Institution: University of Cambridge

Unit of Assessment: UoA6

A. Overview

The advancement of knowledge through research is the core ethos of the University of Cambridge's Veterinary School (UCVS) and this underpins all activity undertaken here. Our ambition is to be a centre of outstanding internationally recognised research excellence playing a significant and integrated role in the improvement of human and animal health ('one health'). UCVS is uniquely placed amongst UK Veterinary Schools to achieve this ambition by being a Department within the University's School of Biological Sciences, thus being fully embedded in an environment of internationally renowned research excellence. This is greatly enhanced by its proximity to, and close relationships with, leading research institutes, both within the University (e.g. the Gurdon Institute, the Wellcome Trust-MRC Stem Cell Institute, the Cancer Research UK Cambridge Institute) and externally to the University (e.g. the Wellcome Trust Sanger Institute, the Babraham Institute, the Cambridge Biomedical Campus at Addenbrooke's Hospital). A key aspect of our strategy is the successful identification, nurturing and advancement of individual scientists in our thriving research environment.

Research at UCVS encompasses basic and applied biomedical and veterinary sciences, across scales from the molecular to the population level and with a strong impetus to translate laboratory-based research into clinical practice. Our research activities are configured into **5 research themes**. These form foci for the generation of internal critical mass and provide a clear structure to facilitate interaction with others in the University and with the wider research community. The five research themes are: 1) **infection and immunity**, 2) **mathematical biology**, 3) **neuroscience**, 4) **comparative pathobiology**, and 5) **genetics and oncology**

B. Research strategy

B.1 Achievement of strategic aims during assessment period

A key component of our strategy since 2008 has been to fully integrate into, and to lead elements of the broader life sciences research agenda within the University. UCVS researchers have been key players in major interdisciplinary research initiatives, which have been given high priority and core funding by the University. For example, **Maskell** was the founder of *Cambridge Infectious Disease* and remains on the steering committee, along with **Heeney** and **Wood**. **Franklin** was co-PI for the *Wellcome Trust-MRC Cambridge Stem Cell Institute* award and is a member of the first *Cambridge Neuroscience* steering committee, having helped to found this Initiative. **Maskell** and **Wood** are co-PIs for the new *Wellcome Trust Cambridge Centre for Global Health Research*. **Maskell** is a member of the *Global Food Security Initiative* core steering committee. **Wood** is a member of the *Public Health@Cambridge* steering group and was instrumental in establishing the *Cambridge-Africa* programme, being on the core steering group.

The research strategy outlined in RA5a RAE 2008 was focused around four themes: infection and immunity (I&I), neurosciences, genetics and pathobiology of whole organisms (PWO). Building on success, each of these themes has been developed in the current strategy, and we have built an additional theme, mathematical biology, which has evolved as a separate element from the I&I theme. On average 250 papers per annum have been published from the UCVS between 2008 and 2012, many being in high impact journals (e.g. *Nature, Science, Cell, Cell Stem Cell, PNAS, PLoS Biology, Nature Neuroscience, Nature Genetics, Genes & Development, Lancet Infectious Disease*) and leading veterinary journals (*Veterinary Microbiology, JVIM, JAVMA, Preventive Veterinary Medicine, Veterinary Pathology*). The following summary of the period 2008-2013 provides evidence of the successful implementation of our research strategy using illustrative examples.

In I&I, **Bryant** has established major international standing through her work on pattern recognition receptors, leading to substantial programme-level support from both the Wellcome Trust and the MRC, significant international collaborations with leading players in this highly competitive field, and her promotion to a personal Professorship. Her discoveries include the responses of different domestic species to infectious agents, and led to the establishment of the early events in allergic

responses of humans to cats, published in the *Journal of Immunology*, with attendant world-wide media coverage. Significant developments have taken place in integrating laboratory biological research in I&I with mathematical modelling and physical sciences, with mathematical biology establishing itself as a theme in its own right, led by **Wood, Frost, Restif** and **Russell**. **Bryant** and **Maskell** have established significant and productive interactions with colleagues in the physical sciences, using, for example, optical tweezers and state-of-the-art imaging technology to obtain novel insights into host-pathogen interactions at the level of the individual cell or organism. **Grant**, **Mastroeni**, **Maskell** and **Bryant's** interactions with mathematicians, especially **Restif** at UCVS along with other colleagues from the Department of Applied Mathematics and Theoretical Physics at Cambridge, have led to high-profile publications that have challenged existing dogma about pathogen spread within host organisms. **Maskell** and colleagues (especially at the Sanger Institute) have led the field in the application of new high-throughput genome sequencing technologies to problems of livestock infectious diseases. This has resulted in technology development and the generation of key datasets published in high profile journals. This also resulted in **Maskell** and **Tucker** being awarded one of the largest BBSRC LoLa grants, with significant support from Pfizer Animal Health (now Zoetis), for research into respiratory pathogens in pigs. **Heeney** has been leading on lentiviral vaccine development, supported at Programme Grant level by the Wellcome Trust and the Bill and Melinda Gates Foundation. **Tiley** has led ground-breaking and widely publicised work, published in *Science*, demonstrating that transgenic integration of viral interfering genes can limit the transmission of avian influenza between infected chickens. **Wood** pioneered experiments that set up transmission chains between animals to characterise within-host evolution of influenza virus in naïve and vaccinated pigs and horses. He also developed epidemiology and mathematical biology, along with **Frost** and **Restif**, as a major UCVS research activity leading to the new mathematical biology research theme. **Russell** has pioneered the application of antigenic cartography and viral phylogenies to understand the annual global circulation and evolution of influenza viruses, with a series of publications in *Science* and *PNAS* leading to his direct involvement in the decision-making process at the World Health Organisation concerning which influenza vaccine to use each year. Highly significant advances have been made in understanding bovine TB in cattle (with **Brooks-Pollock**, **McKinley** and **Conlan**), bat-borne potentially zoonotic diseases in Africa (**Wood, Restif**) and in human meningitis epidemiology and vaccination (**Trotter**).. Pioneering work in experimental design and measles epidemiology has also been made by **Conlan** and in Bayesian epidemic model-fitting by **McKinley**. The discovery of a new MRSA in animal and human populations by **Holmes,** published in *Lancet Infectious Disease*, has triggered an extensive and important programme of work with international collaborators, significant funding from the MRC, and changes in the nature of the diagnostic test used to identify MRSA in public health laboratories. **Kaufman** continued his work on avian immunology with publications in *PNAS*, developing important conceptual frameworks to explain how the MHC of non-mammalian vertebrates works in comparison to typical mammals. **Cantacessi** has maintained a high level of research activity in molecular parasitology, studying several parasitic species of significance to animal and human health.

In Neuroscience, **Franklin** and **Zhao** made several important, high-profile discoveries regarding the regulation of remyelination (published in *Nature Neuroscience, Genes & Development* and *Cell Stem Cell*). These received extensive media coverage and have opened up exciting new avenues for the development of regenerative therapies for demyelinating diseases such as multiple sclerosis. This has led to the first clinical trial of a small molecule as a regenerative therapy for MS. **Franklin**, **Zhao** and **Karadottir** secured renewed significant programme grant funding from the UK MS Society for the Cambridge Centre for Myelin Repair. **Franklin** gained MRC support to conduct the first randomised double blinded cell therapy trial in spinal cord injury. In a study using domestic dogs with clinical spinal cord injury that received world-wide media coverage, he established that autologous olfactory ensheathing cell transplantation restored locomotor function and at the same time validated veterinary clinical cases as intermediate models for translation between laboratory species and human disease. **Karadottir** obtained a Wellcome Trust Career Development Fellowship, working on the electrophysiological function of CNS stem cells, resulting in a publication in *Nature Neuroscience*. **Franklin** (via a Human Frontiers Science Programme) and **Karadottir** developed key links with physicists to explore the mechanical properties of adult CNS stem cells and damaged CNS. This theme made a key contribution to the establishment of the

MRC Cambridge Centre for Stem Cell Biology and Regenerative Medicine and subsequently the Wellcome Trust-MRC Cambridge Stem Cell Institute (with **Franklin** directing the neural stem cell theme). In the prion disease group **Bujdoso** established an important new model for prion disease in Drosophila while **Williams** continued working on the mechanisms of prion-mediated cell death.

In Genetics and Oncology, **Sargan** worked on inherited eye diseases of dogs and, through membership of a consortium funded by EU Framework 7, identified genetic factors predisposing dogs to anal sac carcinoma. **Dobson** continued her programme in comparative oncology, developing an miRNA-based sarcoma classification and a topical photodynamic treatment for feline squamous cell carcinoma. The genetics and oncology theme has been significantly strengthened, as an important part of our future strategy, by the recruitment of **Murchison**, a young scientist of outstanding promise. Her work on a transmissible tumour of marsupials has been reported in a series of high profile publications in *Nature, Science* and *Cell*. UCVS will continue to support growth in oncological genetics, a natural evolution of this theme's work.

The diverse achievements in the Pathobiology of Whole Organisms theme reflect the wide range of topics covered. **Davison** obtained a Wellcome Trust Intermediate Fellowship to continue her work on the genetics of endocrine disease. **Gibson** made several key discoveries relating to the pathophysiology of red blood cells, including the first demonstration that sickle cells can be patch-clamped in order to record deoxygenation-induced conductance. **Henson** established key collaborations with the Orthopaedics Research Unit at the University's Biomedical Campus enabling her to make significant progress with her programme on osteochondral healing in horses and to establish strong links with the pharmaceutical sector. **Watson** identified chronic canine pancreatitis as being a significant clinical problem and identified breed predisposition to chronic hepatitis, focusing now on the English Springer Spaniel.

B.2 Future strategic aims for research over the next 5 years

Our high-level strategic aims over the next 5 years are: 1) to consolidate and enhance UCVS as an internationally recognised centre for research excellence in veterinary and comparative biomedical sciences, 2) to take our distinctive and defining ethos of research excellence and to ensure that it is the driver of all of our activity, especially embedding this in the teaching of our undergraduate students and 3) to lead the University of Cambridge in comparative biomedical science by extending and integrating our science into the activities of the broader research-driven University as well as into our extensive international collaborations and initiatives. We are actively pursuing opportunities for expansion and future development, including the establishment of a centre for post-graduate training in veterinary research (to which end we will continue to maintain a dialogue with key policy makers within agencies such as the Research Councils and the Wellcome Trust).

B.2.1 Developing and sustaining an active and vital research culture

Overall responsibility for research lies with the **Head of Department** (HoD, **Maskell**), who, through membership of the Council of the School of Biological Sciences (SBS), integrates UCVS research activities with wider initiatives within the SBS and the University. Within UCVS, research strategy is the responsibility of the **Director of Research** (DoR - **Franklin**), who promotes and facilitates research through chairmanship of the **Research Strategy Board**, and by providing advice, guidance and feedback on grant submissions. The DoR is assisted by a full-time **administrator** dedicated wholly to research, who provides detailed support on grant budgeting and management, and regularly disseminates information on funding opportunities to all academic staff. We have recently invested in an additional support position in this area to aid implementation of research strategy. The roles of these positions are being developed to build on the progressive successes in our grant funding over the review period. Critical to our success has been personal encouragement of and support for all academic staff in grant-writing.

Within the department, co-ordinated research activities are promoted by the following mechanisms. 1) **Friday morning seminar** (FMS) – this occurs for one hour throughout term time and involves two members of staff, post-doctoral research associates or students giving a 20 min presentation with 10 min of questions. It is attended by and contributed to by all academic staff and post-graduate trainees (both clinical and research). 2) **Research workshops** – these occur 2-3 times per term, chaired by the DoR. The content is varied and includes presentations and

discussion on grant writing and submission, using statistical analysis in planning experimental and clinical studies, funding opportunities, major research initiatives *inter alia* 3) **Departmental seminars**, held weekly during term time, at which international-level speakers from the UK and overseas are hosted by each of the research themes. 4) **Frequent electronic communications** to academic staff with focussed funding opportunities. 5) **Research notice board** and **research news feeds** on the departmental website homepage displaying recent papers published by, and grants awarded to, staff members and news on funding opportunities. 6) Announcements of major research initiatives and discoveries on the **departmental website**. 7) Frequent research-focussed **press releases** via the University's Office of External Affairs and Communications. To facilitate research using clinical cases we have instigated an efficient, rapid-response system for undertaking **ethical review**. Outcomes are reported annually to the University's Ethics Committee. In support of the UCVS mechanisms for promoting research, the University has significantly enhanced its research website, providing a suitable online presence for the range of research carried out at Cambridge. The website ensures a strong institutional interdisciplinary research culture and acts as a home for the University's Strategic Initiatives and Networks.

B.2.2 Promoting interdisciplinary research

Many UCVS researchers play key roles in the University's **Strategic Research Initiatives** (SRI), selected by the University's Research Policy Committee (RPC). SRI status is awarded for 3 years, renewable for a further 3 years. The University funding that accompanies this recognition supports dedicated co-ordinators, who bring researchers together to undertake innovative interdisciplinary work. Several **Centres** and **Institutes** are associated with or have emerged from these SRIs.

SRIs involving UCVS researchers include:

- Global Food Security *(Heeney, Maskell, Tiley)*
- Cambridge Infectious Disease *(Blacklaws, Brooks-Pollock, Bryant, Bujdoso, Conlan, Frost, Grant, Heeney, Holmes, Maskell, Mastroeni, McKinley, Restif, Russell, Tiley, Trotter, Tucker, Wood)*
- Cambridge Neuroscience (*Franklin, Zhao, Karadottir, Kazanis, Bujdoso, Williams*)
- Cambridge Immunology *(Blacklaws, Bryant, Bujdoso, Frost, Heeney, Maskell)*
- Cambridge-Africa programme *(Wood)*
- Public Health@Cambridge *(Frost, Grant, Heeney, Wood, Maskell)*

Centres and Institutes that include UCVS researchers:

- The Cambridge Cancer Centre *(Dobson, Constantino-Casas, Sargan, Murchison)*
- Wellcome Trust-MRC Cambridge Stem Cell Institute *(Franklin, Karadottir)*
- Wellcome Trust Cambridge Centre for Global Health Research (*Wood, Maskell*)
- John van Geest Centre for Brain Repair *(Franklin, Karadottir, Zhao)*

B.2.3 Facilitating research by clinical staff

All members of academic staff are expected to maintain activity in teaching, research and administration. For clinical staff there is an additional and substantial role in providing a high quality clinical service. Finding time to commit to pure research activities can prove immensely difficult. To facilitate research by clinical staff, UCVS has instigated the following measures:
Optimising research time for clinical staff. **Staff clinicians** have been employed in all major clinical disciplines, with a specific remit to undertake clinical referral work in order to allow clinical academic staff significant protected time (up to 50%) to pursue their research programmes.
Promoting research training for future recruitment of research-trained clinicians. An over-riding priority of our research strategy is to secure the highest quality research training for young and ambitious academic clinicians who will in the future form the basis of the profession's clinical academic staff. This involves continued maximum use of Wellcome Trust and other fellowship programmes at both PhD and post-doctoral levels. We have encouraged individuals to embrace broad biomedical sciences with considerable success.

C. People

C.1 Staffing strategy and staff development

C.1.1 New staff appointments

UCVS obtained a benefaction from the Alborada Trust to establish a Chair in Equine and Farm Animal Science to which **Wood** was appointed; a further benefaction from the same Trust has allowed the establishment of a Lectureship in Epidemiology, which allowed progression of **Restif** from a successfully sponsored Royal Society University Research Fellowship (URF) into a permanent position. **Russell** was recruited to the department while on a Royal Society URF. **Cantacessi** was appointed to a Lectureship in Parasitology. **Bryant** obtained a BBSRC Research Development Fellowship, supporting her interactions with collaborators in mathematics and the physical sciences, and was promoted to a personal Professorship. **Brooks-Pollock** was recruited on an EPSRC Fellowship, and **Trotter** to a Fellowship funded by the Bill and Melinda Gates Foundation. In Neuroscience **Zhao** was appointed as an Assistant Director of Research (a position equating to a non-teaching Lectureship) while **Karadottir** was successfully sponsored for a Wellcome Trust Research Career Development Fellowship. In the newly created theme of Genetics and Oncology **Murchison** has been appointed to a Readership. In PWO **Davison**, an active clinician in small animal medicine, obtained a Wellcome Trust Clinical Intermediate Fellowship to establish research independence.

C.1.2 Supporting Research Career Development

The University has a generous scheme whereby UCVS Teaching Officers are entitled to **sabbatical leave** of 1 term for every 6 terms served, up to a maximum of 3 terms at any one time. During this period 8 staff (from approximately 30 eligible staff) have benefitted from this scheme. The UCVS has established a **mentoring** scheme for newly appointed staff, especially with regard to helping them establish independent and collaborative research programmes. Mentors meet regularly with mentees, discussing research directions and strategy, identifying funding opportunities and giving support in writing grant applications. Mentors discuss publication strategy and help with any day-to-day issues that arise in managing a research group. All UCVS staff participate in the **Staff Review and Development (Appraisal) Scheme**, based on a centrally approved framework. The appraiser may be the HoD but may also be a nominated trained representative, as appropriate to the appraisee's needs. A joint review is carried out on the completion of any probationary period and at least every two years thereafter. Each review consists of a self-assessment by the staff member, its assessment by the reviewer, a face-to-face meeting to discuss specific needs, and plans for the next review period. A written record of the process (including an action plan) is then made. Staff training and development needs are met from courses offered by the University's **Personal and Professional Development** unit, which cover subjects from teaching and administration, to data security, managing stress, and leadership. Other training courses are provided by the University Language Centre, Computing Services and the University Library. The **Newcomers and Visiting Scholars Group** meets weekly and aims to help new staff to meet and to network with fellow new arrivals.

Concordat to Support Career Development of Researchers. The UCVS recognises and implements the seven principles of the **Concordat to Support Career Development of Researchers**, in conjunction with University policies and procedures. In recognition of its work fostering good working conditions and career development, the University has received the European Commission's **HR Excellence in Research** badge. The University launched its **Employment and Career Management Scheme (ECMS)** in April 2011, which sets out a clear framework for the induction, probation and appraisal of contract research staff. Here, all members of research staff have an initial induction meeting with their PI to identify their development needs and make arrangements for mentoring and appraisal. We also meet the Concordat principles through: 1) a University accommodation service, which gives priority to new arrivals; 2) transparent pay scales, clearly aligned to grade profiles; 3) extensive specialist and transferable skills training at early and later career levels; 4) HR teams offering meetings to staff at risk of redundancy to discuss future options and support. If posts cannot be renewed, research staff receive internal vacancy lists for 6 months and will be interviewed if they apply for roles advertised therein.

C.1.3 Development of early career researchers (ECR)

Pathways in Higher Education Practice (PHEP) is a scheme designed to offer personal, flexible orientation and professional development for newly appointed Lecturers. The course begins with two compulsory components: a one-to-one meeting with a PHEP Consultant to discuss the

teaching and learning environment at Cambridge, to address any questions the new employee has, and to discuss career progression; and a two and a half day seminar addressing teaching, research and administration. ECRs can take advantage of training specifically designed for Research Staff and the 'Academic Practice' programme for new lecturers. Practical support in public engagement is provided by the **Office of External Affairs and Communications** (OEAC). OEAC provides researchers with outreach opportunities, including the annual Cambridge Science Festival, which attracted over 35,000 visitors in 2012.

The **Careers Service** offers specialist careers advice for contract research staff. ECRs in UCVS can draw on a bespoke Life Science advice programme. ECRs are provided with detailed online careers advice, seminars and face-to-face advice with a dedicated advisor.

Postdocs Of Cambridge is a University Society for early-career researchers. It offers guidance on opportunities available around Cambridge and organises monthly networking meetings. UCVS also has its own Post-docs group, affiliated to Postdocs of Cambridge, which meets regularly to discuss science as well as to provide social events. Professor Chris Abell of the Department of Chemistry has been appointed Director of Post-Doctoral Affairs at the University.

C.1.4 Supporting equality and diversity

The University of Cambridge abides by its **Equal Opportunities Policy** in all matters relating to staffing. It is committed to ensuring that no applicant for a University post, nor any member of staff, is treated less favourably on a wide range of grounds as embodied in the Equality Act 2010. The University has a **Disability and Employment Policy** that formalises Cambridge's anti-discrimination policies and a Dignity@Work policy with procedures for dealing with harassment, bullying and other inappropriate behaviours. In 2010 the University adopted a **Combined Equality Scheme** that creates a unified strategy for improvement in these areas. Since October 2009, the University's **Equality Champions** have supported the **University Diversity Networks**. In 2011/2 the University won a number of awards for its work in engaging and working with staff, being ranked 11th (the highest for any UK HEI) on the **Stonewall list** and winning an **Employee Engagement award** from the Employers Network for Equality and Inclusion.

The **Gender Equality Group** advises the University on equal pay and continually monitors pay levels: it makes recommendations to ensure continued improvement. A range of **equality and diversity training opportunities** is offered. The University's **Women in Science, Engineering and Technology Initiative** (WiSETI) promotes and supports women at all levels in STEM subjects. The WiSETI committee led the successful renewal of the University's Bronze **Athena SWAN award** in 2013. **UCVS was awarded an Athena SWAN Bronze Award in September 2013**. Staff have extensive parental leave entitlements, and in particular circumstances, the University allows a career break of up to 2 years after maternity leave. UCVS staff have taken advantage of the availability of **flexible working hours** to fit personal circumstances. The University has two **workplace nurseries**, costs of which can be paid in Salary Exchange schemes. The University's Holiday Playscheme offers activities for children between the ages of 5 and 14. **Cambridge Occupational Health** provides support for the physical and mental well-being of all staff. The **Disability Resource Centre** provides wide-ranging advice on providing resources for disabled staff. A free **Counselling Service** is offered to University staff, for work-related or personal issues, with various self-help guides.

C.2 Research students

UCVS offers MPhil by research and PhD training to 30-40 students at any one time. In keeping with a 'one health', interdisciplinary philosophy, the Department accepts medical and biological science students as well as veterinary students. UCVS students receive funding from BBSRC, MRC, the Wellcome Trust, the Gates Foundation, the Cambridge Overseas Trust/Cambridge International Scholarship Scheme, the Cambridge Home and European Scholarship Scheme and various other funders. The 3-year PhD route is increasingly being replaced by 4-year courses.

C.2.1 Wellcome Trust Clinical Veterinary Research Training Award (CVRT)

Maskell was a co-applicant on CVRT. **Franklin** chaired the UK Veterinary Schools' Research Directors/Deans CVRT Advisory Group and was a member of the CVRT Steering Committee, ensuring that applicants chose research environments on the basis of research excellence. UCVS played an active role in the scheme, obtaining 2 research entry fellowships, 3 integrated clinical

fellowships and 1 post-doctoral fellowship (in addition to the 3 research training fellowships and 2 post-doctoral intermediate fellowships that UCVS applicants have been awarded by the Wellcome Trust since 2008, outwith the dedicated veterinary scheme). **Franklin** was also instrumental in involving veterinary fellows in the Academy of Medical Sciences mentoring scheme.

A component of the CVRT award was continued support for the **Fundamentals of Veterinary Science Summer School**, run by UCVS. This highly successful nine-week residential course is open to veterinary science undergraduates from around the world, offering them the opportunity to consider research-based careers following the successful completion of their clinical training. Participants perform a research project, explore current veterinary problems through discussion with experts in the field and develop skills in problem-solving, teamwork and communication. Symposia guided by expert scientists and veterinarians allow a detailed exploration of potential careers in veterinary science, both clinical and non-clinical, in private or public sectors. The Summer School attracts high-quality, motivated students, many of whom progress to PhD studentships, including at Cambridge. A total of 169 participants have attended the Summer School over its lifetime. Of these, 101 (60%) have gone on to study a second degree and 62 (37%) have gone on to study for a PhD. Alumni have become research leaders in academia and government and senior managers in the pharmaceutical industry.

C.2.2 Generic research skills training

UCVS contributes to and also uses University-wide skills training schemes. All postgraduates spend 10 days per year undertaking training and keep a skills development log. **The Cambridge University Skills Portal** provides an access hub for skills training for all research students for courses offered by the broad range of University providers. The Skills Portal also hosts online courses on research, transferable and career planning skills, and information on key topics such as ethics and intellectual property.

UCVS belongs to **The Graduate School of Life Sciences (GSLS),** which makes decisions on educational policy and training, and co-ordinates funding for graduate students and post-docs in the School of Biological Sciences, the School of Clinical Medicine and UCVS. UCVS research students and post-docs access the GSLS education committee through a Graduate Student and Post-doc Forum (GRASP). UCVS has been well represented on the GSLS committee at both student and academic levels during the period. The GSLS provides a comprehensive list of training offered across the University, including a recommended basic training schedule for PhD students who wish to pursue academic or non-academic careers. Many of these courses are provided by specialists from the University's **Graduate Development Programme (GDP)**, and the **Researcher Development Framewo**rk (RDF), developing skills and understanding to enrich doctoral student approaches to research and teaching. The core programme addresses the PhD experience, writing skills, presentation and communication, commercial awareness and business skills, personal development, stress management, and teaching and lecturing. Subject-specific classes, also open to all research students, enhance their breadth of knowledge and the scope of interdisciplinary study. GSLS also provides business skills courses at Judge Business School and statistical training through the University Statistics Clinic. Free access is available to the residential **GRADschool** for 2nd and 3rd year students, providing a novel slant on skills training.

A broad range of researchers takes advantage of the central training programmes supported by specialist skills training at institutional centres. These include the **University Language Centre** and, the **University of Cambridge Computing Service**. The Research Skills Programme at the **University Library** includes general information skills sessions (including online searching, referencing, and information management) and subject-specific training (including courses designed for science PhDs). Further doctoral student training is also offered by the **OEAC**, which runs the 'Rising Stars' public engagement programme, including public engagement and provision of practical experience through organising and delivering an outreach event.

The University also offers careers advice, which is comprehensive and specific to graduate students, through the **Cambridge Careers Service**. This includes online resources, workshops, events and one-to-one advice with a careers advisor for students planning an academic research career and those planning to move away from academic research. Specialist advisors also offer advice and assistance for job applications and interviews. This support is complemented by training offered by the **Centre for Entrepreneurial Learning** (CfEL). CfEL offers a range of

business and entrepreneurial skills courses, lectures and workshops, as well as direct support for doctoral students developing spin-out companies. Further business skills training is offered by the **Cambridge University Technology and Enterprise Club** (CUTEC), a student-run organisation that hosts a range of talks, workshops, mentoring and networking sessions to develop business-related insights and knowhow. Linked to CUTEC is the **i-teams Cambridge** scheme, where multi-disciplinary teams of students work with researchers and industry mentors to investigate potential markets for new University-produced technology.

UCVS has been especially influential within the GSLS and more widely in graduate education. **Sargan** was Director of Education for the GSLS from 2007-2011. He also co-ordinated and was primary author of the University and Partner Institutes' current **BBSRC** Doctoral Training Partnership (DTP) award as well as co-ordinating the previous group of BBSRC DTG applications. **Maskell** and **Wood** are on the management committee of the current DTP. **Sargan** wrote the University's current Portfolio Agreement with the **MRC** and remains on the management committee for the University's MRC DTA. He represents the Schools of Biological Sciences and Clinical Medicine in the **Gates Cambridge Scholarship** short-listing group and its interview panel, and directs the University's collaboration with the **A*Star** (Singapore) **Graduate Academy**.

C.2.3 Physical Facilities

All students and postdocs have dedicated office and laboratory space, with computers and access to core equipment. The provision of equipment is excellent. The University's copyright deposit and the departmental libraries provide excellent access to written materials (hard copy and eJournals). A public workstation facility is available in UCVS. Common-rooms may be accessed by all members of UCVS. Other recreational facilities (gyms, sports, bars, etc.) are available to all.

C.2.4 Specialist doctoral programmes

The Schools of Biological Sciences and Clinical Medicine host **specialist doctoral programmes**. These are generally 4-year courses that dedicate the first year to preparatory modules. UCVS has hosted PhD students from the Wellcome Trust Programmes in (1) Infection and Immunity, (2) Mathematical Genomics and Medicine and (3) Stem Cell Biology as well as (4) the Cambridge-NIH PhD Programme and (5) the BBSRC DTP in Biological Sciences

C.2.5 Student involvement in Departmental and research communication and management

Students are part of laboratory groups that have regular laboratory meetings at which research is presented and experiments discussed informally and in detail. All students present a 20-minute talk at the FMS at least twice over the PhD course. Students are members of a postgraduate Journal Club, often in addition to their own laboratory-based journal club. Student input into departmental management occurs through representation on the departmental Education Committee. University and departmental developments are discussed at six-monthly meetings led by the HoD.

D. Income, infrastructure and facilities

D.1 Research Income

Since 2008 the UCVS's research income has nearly doubled from around £3m per annum to around £5.6m per annum - 2007-08: £3.320m; 2008-09: £4.578m; 2009-10: £4.295m; 2010-11: £5.006m; 2011-12: £4.930m; 2012-13: £5.640 m. The mainstay of research income support has been from BBSRC, MRC, and The Wellcome Trust with other major awards from medical charities. For example, **Wood** was PI on a grant of £1.7 million for the Wellcome Trust/BBSRC/MRC/DEFRA Combating Swine Influenza Consortium and co-investigator on the £3.2 million ESPA Dynamic Drivers of Disease in Africa Consortium; **Franklin** was PI on a grant of £2.2 million from the UK MS Society for the Cambridge Centre for Myelin Repair; **Maskell** and **Tucker** were part of a consortium awarded a BBSRC LoLa grant worth in total £5.6M with £2.3M for UCVS. Wood and Maskell are co-investigators on the £750,000 *Wellcome Trust "Cambridge Centre for Global Health Research"* Award. The UCVS programme in mathematical biology was strengthened by the £3.4M benefaction from the Alborada Trust, which also provided a research award of US$1M for Cambridge-Africa collaborations.

D.2 Research infrastructure and facilities

D.2.1 Clinical research facilities

Supported by the University, UCVS has undergone extensive laboratory refurbishment over the last 10 years, including the refurbishment of laboratories to provide containment level 3 facilities for infectious disease work (completed April 2008). Recent emphasis has been on improving facilities for clinical research. A former small-animal operating theatre has been converted into a clinical laboratory suite containing, *inter alia*, a whole body plethysmography chamber, and a treadmill and force plate, both of which have been used in the olfactory ensheathing cell clinical trial on canine spinal cord injury and in the orthopaedics clinical research programme within the comparative pathobiology theme. A £3.2M refurbishment project, which began in June 2013, will provide state-of-the-art clinical skills and clinical pathology laboratories, including an area dedicated for small animal clinical research projects.

D.2.2 Equipment

Since 2008 UCVS has made key investments of £1,564,122 in new equipment and infrastructure: examples include two confocal microscopes, a benchtop Illumina sequencer (MiSeq), a laser capture microdissector, high-speed and ultra centrifuge rotors, FACS for the category 3 laboratory, and a Laboratory Information Management System for our clinical research database project.

D.2.3 Clinical Records Archiving

UCVS invested in a **Clinical Records Information System** (CRIS) incorporating a powerful database for storage of patient data, with facilities for searching and retrieval of data for clinical research. This infrastructure is being enhanced in-house and is an invaluable resource for many current clinical research projects.

E. Collaboration and contribution to the discipline or research base

E.1 Collaborative, cross-disciplinary and industrial interaction

UCVS researchers have made significant contributions to national and international research agendas. Many funded interactions occur with other research groups within and around Cambridge, as well as further afield. There are many examples of cross-disciplinary research – e.g. the Human Frontiers Science Programme-funded project involving **Franklin**, and co-PIs from Physics at Dresden and Engineering at MIT concerning mechanotransduction in CNS stem cells. **Bryant**, **Maskell** and **Franklin** all have strong collaborations with colleagues in Physics in Cambridge and several in the Department (**Bryant**, **Mastroeni**, **Wood**, **Restif**, **Frost**, **Maskell**) work nationally and internationally at the interface between mathematics and biomedicine. **Wood** has also worked carefully in his African collaborations to develop a framework for interactions between social, biomedical and quantitative sciences.

E.2 Industry interaction

UCVS regards interactions with industry as a key component of its research strategy and its researchers have had an extensive range of interactions (e.g. consultations, industry-funded collaborations and case studentships). A fuller account is provided in the **Impact statement**.

E.3 Grant committees

UCVS staff have made significant contributions to the broader research community through membership of grant review committees. **Bryant** is a member of the BBSRC Pool of Experts and the Health Research Board (Ireland) Post-Doctoral Fellowship Interview Panel. **Davison** is secretary of the BSAVA Petsavers Grant awarding committee. **Franklin** is on the Wellcome Trust Expert Review Group (Neuroscience), MRC Regenerative Medicines Research Committee and the RCVS Research sub-committee, and the scientific review committees of the International Spinal Research Trust and the UK Multiple Sclerosis (MS) Society, the French MS Society and the European Leukodystrophy Association and has served on the Wellcome Trust Clinical Interview Committee and the Health Research Board of Ireland Neuroscience Panel. **Heeney** was on the Wellcome Trust Infection & Immunity Panel and is on the scientific review committee of the Cancer Vaccine Institute and the Joint DFID/BBSRC/ESRC/MRC/NERC Zoonotic and Emerging Livestock Systems initiative. **Maskell** is a member of the European Research Council LS6 Starter and Consolidator Grants review panel and of the Canada Foundation for Innovation Multi-disciplinary Assessment Committee. He was a member of the Health Protection Agency Strategic Research and Development Fund expert grants panel. He chaired the RCVS Research sub-committee until

its end in 2013. **Mastroeni** has been a member of the Review College for the Strategic Partnership on Animal Science of the Rural and Environmental Research and Analysis Division of the Scottish Government and the Review Committee for the Middle Atlantic Regional Center of Excellence (MARCE) for Biodefense and Emerging Infectious Diseases Research of the United States. **Wood** and **Maskell** are members of The Horse Trust Scientific Sub-Committee.

E.4 Journal editorships

Indicative of the esteem in which UCVS staff are held, many are members of journal editorial boards. **Blacklaws** is on the editorial board of *Small Ruminant Research*. **Bryant** was an associate editor and is now section editor of the *Journal of Immunology*. **Franklin** is a founding co-editor of *Brain Plasticity* and is on the editorial board of *Experimental Neurology* (cellular and molecular section head), *Stem Cell Research and Therapy*, *Glia*, *Cell Death and Disease* and *The MS Journal*. **Heeney** is on the editorial board of *Expert Opinions in Molecular Medicine*, *The Journal of General Virology*, *Molecular Immunology* and *Expert Reviews in Molecular Medicine*. **Gibson** is in the editorial board of *ISRN Haematology*. **Kaufman** is in the editorial board of *Immunogenetics*, *Tissue Antigens* and *Journal of Experimental Zoology B*. **Maskell** is a Section Editor for the *Equine Veterinary Journal* and is an occasional Editor for the ASM journal mBio. **Mastroeni** is on the editorial board of *Microbes and Infection* and has been a guest editor of *PNAS*. **Paterson** is on the editorial boards of *Journal of Applied Microbiology*, *Letters in Applied Microbiology*, and the *International Journal of Medical Microbiology*. **Wood** is on the editorial board of the *Veterinary Record* and chairs *Equine Veterinary Journal Ltd*.

E.5 Consultative or policy committees

Bryant is a member of the UK Veterinary Products Committee. **Dobson** is an expert advisor to the European Medicines Agency (EMA) Scientific Committee. **Franklin** is a member of the scientific advisory committee of the Combined UK MS and Parkinson's Society Brain Bank, and served on the MS Society Research Strategy Committee. **Gibson** is on the steering committee of the European Red Cell Society. **Heeney** is chairman of The Jenner Institute Scientific Advisory Board and an expert member of European Commission: Infectious and Zoonotic Diseases, The European Medicines Agency and WHO & UNAIDS Vaccine Initiative. **Maskell** is a member of the Food Standards Agency General Advisory Committee on Science, BBSRC Animal Disease Working Group and the Research Excellence Framework (REF) Unit of Assessment 6 Sub-Panel. He is a non-executive Director of the Moredun Research Institute, a member of the International Scientific Advisory Board of the Oxford University Clinical Research Unit, Viet Nam, a Visiting Professor and member of the Scientific Advisory Board of the i3 Institute at the University of Technology, Sydney, a member of the Scientific Advisory Boards of the Pirbright Institute and the Roslin Institute, and a Board Member and Trustee of the Institute of Food Research. He was Deputy Chair of a BBSRC delegation to India to assess livestock research opportunities in 2012. **Sargan** is a member of the Advisory Council for the Welfare Issues of Dog Breeding and a trustee of the University Foundation for Animal Welfare. **Watson** was chair of the British Small Animal Veterinary Association Scientific Committee (2012-13). **Wood** chaired the European Medicines Agency working group on modelling evidence for licencing applications and was a member of the MRC review panel for the Imperial College Outbreak Modelling Centre, and the BBSRC Council sub-committee reviewing financing of the high containment unit at Pirbright. He is currently a member of the Defra TB Eradication Advisory Committee, the Roslin Institute Scientific Advisory Board and the National Equine Disease Coalition.

E.6 Awards

Franklin won the 2011 MS Society Researcher of the Year award and was runner up in 2012. **Maskell** was elected a Fellow of the Academy of Medical Sciences in 2011. **Maskell** and **Tucker** won the Dieter Lutticken Award in 2010 for research contributing to the "3Rs" in animal experimentation. Especially noteworthy has been the success of younger UCVS staff: **Hughes** won the 2012 Royal College of Pathologists Gold Research Medal for Trainees, while **Murchison** has won the L'Oreal UNESCO for Women in Science Award in 2009, The Genome Technology Young Investigator of the Year Award in 2011 and the Eppendorf Young Investigator Award and MRC Jewellery Heirloom Award in 2012.