**Institution: University of Aberdeen**

**Unit of Assessment: 5 - Biological Sciences**

## a. Overview

Biological research has significant international strength and visibility at the University of Aberdeen and is a priority topic for investment. It has built upon past success and has world-leading, focused research programmes with strong translational activity. This submission brings together biologists from three Institutes within the College of Life Sciences and Medicine (CLSM) that focus on organismal biology (Institute of Biological and Environmental Sciences - IBES), medical sciences (Institute of Medical Sciences - IMS) and nutrition (Rowett Institute of Nutrition and Health - RINH). Each Institute has an independent research agenda and objectives but there are also considerable synergies and cross-Institute collaborations, promoted through the sharing of facilities, seminar series, and monthly meetings of research directors to discuss research strategy, direction and integration.

The IBES has a research portfolio that covers pure and applied research, with a broad cross-cutting theme of understanding the biological consequences of environmental change. Activity spans scales of analysis from single molecules to complex terrestrial, marine and aquatic ecosystems, and encompasses both theoretical and empirical approaches. Activity is structured into three major research programmes: i) *Ecology and Evolution*; ii) *Integrative Environmental Physiology* and iii) *Biological Interactions in Soil*. The first two of these programmes comprise the IBES submission to this UoA. Most IBES staff are housed in adjacent buildings within the King's College campus of the University, the remainder being located permanently at two strategically located field stations – the Oceanlab complex in Newburgh, which is a purpose-built research facility established to enable marine science from coastal to hadal environments; and the Cromarty Lighthouse field station, a dedicated facility for marine top predator research.

The IMS is an integrative centre for research into human body function in both health and disease. The IMS underwent a £12m expansion in 2002 and now houses over 400 active researchers. It is situated on the Foresterhill Health Campus, which includes the regional acute, maternity and children's hospitals and the medical school, the entire complex making up one of the largest single-site medical centres in Europe. The IMS blends basic, preclinical and clinical research to encourage dialogue and interdisciplinary interactions, and this submission encompasses basic to preclinical research. Research activity is coordinated so that researchers are intensely interactive, with basic and preclinical scientists and clinicians working together in six strategic research programmes: i) *Microbiology*; ii) *Cell, Developmental and Cancer Biology*; iii) *Translational Neuroscience*; iv) *Musculoskeletal*; v) *Cardiovascular* and vi) *Immunity, Infection and Inflammation*. The first three of these programmes are included in this UoA. However, all six function in an integrated fashion, as evidenced by many joint outputs between programme members.

The RINH, one of the UK's leading institutions for basic and applied nutrition research, has made major contributions to the understanding of nutrition and its relationship with health through its 100 year history. RINH merged with the University of Aberdeen in 2008 to provide a broader base of expertise and facilities to engage in nutrition research and to foster collaboration. This will be further enhanced by the relocation of RINH to the Foresterhill Health Campus in summer 2015 in a bespoke new building adjacent and linked to the IMS. RINH has three research programmes that each address major societal challenges in nutrition: i) *Obesity and Metabolic Health*; ii) *Gut Health* and iii) *Lifelong Health*. RINH staff contribute to the Scottish Government's Rural and Environmental Science and Analytical Services Division (RESAS)'s strategic research programme on *Food, Land and People,* which is aligned with the UK Global Food Security Programme, especially in Theme 7 *Healthy Safe Diets*.

Individual research programmes within the Institutes consist of a cohesive group of typically 15-25 PIs and associated post-docs and PhD students, managed by a lead and deputy, who meet frequently to brainstorm ideas and methods, horizon-scan and develop future strategy. The programmes have a budget for research pump-priming, travel, hosting workshops and purchase of smaller items of equipment which can be augmented from other sources (see below).

**b. Research strategy**

The underlying principles of our strategic plan are to continually improve our research environment to nurture research excellence that enhances our international profile, and to ensure our research addresses issues of societal relevance and importance. Research strategy at the University is overseen by two Vice-Principals and our Research Directors. Five year targets are outlined in the University strategic plan, and progress towards them reported annually to the University Court. The University's commitment to supporting high quality research in Biological and Biomedical Sciences is exemplified by the major investment since RAE2008 in high quality infrastructure, central support for research and investment in staff (via new positions, promotions, mentoring), as detailed below.

Our research programmes dovetail with four pan-University multidisciplinary research themes that address major global challenges of fundamental societal concern, and where Aberdeen is, or aims to be, a world leader or global partner of choice. The four themes cut across the traditional University structure of Colleges, Schools and Institutes, and are: *Environment and Food Security*, *Pathways to a Healthy Life*, *Energy* and *The North* (www.abdn.ac.uk/research). Focus in the first two areas is a consequence of our strengths in Biological Sciences, and the future investment earmarked for these areas highlight University commitment to further enhance activity and profile.

Within CLSM research strategy and direction is overseen by the College Research Committee, consisting of the College Research Director, Head of College, Institute Research Directors, and Heads of School. The College Research Committee is a crucial conduit for inputting into the institutional research vision, for information flow and target setting to individual Institutes/research programmes. Each Institute has its own research director who heads a management team composed of programme leads, relevant Heads of School and representation from senior, junior and postdoctoral staff, and a member of the Research and Innovation team. Each management group meets monthly for information exchange, horizon scanning activities and identification of research opportunities.

Each of the three Institutes has a strategic plan developed by the research directors that identifies future research priorities within their respective areas and targets each objective via existing researchers, new recruits and new cutting edge research tools to achieve goals within the associated operating plan. The operating plan defines mechanisms ensuring achievement of research goals within the research priorities, enabling researchers at all levels to secure research funding from a broad base of funding bodies, ensuring that research is undertaken in accordance with the University's research governance framework and facilitating effective communication of research findings to a range of audiences to maximise impact.

The operating plan is supported by dedicated central support for: 1) application development (Research Financial Services), 2) research contracts and technology transfer (Research and Innovation), and 3) recruitment to academic and research positions, staffing strategy and staff development (Human Resources). Under this structure research activity is coordinated from postgraduate level upwards, from research grant application through execution and dissemination of research outputs. Individual programme leads are responsible for driving and stimulating research in their areas. They organise specific events, including symposia and journal clubs, and seminar series, inviting internationally renowned scientists to Aberdeen to meet with researchers. Also organized each year are cross-Programme meetings, some as off-site retreats, for Institute PIs to discuss research and promote cross-disciplinary approaches.

Thus the three Institutes share a fully integrated research vision and strategy, with considerable cross-talk and collaboration in key areas, such as systems biology and 'omics technology, and they share training and mentoring activities to provide an integrated stimulating environment for biological research. Examples of the success achieved by this strategy for nurturing world class research are given below. The key areas of international strength will continue to be a focus for future investment.

(i) ***Microbiology Programme (IMS)***

The **Aberdeen Fungal group** (AFG), comprising staff returned here and fungal immunologists and a recently appointed clinical mycologist returned in UoA1, holds more than £18m in research funding. The group is one of the largest academic centres for medical mycology in the world with the objective to understand and treat fungal infections. Their study of the fungal cell wall has led to

a series of outstanding publications related to its potential as an immunological agonist and pharmaceutical drug target (**Gow, Brown-A** and **Munro**). Application of integrated genomics/proteomics, molecular and cellular biology and systems biology has helped determine how fungal pathogens undergo cell division (**Lenardon**) and adapt to stress during infection (**Brown**), and how *in-vivo* virulence is determined (**MacCallum)**. The mechanism by which fungal hyphae elongate and navigate has been successfully elucidated by **Brand** and **Gow**. A targeted translational approach is leading to the development of novel diagnostics and therapeutics for fungal diseases. **Gow, Brown-A** and Brown-G (UoA1) spearhead a £5m Wellcome Trust Strategic Award (from 2012) that coordinates pan-UK activity in medical mycology and fungal immunology though interdisciplinary research and the building of national and international capacity and discipline-specific training. The Programme also has major strength in research on the physiology of bacterial pathogens with the aim to develop novel routes to block infection. **Miller** leads a Wellcome Programme grant award and is part of a team making outstanding discoveries on the protein topology of bacterial ion channels and the relationship to bacterial homeostasis. A new appointment, **Carabeo**, is a young scientist already with a significant reputation in the field of chlamydial cell biology and the precise mechanisms of chlamydia attachment and invasion of host. **Lorenz** has an international reputation in molecular processes regulating recombination in meiosis. **Van West** has a major presence in the field of oomycete biology and has one of the largest laboratories in the world studying animal pathogenic oomycetes. He has pioneered the genomics of several species as well as the analysis of effector protein translocation during oomycete-host interactions, as with Saprolegnia in salmon in collaboration with **Secombes**.

A major focus is in the **systems biology** of microorganisms targeted towards a holistic approach to understanding complex interactions within complex dynamical biological systems, leveraged through mathematical and quantitative modelling, simulation and control theory. Our microbiology programme has used systems biology approaches to make major advances over the assessment period including the formation of the Combinatorial Responses in Stress Pathway (CRISP) multicentre group, centred in Aberdeen and funded by a BBSRC SABR grant. This employs integrative systems biology to determine how pathogenic fungi respond to the combination of varied stressors when invading a human host (**Brown, Gow**). **Ebenhoeh** has used, for the first time, statistical thermodynamics to study biochemical problems in cells. **Stansfield** has provided the first determination of mRNA-specific translation initiation rates across the whole yeast transcriptome, derived from simulating ribosome flux across all 6,000 yeast mRNAs and in the regulation of polyamine metabolism. Over a dozen investigators in the IMS and IBES are collaborating on systems biology projects. Their success is evident in 44 published papers, with several published in the leading systems biology journals (eg Plos Computational Biology and Bioinformatics). Key to the success of this research has been the interactions between biologists and the mathematicians and physicists of the University's Institute for Complex Systems and Mathematical Biology (ICSMB - http://www.abdn.ac.uk/icsmb/), which has grown by 11 staff since 2008.

(ii) ***Cell, Developmental and Cancer Biology and Translational Neuroscience programmes (IMS)***

These two integrated IMS programmes are directed towards the goals of analysis of cell signalling pathways to determine the molecular basis of human disease. In **Developmental Biology** this includes the involvement of a variety of genes linked to Down's syndrome, control of blood vessel development (**Erskine**) or adhesion (**Pettitt**) and the setup of patterned connectivity of the brain, as well as nerve regeneration and the influence of electric fields on cellular migration (**McCaig**). Discoveries have been made in the signalling pathways that underlie the mechanism of action of teratogens from thalidomide (**Vargesson**) to retinoic acid (**McCaffery**). In **Cancer** several fundamental discoveries have been made in the control of DNA replication in yeast (**Donaldson**) while expertise in androgen receptor function has led to development of a new approach to treat prostate cancer (**McEwan**). **Neuroscience** research in cell signalling pathways has linked growth factors such as TGF-β to neuromuscular disease (**Bewick**) while a series of fundamental discoveries have been made in the genetics of schizophrenia (**St Clair**). The latter studies have led to development of one of the best animal models of schizophrenia in the form of the truncated DISC1 transgenic mouse. Important strides have been made in the fundamental action of cannabinoids and endocannabinoids (**Pertwee, Greig**) while vital steps are being made in

research into Parkinson's disease (**Teismann**), Alzheimer's disease (**Reidel**, **Platt**) and depression (**MacKenzie**).

(iii) ***Ecology and Evolution Programme (IBES)***

Our **Population Biology group** is one of the largest concentrations of internationally recognised ecologists globally, with expertise ranging from studies of individual organisms, to populations, communities and global processes. Key areas of research are on factors affecting species demography, trophic interactions, population dynamics, dispersal, and disease dynamics in relation to ecological process. Research highlights include: the dispersal dynamics of mink invasion and apparent competition on prey species (**Lambin**), factors affecting disease dynamics in natural populations (**Telfer**), modelling dispersal and life history evolution during range expansion (**Travis**), causes and consequences of inbreeding and extra-pair mating in bird populations (**Reid**).

The world-leading **Deep-ocean Biology group** based at the dedicated *Oceanlab* complex specialises in experimental marine ecology from intertidal to hadal depths. Researchers have specialised expertise in the use of *in situ* autonomous instrumentation packages capable of time-series measurements, imaging, sampling and pulse input of nutrients or tracers. Recent achievements include: first descriptions of carbon dynamics in deep ocean sediments (**Mayor**, **Witte**), effects of deep-sea topology on biodiversity and abundance (**Priede**) and the characterisation of hadal trench communities (**Jamieson**).

Aberdeen has developed novel and emerging technologies in **molecular ecology and evolutionary genomics** to further advance an understanding of fundamental issues in ecology and evolution. A major focus has been on understanding the evolutionary causes and the ecological consequences of varying levels of neutral and adaptive genetic diversity in non-model species. Highlights include: effects of major histocompatibility complex variation on individual fitness (**Piertney**), impact of whole genome duplication on fish speciation and evolution (**MacQueen**), transcriptomic effects of starvation (**Martin**), phylogeographic inference of commensalism between mice and Vikings (**Jones**), molecular mechanisms for photoperiodic responses in mammals (**Hazlerigg**) and transcriptomic effects on population dynamics (**Piertney**).

(iv) ***Integrative Environmental Physiology Programme (IBES)***

Our **Fish Immunology and Applied Fish Health** research, centred on the Scottish Fish Immunology Research Centre (www.abdn.ac.uk/sfirc), is one of the strongest in Europe. Its major research goals are to understand the function of the fish immune system and to shed light on the evolution of immune systems in vertebrates. Much of this research feeds into improvements in fish health in aquaculture. The group has notable long-term collaborations with the CAS Institute of Hydrobiology in Wuhan, China. Research in the assessment period has characterised anti-viral sensing in fish (**Zou**), the salmonid interferon system (**Secombes**, **Zou**), the role of cytokines involved in adaptive immunity (**Secombes**, **Wang**), and the evolution of antibody-mediated immunity (**Dooley**).

Our **Energy Regulation group** investigates energy regulation in the context of obesity and ageing. All researchers are members of the Aberdeen Centre for Energy Regulation and Obesity (ACERO) comprising 35 research groups from relevant research Institutes in Aberdeen, creating one of the strongest obesity research centres in Europe, and exemplifying how we exploit commonality and complementarity to maximise activity and output in a major programme that cuts across our institutes. Key research areas are in examining relationships between genetic polymorphism, energy intake and expenditure, and obesity (**Speakman**) and metabolic and behavioural responses to high fat feeding in mouse models (**Vaanholt**).

(v) ***Obesity and Metabolic Health Programme (RINH)***

The **Ingestive Behaviour group** brings together investigators from the RINH, submitted to both UoA5 and UoA1, whose research activities provide an integrated approach to understanding the mechanism of satiety. For example, impact of food structure on neural mechanisms of satiety (**Barrett**), nutrient sensing at the level of the gut (**Barrett**), the effect of macronutrient composition on satiety (**Adam**, **Morgan**) brings together research which provides fundamental information on the interaction between macronutrient components of food, gut hormone responses and signalling of satiety to the brain. The work informs human intervention studies that generate evidence for the food industry and government on possible solutions to over-consumption of food in industrialised

nations through food reformulation and policy-interventions. This is evidenced by impact case studies submitted in UoA1. The Ingestive Behaviour Group have close synergies with the **Metabolic Health group**, a group that combines basic research with human intervention studies to provide an integrated approach to understanding nutritional influences across the life course. Investigators from this group, submitted mostly in UoA1, reflect the translational research of the Obesity and Metabolic Health Programme.

(vi) ***Gut Health Programme (RINH)***
The **Gut Microbiology group** brings together expertise in nutritional chemistry, anaerobic microbiology, molecular ecology and immunology, to study the dietary impacts of the interaction of bacteria with the gut and gut physiology (submissions in both UoA5 and UoA1). The group have made major contributions to our understanding of the role of gut bacteria in relation to diet and health, with the first demonstration of changes in gut bacteria with diet and major inter-individual variation in gut bacterial populations, identification of key bacteria in the degradation of resistant starch in the human colon and contribution to a recent study "Bacteriotherapy approach to combating the contagious chronic intestinal disease caused by *Clostridium difficile*" (**Flint**). Work encompassing immunological interactions between bacteria and the gut has recently led to a multi-million pound investment into a spin-out company (**GT Biologics**) for the development of novel drug compounds from gut bacteria, for therapies targeting inflammation induced conditions such as inflammatory bowel disease, Crohn's disease and ulcerative colitis. This group also discovered that the addition of yeast to ruminant feed resulted in protection of anaerobic gut microorganisms from oxygen toxicity and led to significant improvements in the health and productivity of cattle. This discovery has led to yeast being routinely used as a feed additive by global commercial suppliers of ruminant nutritional feed compounds (**Wallace**). The move of RINH to the Foresterhill Health Campus will foster further integration and synergies within our microbiology programmes.

(vii) ***Lifelong Health Programme (RINH)***
RINH has a sustained worldwide reputation for excellence in the micronutrient research field, with key contributions from successive trace mineral and vitamin research programmes. Current activity of the **Micronutrients team** focuses on how zinc, selenium, folate, and vitamin B influence the development of atherosclerosis and how dietary iron and copper absorption, metabolism and placental transfer can influence foetal development and programming, with life-changing consequences (**McArdle**).

Clear goals are set for short-, medium- and long-term research priorities by each of the submitted Institutes. In the short-term we have continued plans for recruiting into successful research groups. For example, the Microbiology Programme and Aberdeen Fungal Group have enjoyed major research funding successes and will continue to expand their research portfolio with new appointments, with an emphasis on translational research and Early Career Researcher (ECR) development. Systems Biology will also be further expanded with recruiting targeted to expertise in systems biological approaches to cell or developmental biology to further develop links with the *Cell, Developmental and Cancer Biology Programme*. Growth in this programme will also be directed towards energy metabolism and obesity and new RINH recruits (eg **Heisler**) will be housed in the IMS during construction of the new RINH building (adjacent to the IMS), helping to build this cross-institutional research area. Recruitment in neuroscience is active in combination with the strong team in developmental biology, with a recently made appointment in spinal research and translational neuroscience (**Huang**). An additional appointment has been made to add further expertise in electrophysiology (**Zhang**). Within IBES, there will be continued investment in population biology, deep sea biology and integrative physiology as areas of research strength where we have an international profile. We are aware that in some key research areas, leading members of staff are within 5 years of retirement, and have in place succession planning with targeted recruitments to ensure there is no loss in strategic priorities or research quality.

The advances that can be made through the utilisation of 'omics' technologies means we will continue to invest in both infrastructure and bioinformatics support as well as leading researchers in this area. Our strategy is to identify and then invest in emerging areas, where omics technology will prove pivotal for success, especially when crossing between our areas of disciplinary strength to deliver integrated approaches to generate new principles and perspectives leading to broad new

syntheses. Examples include areas such as genome enabled eco-physiology, ecological immunogenomics and deep ocean biodiscovery facilitated through the newly established *Centre of Genome Enabled Biology and Medicine* (see section d). One element essential for medium term research is the relocation of the RINH to the Foresterhill Health Campus. Collaborative research between IMS and RINH has been promoted over the past five years, and this has effectively brought together researchers in all IMS programmes into the study of food, nutrition and obesity, high priority areas for the UK.

Increased national and international collaboration is a goal to promote future growth long-term. Our involvement in pooling initiatives (see section e) provides a route to collaboration with other Scottish universities via the Scottish Universities Life Sciences Alliance (SULSA) and the Marine Alliance for Science & Technology Scotland (MASTS). The former has greatly increased funding for drug discovery, amongst other things, which we plan to exploit via the *Kosterlitz Centre for Therapeutics* (see section d), that was set up to encourage and facilitate translation of discoveries into disease therapeutics and diagnostics. In addition, research through mechanisms such as the Scottish Food and Health Innovation Service, Interface Food and Drink, and a proposed Aquaculture Innovation Centre for Scotland will provide relevant research and interactions industry.

**c. People**

***i. Staffing strategy and staff development***

The University promotes a staffing policy that focuses on making appointments at the highest levels of academic excellence and developing careers through mentoring and in house continuous professional development (CPD). All recently appointed staff in this UoA have been selected and promoted on this basis, and over the REF period 18 staff in this unit of assessment were promoted to Professor, 13 to Reader and 10 to SL. We have recruited to areas of recognised research strength and/or areas where we wish to build capacity. For example, in our *Microbiology Programme* we appointed **Carabeo** from Imperial College to study the cell biology of *Chlamydia* pathogenesis, including signalling pathways involved and the importance of iron metabolism, **Spano** from Yale University to investigate the mechanism of infection of *Salmonella typhi*, **Lorenz** from Oxford as an expert in fission yeast meiosis, and **Ebenhoeh** to strengthen further systems biology. **Brown** (G) was recruited to strengthen fungal immunology (UoA1) and the AFG has been further strengthened by a senior clinical mycologist (**Warris**, UoA1). **Hislop** was recruited in the *Translational Neuroscience* programme to study the action of ubiquitination in endocytic trafficking and its role in G-protein-coupled receptors. Similarly **Huang** was recruited to develop in-vivo models of spinal cord repair. Within the *Cell, Developmental and Cancer Biology Programme* **Murray** was recruited to further strengthen pharmacology and study of G-protein coupled receptors and cAMP signalling, **Sekido** has joined to study the molecular actions of genes that set up sex determination in mammalian embryos, while **Baldassarre** from Yale University was recruited to study the role of cytoskeletal proteins, such as filamin, in cell function. **Zanda** was also appointed to this programme as Chair in Medical Technologies, funded by the Scottish Northern Research Partnership (an affiliation of UoA, University of Dundee and Robert Gordon University), to accelerate growth in PET ligand design, and assist in advancement of drug development. Several new appointments within this and other complementary UoAs are currently underway in health economics, health psychology and social science, to add to our portfolio work that will add value and complement research in the RINH *Obesity and Metabolic Health Programme*. We are also strengthening our research in this programme through two appointments in human nutrition (**Heisler**) and genetics/epigenetics and nutrition (**Rochford,** UoA1) together with an electrophysiologist (**Zhang**). In the *Ecology and Evolution Programme* we have recruited **Kuepper** to a Chair in Marine Biodiversity, **Fernandes** in marine fisheries management, **Lusseau** in marine top predator ecology, **Jamieson** in hadal ecology, **Martin** in population ecology, and **Lancaster** in evolutionary ecology. In the *Integrative Environmental Physiology Programme* we have appointed, **Dooley** and **MacQueen** into fish immunology and fish genomics, **Bize** in ecophysiology and **Stephenson** in chronobiology and epigenetics. Given our increasing requirement for biostatistics and bioinformatics support we have appointed **Douglas** as Biological Sciences statistics team leader and **Cornulier** to our statistics team.

Our postdoctoral mentorship programme has assisted successful fellowships for **Brand, Leach** and **Lenardon** (fungal pathogen biology), and helped **Munro** and **van West** to develop their research in studying fundamental fungal and oomycete biology and its translation to therapies for

fungal disease. **Wilson** will move from Jena, Germany to join the Aberdeen Fungal Group, as a new Sir Henry Dale Wellcome Trust fellow in 2014. We have also guided **Mayor** (benthic and pelagic marine ecosystems), **Telfer** (ecological epidemiology and disease risk) and **Martin** (evolutionary ecology) from senior independent fellowships (with NERC, Wellcome Trust and Marie Curie, respectively) through to established lectureships.

In parallel we have appointed a number of full-time and part-time teaching fellows to strategic areas. These positions, which are not themselves intended for research-active staff, enhance our research activity by freeing time to enable mid-career researchers to maximise research application, output and impact. Furthermore, these staff all have research expertise and contribute to seminar groups and research events.

New academic staff prepare a three-year plan with an assigned mentor during their probationary period, which is reviewed annually at appraisal meetings. New appointees are given small teaching and administration loads in the first two years, to allow them to establish research groups. All new staff are given dedicated research laboratory space, and are prioritised in resource allocations and PhD studentships by the relevant Programme leads and Research Committees.

The University promotes excellence in research through supporting professional and career development of research staff, in accord with the UK wide Concordat to support the Career Development of Researchers. The University has achieved Investors in People (IiP) status across the institution, recognising and valuing the contribution of employees in accordance with the IiP standard. The ethos is commitment and support of personal, professional and career development of our researchers not only to conduct excellent research but also to excel as leaders in their chosen field. The Research Institutes fully embrace this Researcher Development Agenda ensuring policies and procedures reflect the principles of the Concordat. The University Researcher Development Unit *(*www.abdn.ac.uk/develop*)* offers a range of development opportunities for researchers, from specific staff development for PI training through to an award winning International Leadership Development Programme (http://www.abdn.ac.uk/staffnet/working-here/ildp-986.php) for potential senior managers. All researchers, regardless of stage or discipline, have the opportunity to have a mentor to support their own career development. A Framework for Academic Expectations was introduced in 2011 as an integral part of the reflective appraisal process. Staff set their own objectives and benchmark this against university-set standards, which enable them to self-assess progress. The ethos of appraisers and line managers is one of support and encouragement to help researchers perform to the best of their abilities.

The advancement of independent research fellows to core staff outlined above exemplifies our support network for ECRs. There is an established framework of mentoring postdoctoral staff (http://www.abdn.ac.uk/develop/researchers/coaching-and-mentoring-275.php), that includes a defined procedure to develop their CVs and help them produce competitive independent fellowship applications. ECRs are represented on the Institute management groups, and encouraged to take an active role in driving the research agenda and activity within our programmes. We also have an active Postdoctoral Society that provides support and encouragement to the postdoctoral community through events such as symposia showcasing postdoctoral work in the Institutes and by promoting awareness about career development and extracurricular activities such as public engagement. The society aims to create an environment for interaction and knowledge exchange within the postdoctoral population to establish a strong network. For example, our PGs recently organised a major international postgraduate meeting of 220 attendees including delegates from over half a dozen countries around Europe, Asia and South America.

The University is committed to equality for all staff and students, and the University Court oversees implementation of its Equality and Diversity Policy. The University applies this policy to all aspects of employment within the Research Institutes, including recruitment, promotion, development opportunities and disciplinary procedures. All staff have access to Equality and Diversity training providing fundamental education in the legislative framework and its practical implementation. This training is mandatory for all staff with supervisory and recruitment responsibilities. In 2011 we received membership of Athena SWAN, in recognition of good employment practice for women working in science, engineering and technology that included the CLSM Esslemont Group - a women's network that raises awareness of gender issues and provides support for activities related to gender and science for women.

### *ii. Research students*

Research students are a key component of our research portfolio, and within IBES/IMS/RINH there are currently 318 registered PhD students, making biologists the largest PhD student population in the University. This has been achieved through success in Research Council (BBSRC, NERC) Doctoral Training Grants (DTG) and Doctoral Training Partnerships (DTP), together with Industrial CASE awards, a Wellcome Trust Strategic Award and funded overseas students such as Marie Curie training awards. Our flagship schemes include membership of the BBSRC EASTBIO DTP, the most successful DTP in the UK in terms of studentships awarded. We have also obtained PhD positions from the SULSA and MASTS pooling initiatives in Scotland, and have co-funded posts with research Institutes (eg Marine Scotland Science) and industry, from internal monies, as a means to encourage joint activity. Lastly, we have had success with EC funded Marie Curie Initial Training Networks (ITN) (eg SAPRO, FINSYSB, AccliPhot, ARIADNE, NICHE, FUNGIBRAIN), that provide training opportunities throughout Europe with our partners. Good links to the commercial sector benefit many of our PhD students, who have been funded by industrial CASE awards or wholly funded by industry. Examples of Industrial CASE/CASE studentships include awards with: 1) **Pfizer** to look at shark IgNAR platform for clinical use and via BioSkape the development of single B cell fungal vaccines; 2) **Organon** to study the potential allosteric binding site of the cannabinoid receptor; 3) **Astrazeneca** to investigate the effects of galanin on food choice and 4) **Waltham** to study effects of post restriction food density on weight regain. Industry funded PhD studentships include funding from: 1) **Ewos Innovation** for studies of dietary immunostimulants for fish; 2) **Alltech** for health analysis of selenium supplemented fish diets; 3) **Novartis** and **Merck** for anti-*Saprolegnia* treatments for salmon; 4) **Biomar** for the application of nutrigenomics to develop diets to reduce lice burden in salmon; 5) **Gilead Sciences** to study fungal drug resistance and 6) **NovaBiotics** for antifungal peptides.

The CLSM Graduate School oversees all aspects of PhD student appointments, training and monitoring of progress. Candidates are selected based on strict criteria that include the academic calibre of the student, motivation and potential ability to complete a PhD programme. PhD student training is managed between the Graduate School and Institute Postgraduate (PG) Coordinators. The PG student body is represented on the Graduate School and Institute PG Committees, where they contribute to the development and implementation of the training and monitoring policies. Our development of research skills seeks to match bespoke training provision for the anticipated needs at specific stages of the programme defined by their Personal Development Plan (PDP). A package of mandatory courses are delivered in the first 3 months, beginning with an induction workshop on scientific conduct, research ethics and governance, project design and monitoring of progress. Additional mandatory courses include health and safety training, and relevant home office courses for students working with animals. Later courses cover scientific writing, data handling, statistics, presentation skills, entrepreneurship and knowledge exchange (KE). We encourage participation in KE events and, for example, our students have achieved major successes in International Genetically Engineered Machines (iGEM) and national Biotechnology YES competitions, the former as part of our commitment to the development of systems and synthetic biology. iGEM is run by MIT, Boston USA, and our students were awarded gold and silver medals in the 2009 and 2010 competitions. In the BBSRC Biotechnology YES competition our 2010 team were winners of the Scottish heat, and participated in the national final. Within the RINH, students are encouraged to participate in delivering KE within the Scottish Government Research Programme. All students have access to funding to travel to other centres for specialist training not readily available in Aberdeen.

Each research student has a minimum of two supervisors, and an advisor to whom they can turn for independent advice. Supervisors must have at least monthly recorded meetings with their students, and compulsory progress forms completed at 6 monthly intervals are reviewed by College PG Officers. A formal 9 month review of student progress is by written report, oral presentation and a viva with two members of staff (one of whom is the advisor). Students may be barred from progression, recommended for a remedial programme of work or confirmed for entry into year two. In year 2 students submit a written report in the form of a draft manuscript and present a poster at an internal “Research Day”. In year 3 students give a longer oral presentation at an annual postgraduate symposium run within each Institute. At 27 months students submit a thesis plan and progress is reviewed until completion. The success of our training environment is

evidenced in our thesis submission rate of 88% for the REF period.

**d. Income, infrastructure and facilities**

***Income***

Staff submitted to this UoA have been awarded over £137m in research awards since 2008, with ~20% from Research Councils and ~14% from industry. This includes a pro rata component of the RINH platform funding (currently £8.9m for 2013) provided by the Scottish Government. Examples of major awards within the assessment period include £5.6m for formation of the Combinatorial Responses in Stress Pathway (CRISP) multicentre group, a £5.1m Wellcome Trust award for the "Medical Mycology and Fungal Immunology Consortium", a £2.75m Senior Investigator Award to Gow, a ~£1m Senior Wellcome Fellowship to Telfer and £1m funding from the Food Standards Agency to support a large and holistic approach to biomarker discovery, that involves national and international collaboration with pre-eminent zinc scientists and cutting-edge 'omic' technology researchers.

***Infrastructure and facilities***

Significant investment in infrastructure post-RAE has occurred in IBES, IMS and RINH, totalling **~£55m**. This includes: 1) the construction of the £4.3m **Oceanlab 2 building**, which was opened in 2010, and is a partner to the original Oceanlab 1. The new build creates a unique capability for biological subsea research at the Newburgh site, with enhanced wet lab facilities and increased office space for the growing body of postgraduate and postdoctoral researchers; 2) a £9.7m **refurbishment of the Zoology building** that was commenced and reported in RAE, but finished in August 2009; 3) a £1m **refurbishment of the Aquarium**, that includes freshwater and seawater systems with pathogen containment of the former, and creation of a new zebrafish breeding facility; 4) a £0.11m **refurbishment of the Lighthouse field station** in Cromarty and purchase of estate to increase site size and capability; 5) two **new chemistry laboratories** in IMS (£0.5m) in response to a strong growth in the requirement for synthetic chemistry for drug design and generation of radiolabelled ligands for preclinical PET studies. Purchase of equipment for expansion of synthetic chemistry includes a 400 MHz NMR machine, mass spectrometry and imaging equipment; 6) a £3.5m **Life Science Innovation (LSI) building** on the Foresterhill Health Campus, completed in 2009, in partnership with Scottish Enterprise Grampian that houses successful spin-out companies (eg GT Biologics) plus new biotechnology companies being developed in Aberdeen. LSI contains professional, well-serviced incubator facilities offering specialised laboratory and flexible office accommodation, together with ready access to a wide range of expertise and services at the University; 7) a new, state of the art **RINH building** on the Foresterhill Health Campus, currently being built at a cost of circa £40m, which will be completed by 2015. This new facility for nutrition research will be one of the best worldwide, and has received financial support from the Wolfson Foundation and the Scottish Government.

Investment in core facilities that underpin our research activities has also been significant. This has included the equipment costs together with support staff. All facilities are administered by both a technology manager, with expertise in use of the equipment, and an academic manager to plan and bid for next generation equipment and determine future needs. We ensure open access to our communal facilities for all funded research. This policy enhances research progress by reducing costs and time required to acquire techniques. The economies of scale we enjoy ensure early replacement of aging equipment and timely investment in new technology. New and enhanced facilities include: 1) **FACS facility,** a state-of-the-art multi-user facility with a full range of analytical and sorting capacities, the most recent additions being a BD Fortessa Next generation (2011) and Bio-Rad Luminex 200 (2010). 2) The **Microarray facility**, based on the Affymetrix GeneChip Microarray platform with qPCR verification of results. 3) The **Centre for Genome-Enabled Biology and Medicine**, with next generation sequencing facilities that include Illumina HiSeq 1000 (2012), Illumina MiSeq (2012), and Roche GS Junior 454 Sequencer. A Next Generation Sequencing Bioinformatician is available to assist with data analysis while Biomathematics and Statistics Scotland, based in RINH, also provide bioinformatics assistance. 4) A **research high-performance computing facility** to analyse and archive burgeoning datasets from 'omics' analyses and modelling applications. 5) A **Mass Spectrometry facility** that includes a gas isotope ratio mass spectrometry, three instruments for liquid chromatography/MS/MS for the quantification of metabolites by Multiple Reaction Monitoring and a new ICPMS. 6) A **Proteomics facility** for

electrospray or MALDI-TOF mass spectrometry analysis of protein separated by a variety of 2D gel separation methods. Proteomics robots for mass spectrometry have been upgraded and a new Orbitrap LC/MS purchased. 7) A **Microscopy facility** that provides a full range of services including confocal microscopy (Zeiss LSM700, LSM510 META and LSM10 confocal microscopes), spinning disc microscopy, live cell imaging and laser microdissection. Service provision includes assistance by multi-Wellcome Trust Image Award winner, Kevin McKenzie (http://www.wellcomeimageawards.org/Creators/Kevin-MacKenzie/index.htm). The facility is about to purchase (through Wellcome Trust funding) a new Transmission Electron Microscope (Jeol JEM1400) with Gatan Orius 1000 camera with tomography capability. 8) The **Aberdeen Biomedical Imaging Centre** provides preclinical facilities for animal CT, MRI and PET. The latter uses a GE eXplore Vista PET/CT, with excellent expertise and facilities provided for new PET tracer development in a recently expanded (£1m) centre led by **Prof. Zanda**. 9) Rodent models for research are housed in the state of the art **Medical Research Facility** on the Foresterhill Health Campus with £6M barrier and transgenic wings. Infrastructure completed in 2012 totalling ~£0.1m further improved barrier facilities and created new rooms for circadian and photoperiodic research. 10) **The Human Nutrition Unit**, a metabolic research facility equipped to perform human phenotypic and physiological measurements, and staffed by nutritionists, dieticians and medical staff with expertise to perform a broad range of human nutrition studies. The unit has residential facilities enabling intervention studies.

Cross-cutting Integrative Research Centres are also key for our translational research, and include *The Kosterlitz Centre for Therapeutics*, set up to encourage and facilitate translation of discoveries into disease therapeutics and diagnostics by providing expertise and industrial links not readily available to biomedical and clinical scientists. The Kosterlitz Centre presently oversees a portfolio of over 20 drug discovery projects and has brought in >£2.5m funding for them. Examples in the pipeline include new cannabinoid receptor enhancers and inhibitors for pain and depression (**Pertwee**, **Greig**), new fungal diagnostics and therapeutics (**Gow**, **Munro**), unique antibodies which cross the blood brain barrier as therapies for Parkinson's disease (**Zanda**, **Teismann**), new drugs for neurodegenerative disorders (**Teismann**), new approaches to treat hypertension (**Bewick**), diabetes (**Docherty**), and prostate cancer (**McEwan**), and novel PET tracers for hypoxia, Alzheimer's disease and membrane transporters (**Zanda**).

Staff have access to additional facilities locally through collaboration with key research institutes, such as the Marine Scotland Science laboratories (Aberdeen) and James Hutton Institute (Aberdeen/Dundee), with whom we have developed research alliances, as well as those available from partners within pooling initiatives such as SULSA and MASTS. Numerous staff also exploit the central RCUK research facilities such as Genepool (Edinburgh, Sheffield and Liverpool).

***Governance***

Research is conducted in accordance with a Framework for Research Governance (http://www.abdn.ac.uk/documents/research-governance-framework.pdf) that covers all aspects from ethics and integrity to data storage and safety.

**e. Collaboration or contribution to the discipline or research base**

***Wider influence to discipline/research base***

Many of the staff submitted are Fellows of the Royal Society of Edinburgh (**Brown**, **Gow**, **McCaig**, **Morgan**, **Priede**, **Secombes**, **Speakman**, **Thompson**), the RSE Young Academy (**Delibegovic**, **Lusseau**, **Reid**) or Fellows of other learned Society's (eg Academy of Europe - **Speakman**; Academy of Medical Sciences - **Speakman**; Society of Biology - **Brown**, **Gow**, **Morgan**, **Munro**, **Piertney**, **Secombes**, **Speakman**; Royal Statistical Society - **Lusseau**, **Douglas**; American Academy of Microbiology - **Brown**, **Gow**), and contribute to the wider national/international scientific debate.

Many of the staff submitted also contribute to and influence discipline specific research/activity, through society administrations and conference organisation, and expert groups. For example, **Gow** is on the Pasteur Institute External Audit Committee for Division of Parasitology & Mycology, the Scientific Advisory Board of Dundee/St Andrews University, the EC Aeropath Consortium Scientific Advisory Committee, the CBS Utrecht Int Review panel, and the UK National REF panel. He chaired the Strategy Advisory Group of the British Mycological Society, was a Society for General Microbiology Council member (2006-9), chaired the Eukaryotic Division Society for

General Microbiology (2008-11), founded the journal Medical Mycology Case Reports, and is currently President of the International Society for Animal and Human Mycoses (ISHAM) (2013-15). **Docherty** is meeting organizer for the International Congress of Endocrinology and is on the Board of Trustees of the Society for Endocrinology. He has helped UK societies make international connections, as with the Scottish Stem Cell Group visit to Korea and Scottish Development International Diabetes Team visit to India. **Erskine** is on the Executive Committee of the British Society for Developmental Biology while **MacCallum** is former Treasurer for the British Society for Medical Mycology and Treasurer for ISHAM. **Pertwee** was President, International Secretary, Chairman and Director of the International Cannabinoid Research Society, advisor for the Beckley Foundation, and the British Society for Pharmacology joint coordinator for the Cannabinoid Special Interest Group. **Scott (RH)** is Secretary and meeting organizer of the Scottish Neuroscience Group. **Flint** is on the UK Advisory Committee on Novel Foods and Processes, Scientific Advisory Board of MetaHit and Syral. **Morgan** is a member of Scottish Government Health and Environmental Sustainability Expert Working Group; member of Scottish Scientific Advisory Council, and member of German Institute of Human Nutrition Scientific Advisory Committee. **Speakman** is on Barshop Institute of Science Advisory Board, San Antonio; Methusalah mouse prize Science Advisory Board; National Institute of Ageing (USA) Data Safety and Monitoring Board (CALERIE project). **Lambin** and **Scott** (BE) are on the Scientific Advisory Committee of SNH, with **Scott** also on the DEFRA Marine Protected Area Science Advisory Panel. **Reid** was Director of the British Trust for Ornithology (2008-11), and **Collinson** is on the British Ornithologists Union Council. **Secombes** was a member of Executive Committee (to 2009, as past president) and Organising Committee of 11$^{th}$ Congress (Prague, 2009) of the International Society of Developmental & Comparative Immunology. **Lusseau** is a member of International Whaling Commission Scientific Committee and chair of the International Whaling Commission Large-Scale Whalewatching Experiment; IUCN Species survival Commission Cetacean Specialist Group, IUCN Sustainable Use and Livelihoods Specialist Group Scientist Advisor of Dolphin Space Programme (UK).

***Participation in the peer review process***

Submitted staff review grants for a very wide group of funding bodies, including: 1) in the **UK**; RCUK, Action Medical Research, Alzheimer Research Trust UK, Arthritis and Rheumatism Research Committee, Association for International Cancer Research, British Diabetic Association, British Heart Foundation, Chief Scientist Office, NC3Rs, NHS Endowment, Parkinsons UK, Royal Society, UK Energy Research Centre, and Wellcome Trust, 2) in **Europe**; the European Commission, Academy of Finland, Agence Nationale de la Recherche, Belgian Science Foundation, Biology and Biomedicine of Research Council of Norway (RCN), Czech Science Foundation, Foundation for Polish studies, Helmholtz-Gemeinschaft Deutscher Forschungszentren, Georgian National Science Foundation, German Council of Science and Humanities, Health Research Board (Ireland), Italian Ministry of University and Research Referee Panel, National Science Centre - Poland, Netherlands Organisation for Scientific Research, Netherlands Vidi Fellowship scheme, New Eurasia Foundation, Portuguese Research Council, Research Council KU (Belgium), Swedish Research Council, and Vienna Spots of Excellence; 3) in **Asia and Pacific**; the Human Frontiers Science Programme, Israel Research Council and Israeli Science Foundation, National Natural Science Foundation of China, Neurological Foundation of New Zealand, and the Research Council (Hong Kong), and 4) in **North America**; the National Science Foundation, Alzheimer's Association International and National Institute of Health-NIDDK, Sea Grant programme.

Submitted staff have also chaired and/or participated on grant committees. **Brown** chaired the BBSRC Molecules, Cells and Industrial Biotechnology Committee (10/11). **Docherty** was chair of the Juvenile Diabetes Research Foundation (JDRF) Stem Cell Grants Board, and on the JDRF Research Planning and Advisory Committee. **Gow** was on the ERANET Pathogenomics Scientific Advisory Committee, (2008-11) and Wellcome Trust DBT India Alliance Grant panel (2012-15). **McArdle** was a member of the BBSRC Agri-food Committee. **Morgan** was on the Healthy Organism Panel (2009-11) & Basic Biosciences Underpinning Strategy Panel. **Secombes** chaired an aquaculture panel for the Research Council of Norway (2009-11,2013). **Stansfield** and **Collinson** are on the BBSRC Pool of Experts and **Collinson** is also on the DEFRA registered directory of experts. **Thompson** was on NERC Marine Renewables Sandpit panel. **Lambin,**

**Kuepper**, **Mayor**, **Piertney and Redpath** are members of the NERC College, with Lambin also on the NERC Industrial CASE panel and Terrestrial Ecology Panel (2012-13). **McEwan** and **Reid** are on the Royal Society's Newton Fellowship panel, and **Vargesson** on the NC3Rs advisory panel, while **McCaffery** was on the Evaluation panels for the National Authority for Scientific Research of the Romanian Government and Oak Ridge Associated Universities, Pennsylvania. **Zou** is on the National Natural Science Foundation of China Expert Panel.

***Editors/editorial boards***

Many staff have been editors of journals over the REF period, including: Animal Conservation (**Redpath**); Biology Open (**Speakman**); BMC Research Notes (**Collinson**); Chaos (special issue, **Ebenhoeh**); Developmental Dynamics (special issue on Wnt signalling, **Hoppler**)); Fish & Shellfish Immunology (**Secombes**); Frontiers in Molecular Neuroscience (reviews, **Wulff**); Fungal Genetics and Biology (**Gow**); Fungal Biology (**van West**); Fungal Biology Reviews (**Gow**); Ibis (**Collinson**); Journal of Applied Ecology (**Thompson**); Microbiology (**Flint**); Microbiology Research (**Munro**); Open Ophthalmology (**Collinson**); Open Ornithology (**Collinson**); Medical Mycology (**MacCallum**); Molecular Plant-Microbe Interactions (**van West**); Oikos (subject editor, **Mayor, Travis**); Preventative Nutrition and Food Science (**Nixon**); Progress in Oceanography (**Scott**); Teratology Studies (**Vargesson**).

Most of the staff submitted serve on editorial boards of international journals, including ten journals of impact factor 7 and above (eg **Speakman** is on the Board of Reviewing Editors for Science; **Gow** Highlights advisor for Nature Reviews Microbiology), seventeen of impact factor 3-6 and ten in the 2-3 range. In addition, **Gow** and **Lenardon** are on Faculty 1000 Medicine and many are on the editorial boards of open access journals for which impact factors are still to be assigned.

***Fellowships and relevant awards***

During the REF period several of the submitted staff received prestigious awards. For example, **Speakman** was elected a Fellow of the Academy of Medical Sciences in 2008, and in 2012 was the first non-Chinese to be awarded a Great Wall Professorship from the Chinese Academy of Sciences Novo-Nordisk Foundation. **Thompson** was elected a Fellow of the Royal Society of Edinburgh in 2011. In the same year three of our staff (**Delibegovic**, **Lusseau**, **Reid**) were elected as founder members of the Royal Society of Edinburgh Young Academy. **Delibegovic** was also awarded the Scottish Crucible project award in 2009-10, and **Lusseau** was elected a Fellow of the Royal Statistical Society in 2009. In 2013 **Gow** was awarded the Fred Griffith Review Lecture by the Society for General Microbiology, in recognition of his "outstanding contribution to microbiology", and **Secombes** was awarded life membership of the International Society of Fish & Shellfish Immunology. **Reid** was awarded the Philip Leverhulme prize for Zoology (2008), the Zoological Society of London Scientific medal (2013), and a Royal Society University Research Fellowship to 2013. **Pertwee** was awarded the Wellcome Gold Medal by the British Pharmacological Society (2011) and a special award from the International Association for Cannabinoid Medicines (2013).

***Effective academic collaboration***

Collaboration is a fundamental component of the research ethos within the submitted Institutes given the multidisciplinary, transdisciplinary and interdisciplinary nature of much of our research portfolio. The University of Aberdeen was ranked top university in Scotland and the second in the UK for scientific collaboration with other academic institutions by the Leiden University rankings (2011-12). Thus, we have an outstanding record of international and national collaboration, and within the REF timescale the submitted staff had active collaboration (joint peer-reviewed scientific papers, joint grants/ PhD students) with colleagues in over 60 countries. Our joint research is illustrated by the extensive collaborations of staff within EU funded projects, where involvement ranges from participation to co-ordination. Examples include: Full4Health (co-ordinator, 14 partners), Ruminomics (co-ordinator, 11 partners), Satin (11 partners), TargetFish (29 partners), Lifecycle (14 partners), EcoFishMan (15 partners), and we were a founding member of the Network of Excellence initiative European Nutrigenomics Organisation (NuGO).

***Collaboration with external bodies (i.e. industry, government agencies, etc)***

Staff are encouraged to collaborate with industry and several are Directors or on Science Advisory

Bds. For example, **Pertwee** is Director of Pharmacology for GW Pharmaceuticals, **Gibson** a Director for SIRAKOSS, **Flint** is on the Science Advisory Board for Syral, and **Docherty** is on the Science Advisory Board for BetaLogics. Other industrial collaborations include those with: Abbott pharmaceuticals, Astra Zeneca, Alltech, Bayer Healthcare, Biomar, Brainmarker, Cybula and Apatech Ltd, Eli Lilly and Company, Ewos Innovation, Gilead Sciences, Johnson and Johnson, Lancatch, Marine Harvest, Merck Sharp & Dohme, Novabiotics, Novartis, Organon, Pfizer, RiNA GmbH, Roemex, Royal DSM NV, Syngenta, Spinifex, Takeda Pharmaceuticals, and Waltham. Submitted staff also act as consultants for industry, as with **Jamieson** for deep-water surveys off Angola and Gulf of Mexico for BP, **McCaig** for woundEL GmbH, **Speakman** for Los Gatos Research, **van West** for Novartis and **Vargesson** for Pannone LLP. Extensive collaborations with large multinational companies and SME also occur through the EU funded projects, as outlined above.

There is a demonstrable track-record of long-term collaboration with NGOs and end user and stakeholder groups. This is exemplified by the activities of the Aberdeen Centre for Environmental Sustainability, and its precursor UKPopNET. In addition, RINH leads the Strategic Partnership on Food and Drink (RESAS funded), Scottish Enterprise Funded Food and Health Innovation Centre (led by Campden BRI, but hosted by RINH), and the Interface Food and Drink (SFC funded network, led by University of Aberdeen, hosted at RINH). RESAS KE mechanisms embedded into grant to RINH are about enhancing policy interactions, and Rowett has KE strategy with scheduled KE activities across year, including briefing notes to Scottish Government and NHS Scotland staff.

***Responsiveness to national/international priorities/initiatives***

The University has responded to Scotland wide Scottish Funding Council funded pooling initiatives, and is a major partner in SULSA and MASTS. SULSA is a pooling partnership between the Universities of Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Strathclyde and has funded premier researchers and facilities across Scotland. In Aberdeen this allowed development of systems biology research expertise. The total value of grants awarded to faculty funded by or associated with SULSA (up to 2011) have been over £11m and the faculty were instrumental in development of an MSc in Systems Biology, supported by BBSRC (5 studentships for 3 years). SULSA funding has also assisted in drug discovery in Aberdeen and led to expansion of the Biologics facility which holds antibody/peptide libraries and vectors as part of its biologic drug discovery service to academic institutions. The Natural Products Library, a key part of the successful Marine Biodiscovery Centre, has also benefited from SULSA which provided funds for research appointments including a postdoctoral fellow to the Natural Products Library. SULSA funding for the Aberdeen PET facility has consisted of part purchase of hot cells required for sterile labelled probe preparation as part of the new PET extension. The Kosterlitz Centre has made use of a number of ongoing SULSA projects funded from the 'High Throughput Screening' fund and the 'Chemistry Catalyst' fund from SULSA. MASTS is a nine partner initiative that pools the research talent of about 700 researchers, and the management of resources, consisting of over £66m annually, in marine science from across Scotland. It strives to ensure that marine science in Scotland can remain internationally competitive. It provides the academic platform and knowledge for marine governance and commerce by helping to establish a Scottish strategy for marine science that will deliver increased value to the public from its investments. We have also responded to UK wide initiatives to build critical mass and expertise, including Systems Biology, Food Security, UKPopNet, BBSRC Animal Health Research Club.

***Mechanisms to promote national/international collaborations with academic community or users of research collaborations***

Effective academic collaboration is facilitated from local through to global scales. Among institutes within this unit of assessment, there is a shared and fully integrated research environment based upon a strategy overseen by a University Vice Principal for Research and Knowledge Exchange and a College Director of Research, with generic administrative support from research and innovation. Multidisciplinary collaboration involving this unit of assessment has been enhanced by University wide investment in key cross-cutting research themes, described above, and international collaboration is exploited through our Centre for Sustainable International Development (CSID; www.abdn.ac.uk/sustainable-international-development/).