening platforms.

We will drive development of industry focused **Food & Drink Bioscience** research in partnership with end-users supported by RKT funding (national and EU), Innovate Scotland, engagement with SICSA, R-LINCS studentships, proof-of-concept funds and new staff appointments. We will:
- Capacity build and deepen core expertise in food & drink bioscience particularly Food Product Development (novel and bio-active ingredients for healthy and sustainable food security) and increase the number of returned staff in this area;
- Develop highly interactive mathematical modelling and visualization tools to improve analysis of complex interactions spanning fundamental to end-user (food pipe-line, processing, sensory analysis) in partnership with systems engineering and interactive media groups (UoA15);
- Work in partnership with our internationally leading SIMBIOS and UWTC groups (UoA7) and the food & drink industry to improve sustainability, particularly sustainable soils management, and waste to biogas and biofuel.

As part of our long-term strategy to lever our core competencies, we will exploit systems modelling and industry impact pathways to align our work in neuroscience and microbiology. All of these challenges require inter-disciplinary solutions as supported by R-LINCS.

c. People, including:

i. Staffing strategy and staff development

The University is implementing all 7 principles of the Concordat to Support the Career Development of Researchers (2008) (HR audited in December 2012). Equality and Diversity is supported through the implementation of Equality and Diversity policies for all staff and students, and the monitoring and evaluation of staff data through the Equality and Diversity Sub-Committee. All members of staff complete an e-learning module on Diversity in the Workplace and senior staff, including academic staff responsible for recruiting researchers, are required to undertake specific

Recruitment and Selection training. HR staff are part of the selection panel for Lecturer grade and above. In line with our Public Sector Equality Duties, we have published an Equality and Diversity Action Plan that maintains the process of Equality Impact assessment for admissions policy, statements and procedures and makes accessible relevant software systems and supporting information. The University has made a further commitment (within our SFC Outcome Agreement) to enhancing equality through achieving Athena Swan Bronze Award status (by August 2015) and subsequently to progress to Silver. The resulting principles will guide development of our Equality and Diversity practices for STEM and non-STEM disciplines alike. Our recent Staff Engagement Survey (2013) found that c.90% of staff believe the University respects people equally regardless of their background (protected characteristics). The University recognises and values its cadre of researchers able to carry out excellent research with impact. Thus appointments to lectureship are required to have a minimum PhD or equivalent professional experience, and staff previously on repeated short-term contracts have been offered permanent positions. The University has also appointed new tranches of Chairs, Readers and Senior Lecturers within the review period (3 for UoA5). All promotions are based on research contribution, thus demonstrating the University's policy of rewarding key research staff. To support R-LINCS the University is increasing its research-academic staffing by 35 (c.20%) in 2013-2014.

The University's staff appraisal and workload planning system allows alignment of an individual's responsibilities and personal research objectives with the University Strategic Plan and is important for enhancing RKE–teaching links. The Enhancement-Led Institutional Review (ELIR) report (2012) from the QAA noted that the University's policy of workload planning allows staff to balance time allocated to teaching, research, administration and external commitments (e.g. early career researchers are allocated additional opportunities to develop their research). Career development, training opportunities and needs are discussed with individual staff members at 6 monthly appraisal meetings. An enhanced training package to support researchers to be adaptable and flexible in an increasingly diverse and global research community, has been developed and supported through a dedicated University Researcher Training fund for staff and research students (£10K p.a.) and by discipline (School) specific Professional Development funding (approx. £16K p.a. for UoA5). General researcher training provision has included annual workshops and retreats focussed on grant writing, statistical methods, European Framework funding and KTPs. Given our small size we make best use of regional and national development and training opportunities, e.g. courses provided by the University of Dundee, VITAE and Leadership Foundation, targeting both experienced managers and early career researchers trying to develop a research team. Our membership of the inter-University Scottish Research Pools (SAGES, SICSA and SIPR) also supports researcher development and provides opportunities to share research expertise (both among staff and PhD students) and new discoveries across traditional discipline boundaries, and access to development programmes. Communication with and between the Abertay Research Community (staff and students) is aided via a social media tool to encourage discussion, awareness and to promote inter-disciplinarity.

The Unit's staffing strategy has been developed to retain our recognized position as leaders in inter-disciplinary, systems modelling and interactive visualization research (SIMBIOS and WhiteSpace), and to enable growth and add value in new areas explicitly **Cancer Systems Biology** and **Food & Drink Bioscience**. To deliver this agenda we have adopted a differentiated staffing approach to complement and augment the existing staff expertise profile. In the reporting period, the University were able to retain and promote their established staff (1 awarded Chair, 1 awarded Reader, 2 PG students progressed to Lectureships) whilst recruiting 6 new staff from leading national universities (including Cambridge, Edinburgh, Glasgow, St Andrews) and internationally (Malaysia), with strong research backgrounds in applied mathematics, modelling, visualization and food and nutrition biochemistry. An EPSRC supported Daphne Jackson Fellowship was used to recruit 1 new part-time PD researcher post career break; she has now been appointed as teaching fellow. The unit have a further 3 new posts allocated for 2014 recruitment (2 food security and 1 big data /mathematical modelling). Early career staff, research active and research leading staff are given reduced teaching commitments to assist new staff to build a research career and to attract strong researchers. Early career staff are mentored by senior researchers to grow their publication record and esteem. New researchers have benefited from early career investment opportunities through SICSA which fosters cooperation by providing mutual support, sharing facilities and expertise (e.g. attended workshops and training events (e.g.

"Biology+Computing=??") and have hosted conferences and workshops with SICSA support (e.g. UK-wide workshop on systems medicine). All staff are immersed in an active RKE-teaching environment in open plan office (including social) spaces designed to promote interaction and to maximise mentoring of early career staff. We typically support staff to present work to at least one national or international conference a year, support staff to undertake research visits and have brought leading researchers to the Unit. Our strategy is to appoint excellent research and experienced industry staff with particular discipline expertise to augment existing capacity, to grow research strength through supporting established researchers and to nurture the research esteem of early career staff. The new pan-University Graduate School will support this drive further (see cii below).

ii. Research students

During the assessment period 9 PhD students graduated in the field of Biological Sciences from the University. ELIR (2012) reported that the University's postgraduate research students (currently 94 across the University) were positive about what they described as a friendly, supportive and integrated academic community. This reflects the efficiency of our approach which combines a University-wide strategy with the integration of our students in the Unit's research environment. As a compact University, much of the support provided is offered to both research staff and students alike (see ci), thereby promoting integration, mentoring and a vibrant research culture. Nevertheless in order to support the long-term vitality of the University research culture we have developed ambitious plans and investment in a pan-University Graduate School as part of the new R-LINCS RKE strategy to grow our postgraduate research. We are committed to providing 18 fully funded PhD (or MRes/MPhil equivalent) studentships over the next 3 years (3.5 years RCUK stipend plus expenses). All PG students and research staff will have access to the University Graduate School which will provide a comprehensive training programme within a central physical location with flexible working spaces, open to the entire research community to promote integration and inculcation of an inter-disciplinary ethos. Research students will be guided and supported to make best use of a range of opportunities to enhance their employability skills, including skills training, opportunities to teach and deliver outreach activity.

Our University Research Degree programmes are flexible to cater for a diversity of students. We have introduced (2011) a Masters by Research, which can be transferred towards MPhil or PhD and in 2013 introduced an MProf in Food & Drink Innovation (advanced level programme bridging research and professional practice). The University encourages staff to undertake part-time PhDs where appropriate e.g. staff with industry/ professional backgrounds (2 in U0A5), and to support this we have introduced a PhD by publication route. As an industry-facing university we encourage industry experts to contribute to, research supervision (as Advisors), and industrial sponsorship of studentships (e.g. Lallemand Inc.; SFC Interface Food & Drink/ Macphies; Greek Wine Industry; Institute of Brewing & Distilling). One such sponsored studentship led to a KTP with Diageo for the same individual.

The postgraduate research student community is overseen by the University Research Degrees Sub-Committee (RDS) which approves student admissions, examination teams, ensures that appropriate research support is in place, that at least 2 trained supervisors are allocated, offers training (for staff and students), and an annual Post-graduate conference. Progress is monitored through 6 monthly reports on progress and thesis planning. The RDS also monitors implementation of Personal Development Planning, recorded as an evidence-based training record which is assessed by the RDS prior to submitting the thesis to ensure appropriate engagement. The Roberts Fund is used to support PGR development including conference attendance. Another indication of our inclusive approach to student recruitment is our success in drawing research students from many countries. UoA5 has benefitted from 2 SORSAS (Scottish Overseas Research Students Award Scheme) studentships to attract the highest quality international postgraduate research students to UK and the TETFund (Nigerian Tertiary Education Trust Fund). We have also hosted visiting research students from other HEIs. PGR students were embedded in an inter-disciplinary research environment working alongside supervisors in open plan office spaces and with leading researchers with wide ranging expertise. Students participated in a weekly School seminar series, were required to present at least biannually, encouraged to engage with fortnightly group discussions dealing with topics ranging from funding, KE activities and technical difficulties faced during their research. Students had opportunity to enrol in the SICSA Graduate school offering high level graduate training in Scottish Universities and to participate in an annual PhD

student conference.

d. Income, infrastructure and facilities

Abertay research resources are all based on one site, which encourages regular contact between researchers from different disciplines and thereby helps foster multi-disciplinary groups and inter-disciplinary research (general infrastructure investment c.£15.5M over the reporting period). We have further encouraged this through a move to open plan and shared facilities, with staff in different Unit groups co-located (e.g. many UoA5 with UoA15 and UoA7 researchers). Our laboratory facilities are discipline based, shared by all but overseen by discipline experts and serviced by University technical support. This strategy helps ensure our facilities are used to maximum effect. Existing facilities have been maintained and upgraded (>£100K) for molecular and cell biology, tissue culture, fluorescence and luminescence, ultrasound instrumentation and imaging (fluorescent, Atomic Force Microscopy and PAM). We have secured access to Dundee University imaging facilities and ISIS (Harwell Science and Innovation) Beamtime (worth >£70K). We have invested £19K in specialist FIA labs (inc. sensory analysis, modified atmosphere and rheology) and have upgraded our environmental microbiology labs. UoA5 staff have benefitted from shared facilities and University support for SAGES (£225K) and SICSA (c.£500K (e.g. HIVE)). Our HIVE (Human Immersive Virtual Environment) facility (a large (6mx2m) 3D back-projection facility with motion tracking and 3D sound system for immersive visualisations) is used by UoA5 and UoA15 researchers. A dedicated usability engineering lab houses a state-of-the-art eye tracker. Unit staff have also used our world leading X-ray CT and visualization suite which houses 2 X-ray CT machines with integrated powerful computing facilities (c.1TB data/month) supported by SIMBIOS (>£200K growth and maintenance investment; UoA7).

The University's Estate Strategy is committed to supporting high quality research through our infrastructure, with a design philosophy that ensures new spaces are built to promote RKE-T links. Our focus in the forthcoming period is to develop new laboratory and engineering facilities for the School of Science, Engineering and Technology (where UoA5 primarily sits) together with a dedicated Graduate School in order to accommodate increasing numbers of students undertaking research degrees and to further inculcate inter-disciplinary working in our next generation of researchers (estimated at approx. £14.1M / 2700m^2). Abertay is transforming its ICT environment to support our RKE-T activities including better integration of IT systems and data storage across the University (£2.8M).

UoA5 income (£319k p.a. on average) from a diversified portfolio RCUK, EU, TSB KTP (4 KTPs in total for UoA5), direct industry funding for research/ KT and charities, has allowed steady growth. Strategic relationships with a range of funders (e.g. Royal Society of Edinburgh, Innovation Portal, Northwood Trust, Cyclacel Pharmaceuticals Inc. and Norton Scientific Inc.) has created a virtuous-circle where our research is informed by end-user engagement and can therefore be developed to better suit need. SFC Knowledge Transfer Grant >£1.5M was used to support Research Enterprise and Innovation Services (REIS) IP facility, industry engagement and outreach events, and specific KT equipment resourcing. In addition, we have received donations in the form of equipment and reagents from a local biopharmaceutical company (Cyclacel). Building on the esteem and funding track record established through engagement with end users (e.g. FIA industry track record >£268K has recently led to two CASE studentships c.£150K), we aim to grow research income from RCUK and EU funding bodies. Through our R-LINCS strategy, we will promote cross-fertilisation among REF units in order to give us both a critical mass of researchers and an agility to combine and develop core competencies in disciplines through inter-disciplinary working.

The University promotes data sharing and open access publication where possible through support from a ring-fenced open access publication fund (£10Kp.a.) if other funding sources are not available, and a publicly available Research Repository for all staff publications (bar copyright). Staff research profiles are updated as an on-going practice for all research active staff. In terms of governance, applications for external research funding are reviewed by an ethics committee and for their contribution to full economic costs, with bids where the level of overhead recovery is low requiring a case to be submitted by the Head of School to the Vice-Principal (Academic) advocating its strategic importance to the University. The University's REIS office provides advice and support on research related matters, including costing and applications for external funding; management of the research degree students' process from their initial contact with the University to graduation; and management of IPR and contractual obligations with funders. Bringing these

services together ensures that a consistent approach is taken across the University in relation to management of research projects and improves efficiency by providing a single point of contact for all research related matters.

e. Collaboration and contribution to the discipline or research base

Research collaborations are an important part of the Unit research strategy allowing us to deepen, combine and develop our core discipline competencies through inter-disciplinary working and add value to the research and knowledge base. Staff are actively encouraged (time and funding) and supported to develop these collaborations and networks. We have collaborated and produced joint research papers with more than 35 national and international institutions: e.g. Harvard Medical School, University of Edinburgh, A* STAR Singapore, Medical University Sofia, University of Dundee, The Roslin Institute and Royal School of Veterinary Studies, St James's University Hospital Leeds, Howard Hughes Medical Institute, Novartis Institutes for Biomedical Research and Dana-Farber Cancer Institute, University of St Andrews, Aberdeen University, Cardiff University, St Mary's University College London, James Hutton Institute, University of York.

Unit researchers have strong industry links as evidenced by our roles on advisory groups e.g. the Cross-Party Group in the Scottish Parliament on Renewable Energy and Energy Efficiency and the Executive Board of Advisers for the World Congress on 'Symbiosis: the Art of Living'. We have been invited to present to global companies (eg. Siebel Institute, Chicago; Anchor Yeast, Cape Town; Fermentec, Brazil; Lallemand, Canada). Researchers act as scientific advisor to the BBSRC's LACE programme, scientific director for industrial training programmes (e.g. Ethanol Technology Institute), we are an associated partner in the new Scottish Innovation Centre for Industrial Biotechnology (£21M), have national research collaborations (e.g. AHRC Design in Action (6 partners) industry/ practitioner facing research hubs), are the academic hub for Scotland Food & Drink Skills Academy, a lead partner University in Interface Food & Drink (driving KE in the Food & Drink sector in Scotland), through FIA have supported >140 Scottish Food & Drink SMEs to innovate and delivered projects for public bodies such as Food Standards Agency Scotland.

Unit cancer biologists have developed strong links with the biotechnology and biopharmaceutical industry e.g. directorships for BioteXel Consulting, LinkCore Pharma Ltd, Biotech Scotland Ltd, scientific advisory board of Pro2Kem Ltd, Scientific Technological Service Ltd and Norton Scientific Inc. Scottish Innovation Portal funding supported a joint project with Cyclacel Pharmaceuticals Inc. on development of novel drugs against cancer and heart hypertrophy and we worked with Norton Scientific Inc on the development of novel advanced protein aggregation instrument (launched 2011). We have chaired/organised major conferences and workshops (e.g. SICSA Systems Medicine), and have been invited plenary speakers (e.g. European Biotechnology Thematic Network Association). Researchers are active BioDundee partners (e.g. chaired the Integrating Life Sciences and Digital Media cross-over event).

We consider editorial positions and reviewing as important contribution to research. UoA5 researchers have peer-reviewed for national and international grant committees (e.g. Medical Research Council (MRC), Bulgarian National Science Fund, Engineering & Physical Sciences Research Council (EPSRC), The Department of Health, Policy Research Programme for 'Research on resistance to antibiotics and other antimicrobial agents', the National Centre for the Replacement, Refinement and Reduction of Animals in Research; UK India Education and Research Initiative (UKIERI) Phase 2 in Innovation Partnership, External Assessor for the Pharmaceutical Microbiology PIAT programme (University of Manchester). Unit members hold 19 positions on editorial boards of international journals (e.g. Technology in Cancer Research and Treatment, Biotechnology & Biotechnological Equipment, Medicine and Sport, Zone4science, Journal of Molecular Engineering and Systems Biology and BioDiscovery, Journal of Bioanalysis & Biomedicine; Frontiers of Systems Physiology and Frontiers of Systems Biology; Journal of Biological Informatics & Biodiversity, BioDiscovery, Letters in Applied Microbiology, Journal of Applied Microbiology, The Biologist, Letters in Applied Microbiology, and Journal of Applied Microbiology, Journal of Forensic Toxicology & Pharmacology and International Journal of Molecular Science and Ionic Liquids).

Unit researchers have, been made Fellows of the Institute of Biology, the Society of Biology, the Bulgarian National Academy of Medicine, the Royal Society for the encouragement of Arts, Manufactures & Commerce, the Linnean Society of London, Honorary Professors (8), received awards (e.g. Archer Daniels Midland Award, American Oil Chemists' Society, USA), and are a member of the Accreditation Assessment Panel for the Society of Biology.