Institution: University of York

Unit of Assessment: 5 - Biological Sciences

A. Overview

The University of York (UoY) Biological Sciences submission covers the Department of Biology and its associated research centres. We operate a 'biology without boundaries' ethos to nuture excellence across a broad spectrum of subjects, creating an exciting environment for science. Innovative research is organised into eight inter-connected, fundamental science research foci that underpin three impact-oriented and multi-disciplinary research centres, which in turn address three global challenges (Fig 1). Our Bioscience *Technology Facility* (*TF*) and other support structures provide access to a wide range of world-class facilities to achieve research excellence.

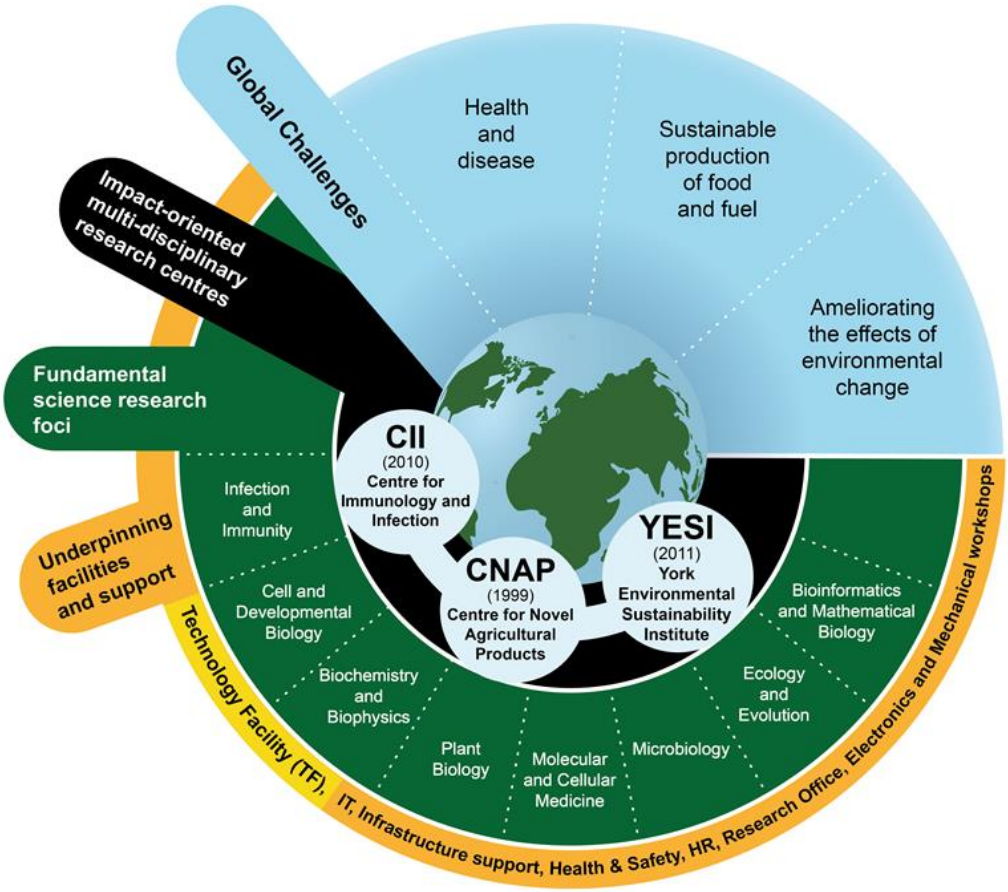

Fig 1. Schematic of Biological Sciences research structure at the University of York

B. Research strategy

We achieved our strategic aims for 2008-13, which were to:

- **Create an environment where internationally leading research flourishes.** We have maintained critical mass in our research foci, encouraged collaboration, and provided facilities and expert support for research. Our staff achieved cutting-edge research in all foci, with 40% of REF outputs in *Science*, *Nature*, *Cell*, *PNAS*, *Current Biology*, and *Nature* and *PLOS* family journals. The other outputs are all in leading specialist journals.
- **Address global challenges.** Our policy of developing research centres (*CII*, *CNAP* and *YESI*, Fig 1) has facilitated the translation of our world-class research into impacts, such as the *CNAP* development of plant-derived pharmaceuticals (REF3).
- **Catalyse interdisciplinary research.** Strategic appointments and development of inter-departmental centres have enabled high quality interdisciplinary research to be achieved, with >80% of REF outputs involving substantive collaborations (sections B and D).
- **Develop the next generation of excellent research scientists.** This is demonstrated by the achievements and employment statistics for PhD students, post-doctoral researchers (PDRAs) and early career researchers (ECRs) (section C).

Significant changes to the research environment over the assessment period.

- **New appointments** sustained and increased critical mass in our research foci, enhancing our capacity to respond to global challenges (9 new Professors, 13 new Lecturers/Senior Lecturers, and 2 Fellows with proleptic Lectureships; *vs* 10 retirements and 7 departures).
- **New-build** for the *Centre for Immunology & Infection* (*CII*) opened in 2010 (£4M).
- **New equipment and facilities** have been provided in the *TF* (section D).
- **New inter-departmental research centres** have strengthened collaborative, interdisciplinary and impact-oriented research.

Details of strategic aims and goals for research over the next five years. 'Biology without boundaries' is the ethos underpinning the Department's future strategy, forging collaborative research links within and beyond the UoY, addressing fundamental questions relevant to our global challenges, and supporting the translation of discoveries into practice. We aim to:

- **Enhance our world-leading core strengths** in *Ecology & Evolution*, *Plant Biology*, *Microbiology* and *Infection & Immunity* by recruitment and further infrastructure upgrades to foster a research environment that supports transformational change.
- **Establish a strategic initiative in Biomedicine** to consolidate our leadership in *Infection & Immunity* and *Microbiology*, and increase strength in *Molecular & Cellular Medicine*, by the recruitment of 7 new academics in 2014-16, secured by the 2014 launch of a non-clinical BSc Biomedical Sciences degree (joint with the Hull York Medical School, HYMS).
- **Strengthen and develop interdisciplinary research centres** to accelerate rates of discovery and translation of research into impacts. This will involve infrastructure, personnel, and seedcorn support for *CII*, *CNAP*, *YESI* (Fig 1) and inter-departmental research centres such as the *York Centre for Complex Systems Analysis* (*YCCSA*) and the Wellcome-supported *Centre for Chronic Diseases and Disorders* (*C2D2*, since 2012). We will foster inter-institutional ventures such as the *Initiative in Agrifood Resilience*, jointly launched by the Food & Environment Research Agency (Fera) and *YESI* in July 2013.

We will also develop our capacity by:

- **Aligning research student recruitment and training with our priority research areas** through new interdisciplinary Doctoral Training Programmes (e.g. NERC DTP from 2014).
- **Development of infrastructure to facilitate research.** An exciting phase of infrastructure provision will establish three new Biological Sciences buildings, which will (i) boost research links by co-housing Biology (*YESI*), Environment and Archaeology staff in 2014-15 (£10M), (ii) provide new Biology teaching labs in 2013-15, (£18.75M), and (iii) support new research initiatives within our priority research foci (target 2015-18).
- **Upgrading *TF* resources** with new equipment to support our research priorities and industrial partners, and match funding for equipment bids to RCUK and other funders.

Research policy is devised and implemented through the Dept. Research Committee (DRC), with senior academic staff, ECR, and PDRA representation, and feeds into the Dept. Strategy Group (DSG) to ensure coherent planning across teaching and research. Additional input comes from regular Academic Staff Meetings and our distinguished external Science Advisory Board.

Responsiveness to national and international priorities and initiatives. Our global challenges reflect national, EU and UN priorities for health, food, fuel and environmental sustainability. Our research centres, supported by the *TF,* provide platforms for coordinating responses to national and international initiatives: e.g. *CNAP* was awarded 3 grants (total $27M) in response to the Bill & Melinda Gates Foundation's commitment to improve access to anti-malarial drugs (REF3); *YESI* and *CNAP* collaborated to obtain BBSRC special initiative funding (£2.2M) to increase resilience in rain-fed rice. Our success is demonstrated by >40% of funding in the REF period coming from charities whose spending prioritises societal needs.

Mechanisms for the development, promotion and dissemination of research. We support all stages of research from networking, pump priming and peer review of applications, to dissemination and outreach. Networking is achieved through research foci, inter-departmental centres, seminar series, research awaydays, support for meetings, and travel funds. Pump priming is provided by: (i) DRC (£74.5k in 2012), (ii) UoY Central Research Priming Fund (£144K to

Biology in 2011-13), (iii) the Environmental Research Initiative (UoY £200K in 2008-10; giving rise to *YESI* in 2011, attracting £3.3M external funding 2011-13), and (iv) the *C2D2* research centre (£1.4M spent on 23 projects to 2013; 48% Biology/HYMS, leveraging £1.9M external funding to date). Our Peer Review Colleges (section C) provide a mechanism to develop high quality funding applications. DRC also provides paper-completion and conference travel grants to assist dissemination. We provide training to support outreach (REF3) and school visits (e.g. 2 Biology staff have been BBSRC Schools Regional Champions).

Research groupings, their rationale, activities and main achievements. Memberships of research foci and centres are non-exclusive, maximising opportunities for interdisciplinarity. Research coalesces around 8 fundamental science research foci (Fig 1) and 3 impact-oriented research centres (REF3), providing (i) the knowledge-base and facilities to carry out internationally-competitive research, and (ii) firm foundations for interdisciplinary collaboration.

Infection & Immunity addresses basic science that underpins *CII*, discovering non-coding RNA regulation of antiviral immunity (Lagos in *Nature Cell Biology*), a therapeutic target for sleeping sickness (Smith D in *Nature*) and immune regulation by NK cells (Kaye in *Immunity*).

Molecular & Cellular Medicine tackles global health challenges, finding regulating mechanisms for fused genes in prostate cancer (Maitland in *Nature Comm.*), a biomarker for early-stage lung cancer detection (Coverley in *PNAS*), and trials of viral-vectored leishmaniasis vaccine.

Cell & Developmental Biology links complex cellular processes to developmental diseases, finding that oxidative stress regulates synapse growth at neuromuscular junctions (Sweeney in *PNAS*) and that thymus development depends on effective protein signalling (Coles in *PNAS*).

Microbiology spans fundamental and applied research. Discoveries include protein interactions that are essential for chromosome segregation in Archaea (Barillà in *PNAS*) and that bacterial evolution accelerates the molecular evolution of phage parasites (Brockhurst in *Nature*).

Plant Biology investigates model and crop plants relevant to *CNAP* impacts, elucidating a gene cluster responsible for the synthesis of an anticancer alkaloid (Graham in *Science*) and enzymatic determinants of multiple-herbicide resistance in weeds (Edwards in *PNAS*).

Biochemistry & Biophysics research with Chemistry and Physics has established how single-molecule molecular motors are critical to DNA replication (Leake in *Science*) and discovered novel rod-like proteins responsible for biofilm formation (Potts in *PNAS*).

Ecology & Evolution research is relevant to *YESI* impacts, discovering that biodiversity increased following climate warming in the fossil record (Mayhew in *PNAS*) and that responses to recent climate change are accelerating (Thomas C & Hill *Science* papers).

Bioinformatics & Mathematical Biology ensures a rigorous numerical basis for biological research, revealing the transfer of adaptive genes between species (Dasmahapatra in *Nature*) and the fitness benefits of menopause in cetaceans (Franks in *Science*).

Multi-disciplinary developments. All Biology research staff are members of at least one interdisciplinary research centre. We established the *York Environmental Research Institute* (*YESI*) in 2011 as a Biology-initiated research centre spanning physical, natural and social sciences, with Hartley appointed as its first Director. *YESI* has increased interdisciplinary research on environmental sustainability, with 32 academics from 8 departments already undertaking collaborative *YESI* projects. Biology and HYMS jointly established the *Centre for Immunology & Infection* (*CII*) in 2010, with Kaye as Director, to undertake research at the interface of biology and medicine, leading to the successful creation in 2012 of the Wellcome-funded *C2D2*, to promote fundamental and translational biomedical and health research. We also further developed *YCCSA*, which is an inter-departmental centre (initiated originally by Biology) comprised of researchers modelling and analysing complex biological, physical and social systems; during the REF period, we co-located 6 Biology academics with staff from 6 other departments to develop quantitative approaches and techniques for the biological sciences. We have also enhanced interdisciplinarity through 3 new joint academic appointments with other departments (Franks, joint Lecturer with Computer Science, 2011; Wood, joint Lecturer with Maths, 2012; Leake, joint independent research fellow (IRF)/Prof with Physics, 2013). Leake has already established the *Biological Physical Sciences Institute* as a new collaborative centre across 7 UoY departments. A further 27 academics

from other departments (HYMS, Archaeology, Chemistry, Maths) reside in the Biology complex to facilitate interactions and access to the *TF*. The archaeologists and their Biology collaborators together engage in the *Palaeo* research centre, which was formed in 2011 to enhance inter-departmental research into palaeobiology. Edwards' joint appointment (2010) as Professor of Crop Protection in Biology and Chief Scientist at Fera has cemented our links with Fera, including our joint PhD programme.

C. PEOPLE

i) Staffing strategy and staff development.

We foster excellence by attracting, retaining and supporting outstanding researchers and providing an environment that nurtures potential and promotes excellence at all career stages.

Staffing in relation to our research strategy. We aim for critical mass of people and shared infrastructure within each research focus, whilst retaining a broad biological sciences base to facilitate the cross-fertilisation of scientific ideas between disciplines. Annual 'people plans' cover recruitment, retention, development and planning; maintaining financial sustainability and excellence in research. We employ a pool of experienced technicians on grants to maintain expertise, and develop new skills for these staff. We normally appoint academic staff at three levels: (i) academic leaders to support new initiatives and meet new challenges (9 Chairs appointed since 2008), (ii) lecturers in areas of existing strength and strategic growth (9 appointed, mostly ECRs) and (iii) IRFs, facilitating their transition into full academic positions (4 of our IRFs transferred to York lectureships in the REF period; 2 more have proleptic lectureships). This provides a sustainable mix of experienced leaders and ECRs. Recruitment prioritises those with potential to tackle fundamental scientific questions, especially where this can contribute to future impacts. For example, we have strengthened fundamental research by 11 new appointments in *Biochemistry & Biophysics*, *Molecular & Cellular Medicine*, *Cell & Developmental Biology* and *Microbiology*, underpinning future impacts in *Health & Disease*. We maintained international leadership in *Plant Biology* by replacing 1 retiring and 2 departing professors with 3 new Chairs (Bancroft, Davis, Edwards) and 1 ECR (Haydon). Vitality was ensured in *Ecology & Evolution* by replacing retiring staff with 3 new lecturers (ECRs Beale, Dasmahapatra and Robinson). Research breadth and collaboration are facilitated by joint appointments with Maths, Computer Science, and Physics (section B); and by academic staff from HYMS (11, mainly in *CII*), Chemistry (10, including two FRSs, in the *York Structural Biology Laboratories*), Archaeology (5) and Maths (1) being physically located in Biology.

Equality and diversity. We champion a departmental culture that is inclusive, democratic and promotes gender, race and age equality. Departmental policies include: compulsory diversity and recruitment training, female academic membership of appointments panels, flexible working, and equality-sensitive promotions criteria. We have held an Athena SWAN Silver award longer than any other Biology Department (since 2006, with a Gold application pending), reflecting our strong commitment to gender equality. This has ensured higher female representation than similar Biological Sciences departments; 29% of Professors (including HoD Smith D and Associate HoD Hill) and 34% of other academics are female, providing excellent role models for students and staff. Biology has an international mixture of staff (12 nationalities) and UK ethnicity (British Chinese and British Indian), providing a diversity of cultural backgrounds. Over 10% of staff took opportunities to work more flexible hours and/or part-time during the REF period. Flexible retirement and *Emeritus* Prof/Fellow status provide rewarding opportunities for former staff, increasing research activity and ensuring that the Department retains valuable experience; 14 *Emeritus* staff produced 150 publications in major journals in 2008-13, including 3 in *Nature*, 3 in *Science*, and 1 in *PNAS*, and they produced 4 books and contributed to impacts (REF3).

Effective development and support of the research work of staff. Personal development and career progression are based on individual needs and aspirations, with 1:1 mentoring and annual performance reviews, as well as professional training, access to high quality research infrastructure, and peer support through research foci and centres. Peer Review Colleges, allied to research foci, were introduced in March 2011 to nurture new initiatives, mentor staff in writing grant applications and enhance research collaboration (chaired by staff with RCUK peer review panel experience). Since their introduction, RC grant success has doubled, with 44% funding success for 2012 applications.

Admin and technical support. We release academic staff from duties that can be undertaken more effectively by professional and administrative staff. The Department employs in-house specialists in HR, Finance, IT, Health & Safety, Infrastructure Management, Supplies, Photo-Graphics services and Horticulture; and in our Electronics and Mechanical Workshops. Our departmental Research Support Office assists with the preparation of grant applications and highlights new funding opportunities.

Sabbatical policy. We encourage academic staff to apply for sabbatical leave of ~1 term every 3 years, recognising the importance of time to focus on research (e.g. Pitchford's 2011 sabbatical research on community stability published in *Nature*; Chong working on Achaea in Antarctica). Staff returning from extended absences (e.g. maternity, sick leave) or after heavy admin roles are expected to apply, recognising the importance of revitalising their research.

Research-teaching balance. We are proud of our excellent teaching. Biology ranked 2nd 3rd and 4th in the Guardian, Times and Complete University Guides for 2014, and scored >95% for student satisfaction in the NSS (2012/13), reflecting our desire that the next generation of bioscientists should be trained by this generation's world-class research leaders. All academic staff contribute to teaching, which is shared in an even-handed and transparent way to ensure that they all have time to develop their research. Teaching is facilitated by a support team and by 6 Teaching Fellows on indefinite contracts, with career development opportunities reflecting their commitment to teaching.

Developing and supporting the research of early career researchers. We engage actively with the Concordat to Support the Career Development of Researchers. We support PhDs, PDRAs, IRFs, newly arrived ECRs and other staff with professional development opportunities. Our HR team includes a Training and Careers Officer specifically for PhDs, PDRAs and IRFs. Departmental decision-making is transparent: PhD and/or PDRA representatives sit on Boards of Studies, DRC, Athena-SWAN and Staff committees. The Department funds a Postdoc Society, which includes the provision of 'buddies' for new staff. We provide 1:1 career counselling, sessions on grant writing, opportunities to gain teaching experience, interview and CV preparation, an annual careers conference and drop-in 'Coffee and Careers' events, as well as mentorship by the PI. PDRAs can apply to DRC for summer student funding, gaining experience in writing proposals and managing research budgets and staff. We recognise the potential insecurity of postdoctoral careers, and the DRC provides ~3 month bridging funds to promote continuity of employment between post-doctoral contracts. Vacancies are advertised internally before external advertising to facilitate continuity. Many York PDRAs have obtained tenure-track positions in 2008-13, reflecting our success in supporting ECR research. In addition, IRFs Dodd, Penfield and Rowntree obtained positions at Bristol, Exeter and Manchester, while 6 of our IRFs obtained tenure-track positions at York; e.g. Green transferring from a Wellcome Trust Senior Research Fellowship to Senior Lecturer in 2011.

Effective ECR development. 8 ECRs obtained their first academic positions with us during the REF period. New academics and IRFs are assigned an academic mentor and an induction programme is developed for them. The York Post-Graduate Certificate of Academic Practice is mandatory for new lecturers, and includes research-related training. Teaching and administration duties are introduced slowly for new academics: 1/3, 2/3, full load over the first 3 years. New staff are given start-up funds and priority in applications for DRC funds. Success in ECR development is evident in that, of 16 staff that we appointed to their first lectureship in 2001-07, 70% were promoted in the REF period: 8 to Senior Lecturer, 3 to Reader and 1 to Professor, reflecting their high external profiles for research excellence.

ii) Research students.

Effective and sustainable PhD programmes. We provide PhDs with an intellectually demanding yet friendly and inspirational research environment. We have developed intra- and inter-institutional Doctoral Training Programmes (DTPs): currently the Wellcome Four Year 'CIDCATS' programme, EU Marie-Curie 'P4FIFTY' and 'STROMA' ITNs, EPSRC DTC in Tissue Engineering & Regenerative Medicine, and BBSRC White Rose DTP in Mechanistic Biology; as well as a joint programme with Fera. Joint supervision of PhDs is common, including co-supervision with 8 other UoY Departments and with non-CASE external partners, ensuring a breadth of skills training and networking across labs. Our 150+ PhD community is supplemented by ~50 Masters students on

four taught MRes/MSc programmes that also provide opportunities for PhDs to gain advanced skills training. The Department provides training and access to *TF* resources, ensuring that PhDs experience cutting-edge technologies. Each PhD student has a Training Advisory Panel of supervisor(s) and two independent academics, which meets at 3 months, 6 months, then 6-month intervals to advise on training and student progress and to offer additional support. Generic skills are supported by departmental Training and Careers officers, and Graduate Development and Careers Liaison officers. The Biology Graduate School provides administrative support for recruitment, finances, progress and completion of PhDs. Our success is reflected in 92% completion rate within 4 years (for full-time PhD students starting Oct 07–Sept 09). Destination data for PhD students graduating in the REF period reveal that 128/129 are employed, with 52% PDRAs, 18% in industry/business, 6% university lecturers, 5% in medicine, 5% in teaching, 4% IRFs, and 10% other. We held 42 CASE awards, exceeding our BBSRC/NERC expectations by 30% over the REF period; 8 out of 21 CASE students graduating in the REF period are employed in business/third sector, half of these with the CASE partner, capitalizing on the student's skills and knowledge. The 9 clinical postgraduates to graduate have all become medics/consultants.

Evidence of a strong and integrated research student culture. Departmental and inter-departmental events foster an atmosphere of peer support and advice. PhD students attend weekly lab meetings and seminars associated with research foci and centres. They also attend York Biology Open Lectures, which bring high profile scientists to York; graduate students meet speakers informally over lunch. All PhDs present their research and receive feedback from the PI and other staff via Poster Days, oral presentations, and participation in the annual Graduate Symposium; the best are awarded prizes. Students receive financial support for conference attendance, and engage in external science competitions (Cottam was Young UK Cell Biologist of the Year in 2010, Turner was awarded Best Scientific Paper by a Young Urologist in 2012). A third of returned outputs include our PhD students as co-authors, evidence that we are enabling students to perform high quality research, benefitting them and the Department. PhD representatives sit on departmental committees, providing feedback and contributing ideas about departmental processes and strategies. We encourage strong collaborative interactions and interdisciplinary work through open plan write-up areas and lab space, and new PhD students are assigned 'buddies' to assist integration. Skills training courses and social activities during the October introductory week, January skills week, and monthly Gradshare meetings (run by PhD students) bring students together across wider subject areas. The Graduate Student Association connects PhD students across the university.

External engagement. PhD students engage actively in many inspiring ways, contributing to professional societies and conference organisation; e.g. Tilley (08-09) and Mair (current) have been national PhD representatives for the Royal Entomological Society, and Lakins & Owens co-founded (in 2010) and Owens chairs the national Stromal Immunology Group. Our students engage with outreach, policy, and the media, give public talks, run workshops in schools and write lay articles; e.g. Walton is currently on POST placement in Westminster.

D. INCOME, INFRASTRUCTURE AND FACILITIES

A strong collegiate ethos is central to our strategy. We work together to obtain resources, share facilities, and build interactions in open plan laboratories and infrastructure. Our average annual research income has been £268K per FTE from 2008-13, underpinning high levels of activity in the REF period. Our pattern of spend reflects sector-wide constraints in RC and Charity funding, combined with the funding profile of our largest grant (Gates Foundation funding averaged £2.85M *pa* for 2008-11, but £0.78M in 2012-13) and the departure in 2010-12 of three staff with large incomes (mainly affecting 2011-13 spend). Staff renewal and introduction of the internal Peer Review Colleges described above have reversed this temporary dip, generating a 44% increase in new income awarded from 2011-12 to 2012-13. Our NERC grant success was 1.24 times the sector average during 2012-13 and BBSRC success 1.72 times the sector average; increasing in a year when overall BBSRC awards to research intensive universities (1994 and Russell Group) fell by an average of 63%. Our projected spend of £10.6M for 2013-14 (from already-confirmed grants, excluding new buildings) is 28% up on 2012-13, indicating a strong upwards trajectory.

Infrastructure and facilities provision. Bioscience *Technology Facility*. Housing diverse technologies in one facility is efficient, and exemplifies our strategy of enabling collaboration

between disciplines to solve fundamental and applied biological challenges. The *TF* (est 2002 with a £23M BBSRC JIF award) has been updated with £3.8M of new equipment since 2008.

- The TF provides high-tech facilities within labs dedicated to Imaging & Cytometry, Protein Production, Molecular Interactions, Genomics, Proteomics & Bioinformatics Computation. Each lab is headed by a specialist who, with a technical team, provide scientific and technical input and advice; e.g. Maathuis' proteomic analysis of membranes in *Plant J* and Sweeney's and Potts' papers in *PNAS* include TF staff as co-authors.
- Income generation from grants with *TF* input (>£20M) and >50 external organizations *pa* (50:50, HEI:Commerce) achieved long-term sustainability for the *TF* (74% cost recovery).
- Notable developments in the REF period include: super-resolution microscopy; first-in-world to install Zeiss Axioscan Z1 digital scanner to facilitate new initiatives in quantitative pathology; a new small animal MRI facility (Wellcome/Wolfson Capital Award) and Bruker maXis for enhanced proteomic capabilities. A £1.4M investment (49% UoY, 51% RCs, Wolfson, Wellcome, Yorkshire Cancer Research) up-dated our confocal and electron microscopes and flow cytometers, and introduced intra-vital 2-photon microscopy (supporting 26 grants, total value £12M). Along with co-location of the *York Structural Biology Laboratory* (with Chemistry, housed in Biology), our enhanced imaging facilities enable study of a disease (e.g. human leishmaniasis) from atom (development of novel enzyme inhibitors; Smith D) to organism (spleen pathology; Kaye).
- A joint initiative with Chemistry created the *Centre of Excellence in Mass Spectrometry* (with £1.6M Yorkshire Forward/Northern Way investment), expanding our proteomics work into label-free quantification and phosphoproteome studies, supporting 9 grants (£5M).

Centre for Immunology and Infection. The new £4M *CII* building (opened 2010) provides state-of-the-art facilities for pathogen containment (to ACDP CL3) and a translational research suite that operates as part of a new UoY / York Teaching Hospital NHS Foundation Trust Clinical Research Facility. This provides enhanced infrastructure for early phase clinical trials and for fundamental and translational research using clinical material.

Centre for Novel Agricultural Products. In 2011, *CNAP* secured £2.5M from the UK Government Department for Business, Innovation & Skills, matched by £4.4m from European Regional Development Funds, to establish the *Biorenewables Development Centre*, providing open-access to next generation sequencing, molecular breeding and related bioinformatics.

Other facilities. We have 250m^2 of high quality transgenic glasshouse space and 44 controlled environment plant growth cabinets supporting *Plant Biology*, *CNAP* and *Ecology & Evolution*. Our animal house has full barrier protection with individually ventilated cages, ACDP CL3 and quarantine facilities. Structural biologists (e.g. Plevin, Potts) have access to high-field NMR spectroscopy and X-ray crystallography via the *York Centre for Magnetic Resonance* (joint Biology-Chemistry) and the *York Structural Biology Laboratory* (with Chemistry). The building of new teaching labs to support Biomedical Sciences (£18.75M expansion) commenced in 2013, and work on a new build housing environmental facilities (*YESI*, Environment Department, *Palaeo*; UoY committed to £10M) will start in 2014.

Local equipment purchase. In addition to UoY schemes, the Department equipment budget of £65K *pa* is allocated against bids to the DRC for internal equipment purchases and upgrades. DRC also identifies priority items that enhance research in anticipation of funding, and provides matched funding associated with bids to RCUK (£135K allocated for 2014/15). Departmental policy is to return 6% of research overheads obtained on grants to PIs, helping them to maintain their laboratory infrastructure to a high standard.

General research infrastructure is managed by a team of 40, headed by the departmental Director of Infrastructure and Facilities. We have invested £800K in infrastructure equipment in 2008-13 (on top of the major new equipment purchases listed above) to upgrade autoclaves, centrifuges, growth cabinets and IT infrastructure, and provide modern, computer-controlled machine tools for the workshops. Departmental Supplies and Goods Services, Graphics, and a dedicated Health & Safety Advisor provide essential support. Departmental Electronics and Mechanical workshops build bespoke equipment and customise purchased equipment to add novel functions (e.g. 'SkyGas' ecosystem trace gas measurement; an Ineson/*YESI* project with Engineering and Chemistry, funded

by the NERC Macronutrients programme).

Cross-HEI sharing and collaborative use of research infrastructure. We actively support the N8 Research Partnership initiative to promote and facilitate regional inter-university sharing of major items of equipment. Our *TF* Director is on the N8 Operational Infrastructure working group, Potts on the NMR Assets Sharing group, and our Director of Infrastructure and Facilities is responsible for the N8 equipment database. The N8 partnership builds on our intra- and inter-departmental collaborative approach to equipment access and sharing. We also collaborate with Fera on equipment purchases and access (e.g. coordinating EM and next generation sequencing platforms). NHS ties are increasingly strong, with a MoU between the UoY and York Hospital NHS Foundation Trust focused on the jointly operated Clinical Research Facility based at the hospital and the *CII*. A joint research tissue bank (from 2013) in conjunction with an HTA Licence held in Biology further strengthens research opportunities in relation to human disease, and a co-sponsorship agreement is in place for clinical trials.

Major benefits-in-kind. The *TF* is active in technology development and has formed research alliances with equipment companies for beta testing and applications development. For example, JEOL have loaned their FEG-SEM and nominated the *TF* as their EU demonstration site for ClairScope, a combined light- and electron-microscope, thereby providing access for staff to ~£1M of advanced equipment. It generated proof-of-concept data that were included in our successful application (supported by Cancer Research UK, and by equipment manufacturers JEOL and Delmic) to the 'Next Generation Optical Imaging Initiative' funded by MRC, BBSRC and EPSRC, providing ~£2M investment to achieve imaging from micro- to nano-scales. Many equipment manufacturers support training courses run by the *TF*, providing technical experts and direct sponsorship. Consultancy agreements have been made with equipment manufacturers, including Bruker, Zeiss, Phase Focus, and Beckman Coulter, providing additional access to the latest technologies and advanced training for researchers.

Policy and practice in relation to research governance. Departmental responsibility, integrity and safety information are required for all projects/staff, with clear communication of responsibilities. A standard form ensures that all aspects of research governance are considered by researchers (including legal issues, H&S, data management and storage provision), and this is signed-off by the appropriate officers, who provide training and support. A Home Office Liaison Officer, our ethics committee, and an NHS-funded R&D team support academics with essential regulatory issues concerning animal and human research.

E. COLLABORATION OR CONTRIBUTION TO THE DISCIPLINE OR RESEARCH BASE

We foster a culture in which all staff contribute to the wider discipline and engage in external collaborations.

Invited presentations. We encourage staff to accept invitations to speak at meetings and external organisations by facilitating travel through DRC and UoY funds; all members of staff (except two ECRs) delivered plenary national/international seminars in the REF period. Hartley was the 184th Royal Institution Christmas Lecturer, delivering a lecture series on the "300 Million Year war" between plants and animals, screened on More4 (2009). High regard for our new ECRs is illustrated by invitations to address the South African National Biodiversity Institute (2011, Beale), an international Ion Transport and Cancer Meeting in Wurzburg (Germany 2012, Brackenbury), and to give a Jugatae Lecture at Cornell (2010, Robinson). Barillà (appointed 2007) was Invited Professor at the U Pavia, Italy, sponsored by the CARIPLO foundation (2012-13).

Textbooks and scholarship. Of the books written or edited by Biology staff, *Choosing and using statistics* (Dytham, 3rd ed., Wiley Blackwell 2011) has sold >25,000 copies internationally and is on the reading list of over 25 UK universities, while *Single-molecule cellular biophysics* (Leake, CUP 2013) is innovative in a new research field. Undergraduate and graduate textbooks, reviews and opinion articles are recognised as important scholarship within our performance review and promotions procedures. Most staff published opinion and review articles, helping to shape their research fields, including on prostate cancer (Maitland 2008, *J Clin Oncol* 26, 2862-70, cited x185), plant macronutrient functions (Maathuis 2009, *Curr Opin Plant Biol* 12, 250-8, cited x115), intestinal sugar absorption (*Emeritus* Kellett 2008, *Ann Rev Nutr* 69, 35-54, cited x130), evolutionary responses to climate change (Hill 2011, *Ann Rev Ent* 56, 143-59, cited x50) and

conservation (Thomas C 2008, *Science* 321, 345-6, cited x360).

Contributions to learned societies are recognised in promotions criteria; over 50% of staff contributing. Smith M is on Council for the Society for General Microbiology, helping to steer through multiple policy statements, Hill is on Council for the British Ecological Society, and Potts (Biochemical Society) and Leake (Royal Microscopical Society, British Biophysical Society and Institute of Physics) have committee roles enabling them to contribute nationally to their disciplines. Many staff co-ordinated meetings for learned societies during the REF period; Thomas G organised the Society for General Microbiology Spring Meeting (2011) and the Biochemical Society Harden Conference (2011). Fitter (Council, *Royal Society* 2008-10) chaired the European Academies' working group on Ecosystem Services & Biodiversity (report 2009) and, as Vice-President of the International Association of Ecology, chaired the organising committee of the XIth International Congress of Ecology (INTECOL 2013).

Advisory roles to research organisations, government and international projects. Advisory roles are encouraged and recognised within promotion criteria. Bancroft was on multinational steering groups for *Brassica* (2008-13) and *Arabidopsis* (since 2008, section chair 2010) Genome Projects; and advisor to the Oil Crops Research Institute in Wuhan, China (since 2011) and INRA in France (RAPSODYN project, since 2012). Edwards was advisor on establishing a biotech centre in Saudi Arabia (U Taif) and Defra guest of honour on Implementing UK strategy for Agri-Tech in 2013. Pitchford joined Cefas Science Advisory Committee in 2013; Fitter was a member of Natural England Science Advisory Council 2008-11; Ineson contributed to the International Advisory Panels for CLIMAITE (Denmark, 2007 on) and EU COST SIBAE (2008-11). Hartley was on the GMO panel of the European Food Safety Authority (to 2009) and joined the Science Advisory Board of the Centre for Ecology and Hydrology (since 2013). Graham sat on the Science Advisory Board of the French plant genomics program (Genoplante 2008-2011; GIS Biotechnologies Verte since 2012) and the John Innes Centre Council (Chair of its Science and Impact Advisory Panel since 2010). Several staff contributed to external reviews of HEIs (e.g. Smith M at Galway & Birmingham).

Contributions to policy development by research councils and charities. Biology staff play crucial roles in the strategic developments of funders. Bancroft was advisor to the BBSRC Office on development of a UK *Brassica* research strategy (2012). Edwards was on the BBSRC Technology Strategy Board, Chair of a BBSRC steering group, primary author of the '*Integrated Biorefining Technologies Initiative*' for the BBSRC Industry Club 2008, and Chair of the science panel for the BBSRC/DSTL Joint Synthetic Biology Initiative. Fitter was a member of NERC Council (to 2011). Hartley was a member (2008-09) of the review panel which advised BBSRC on the 5-year future priorities for research in environmental change. Leake was committee member (2011-12) to establish an EPSRC Physics Grand Challenge Network on Understanding the Physics of Life, and also a steering panel member for the UK biological physics network (from 2012). Maitland was chair of the Orchid Trust Advisory Board and Prostate Cancer UK scientific committees. McQueen-Mason was on the Steering Group of the BBSRC Integrated Biorefinery Technologies Initiative Research & Technology Club, and on the Scientific Advisory Committee for Research Councils' Energy Programme, and the Research Council Bioenergy Strategic Coordination Group. Smith D was a member of MRC Strategy Group (2007-10) and co-author of the MRC 5-year strategic plan 2009-14, and Kaye is MRC's advisory group (2012-) developing guidance on funding animal research.

Participation in peer-review. All staff refereed external grant proposals and papers for journals, and two-thirds participated on Research Council moderating panels and peer review colleges during the REF period, with additional roles for 9 charities and several professional societies: e.g. Smith D was MRC Infections & Immunity Board chair (2007-10), Wellcome Trust Investigator Award Interview Panel chair (2011-2013), and held similar positions for international funders in France, Canada, Portugal and Denmark (spanning 2009-13).

Journal editorships. Twenty-nine staff contributed to over 80 journal editor roles during 2008-13. Responsibilities ranged from editorial boards of *Behaviour* (Robinson) and *Animal Conservation* (Dasmahapatra) by ECRs, section editor of *BMC Evolutionary Biology* (Brockhurst) and special issue editor of the *Philosophical Transactions of the Royal Society B* (Leake) by established staff, multiple editorial roles by senior staff (e.g. 5 each by Davis and Hofreiter), through to roles as

editors-in-chief for *Biology Letters* (Fitter), *Ecological Entomology* (Hill), and *Genes* (Young). Hartley chaired the British Ecological Society Publications Committee to 2011, overseeing a >£1M *pa* portfolio and launching a new, highly successful (IF=5 in 2 yr) journal in 2010, *Methods in Ecology & Evolution*.

Fellowships, awards and prominent recognition during the REF period have been received by 22 members of academic staff, of all career stages.

Fellowships. ECRs Beale, Brackenbury and Robinson successfully obtained IRFs (EC, BBSRC, RS), and Walrad an MRC New Investigator Research Grant in 2013. Leake holds a Royal Society URF. Brockhurst and Hofreiter gained European Research Council Consolidator Awards. McGlynn obtained a Royal Society Leverhulme Senior Research Fellowship (2011-2012), Southgate a Japan Health Sciences Foundation Fellowship (2008) and Potts a British Heart Foundation Senior Basic Science Research Fellowship for 5 more years (2012).

Prizes awarded since 2008 include: 2009 British Ecological Society (BES) President's Medal for ecological research and 2012 BES Award for services to the society to Hartley, the 2011 Marsh Award for Conservation Biology to Hill, 2010 Young Investigator Award of the British Biophysical Society to Leake, 2009 Chopin Prize for excellence in European Urological Research to Maitland, 2010 Astellas European Foundation Award to Southgate, and 2011 Marsh Award for Climate Change Research to Thomas C. Bruce obtained the 2009 Environmental Restoration Project Award from the US Department of Defence (SERDP), and Bancroft (2010) and Graham (2013) were BBSRC Innovator of the Year finalists. Graham was also 2010 finalist for the Times Higher International Project of the Year.

Recognition. Fitter (FRS since 2005) was awarded a CBE in 2010, and Honorary Membership of the BES in 2013. Smith D was honoured with an OBE, in 2010, for services to biomedical sciences. Thomas C was elected Fellow of the Royal Society in 2012. Ineson received an Honorary Doctorate from the Swedish Agricultural Univ., Uppsala, in 2010. White FRSE was elected to EMBO (2009) and Fellow of the European Academy of Cancer Sciences (2011).

Effective academic collaboration at York. Collaboration is at the heart of our research foci, centres, and appointments (sections B and C), and shared facilities (section D: e.g. *Centre for Excellence in Mass Spectometry* and *York Centre for Magnetic Resonance*, both joint between Biology and Chemistry); 58% of our returned REF outputs involve collaborations between two or more academic staff at the UoY. Our *C2D2* research centre pump-primed 30 Biology/*CII* staff in inter-departmental collaborative projects.

External collaboration. All staff are encouraged and facilitated to engage in collaborative initiatives through annual performance reviews, criteria for promotion, travel funds, and pump-priming to establish links. Thirty academic staff had direct collaborations and/or funding from external, non-academic partners during the REF period, leading to co-authored outputs and/or impacts; 36% of our REF outputs have non-HEI co-authors. Success of our strategy to foster external collaborations is also indicated by 78% of our outputs involving collaborators with external HEIs and 45% with overseas collaborators. For example, McQueen-Mason has coordinated two EC FP7 programmes, one with 14 academic and 3 industry partners, the other with 7 academic and 6 industry partners in Europe, plus 30 partners in Brazil. Hill's *Science* and *PNAS* papers on insect migration involved collaborations with Rothamsted Research, the Met Office, the Centre for Ecology and Hydrology, and UK universities; and Thomas C collaborated with universities, business, museums, zoos and botanic gardens in 6 countries to define a novel approach to setting conservation priorities, published in *Science*. Staff have successfully responded to external opportunities to establish inter-institutional networks. For example, we established one UoY-coordinated EU Marie-Curie ITN with 7 other European Universities, Astra Zenica and Lonza Chemie (Bruce) and another with 7 other European Universities and MedImmune and Miltenyi Biotech (Kaye). We secured a £132K Flexible Interchange Program award (BBSRC) for Tim Bowser, a senior scientist from GSK, to join us for 18 months from June 2013 to enhance links between York and the pharmaceutical industry. Staff have participated in major collaborative initiatives, such as the National Ecosystem Assessment (Fitter) and 5th Intergovernmental Panel on Climate Change reporting process (Thomas C), helping to establish the national and international science evidence that informs policy.