Institution: Royal Veterinary College

1. Context and mission

The Royal Veterinary College (RVC) is a specialist institution, with an established, world-wide reputation for providing pioneering leadership in developing new insights into animal health and disease. In continually generating new knowledge through research, our mission is to ensure this is applied to advance the practice of veterinary medicine, improve public health, enhance people's livelihoods by addressing global issues of poverty and hunger and inform society's use of animals to improve their welfare. Working with partners and stakeholders we subscribe to the 'One Health' philosophy, recognising that for our contributions to have impact, the solutions we develop need to be economically, socially and politically acceptable. Thus, interdisciplinary approaches are needed to address the challenges we work to solve. Furthermore, the comparative approaches veterinary medicine has taken to study how animals function in health and disease extend to human medicine, and we recognise the great value in working and sharing knowledge with medical colleagues to identify where discovery in veterinary patients may inform human medical advances, and *vice versa*.

The RVC is the only self-governing UK veterinary academic institution. Membership of the federal University of London coupled with the independence to determine our strategic direction makes us unique amongst UK Veterinary Schools. Our international reputation for inspirational leadership of veterinary science is evidenced by our QS University World Ranking. We have ranked in the top 3 (with UC Davis and Cornell, Utrecht or Edinburgh) since veterinary science was introduced (2015), reaching first place in 2019 and 2021. Number of citations over 5 years (normalised for number of academics) is one criterion used to determine these rankings and RVC leads in this with 98.9. Since REF2014, the proportion of our publications including international co-authors has increased from 38.3% in 2013 to 56.8% in 2019; evidence that the RVC is seen internationally as an excellent institution with which to collaborate.

The RVC makes one return to UoA-6 in REF2021. The decision to do this reflects our integrated approach between basic, applied and clinical disciplines. Knowledge generation is a core pillar of RVC's mission, the others being knowledge dissemination and provision of clinical service. We have deliberately not separated management of teaching and clinical service from that of research. Academics belong to one of three departments charged with delivering teaching, research and, if applicable, clinical service against College-wide integrated strategies. We aspire to the ethos that all our academics generate and share new knowledge, disseminating it to our students and stakeholders. The RVC employs 1047 members of staff, of whom 205 hold an academic contract. The vast majority of academics are engaged in research to inform their teaching, clinical service and other professional activity. Exceptions to this are detailed below.

The RVC employs the largest number of clinical specialists of any European veterinary school. These veterinarians spend part of their time working in referral hospitals and specialist diagnostic laboratories generating case material for research and teaching. Flexibility in the proportion of time devoted to clinical service enables those who major in research to have time away from clinical duties to co-ordinate research. Ensuring that we employ at least three academics in each clinical discipline allows such an approach. Those that are new to academia, focus initially on gaining experience in teaching whilst establishing themselves as specialists and are not included in our REF return (see Code of Practice).

Institutional resource allocation is determined by mission (teaching, research and clinical service) with a Vice Principal (VP) leading each mission being responsible for delivering strategic goals and making the case for investments (recurrent and capital). New investments are proposed through institutional strategic committees (Research Strategy Committee (RSC) for research; chaired by the VP Research and Innovation). Heads of academic departments, research programme leads,

Associate Deans (for Research and for Innovation), Head of Graduate School and senior and early career researchers constitute RSC. Academic departments are responsible for ensuring staff deliver the strategy. Academic appointments boards are chaired by VPs and each relevant mission is represented to ensure the best appointments are made taking account of all strategic priorities. This management structure ensures engagement with College-wide strategic objectives across departments. VPs and Heads of Department serve on the College Executive Committee and work together to a common strategy.

2. Strategy

The philosophy underpinning our research strategy is to encourage curiosity-driven research, which answers questions generated by teaching or engaging in professional practice and advising stakeholders. With 61% of our eligible staff being veterinarians, many research questions are defined by a desire to understand either differences between species, (healthy and diseased) or why different animal-derived food production systems lead to distinct animal and human health problems. Veterinarians are trained in comparative approaches to problem solve and to look holistically at livestock production system, identifying disease risk factors. They are strong proponents of the 'One Health' approach to globally important problems, using their comparative reasoning skills. Working with partners from other professions and disciplines to combine knowledge and professional perspectives is, therefore, a strong underlying principle that we facilitate strategically, leading to large interdisciplinary teams working to common goals.

To achieve this aim we recognised the need to develop the skills to analyse different data types, combine, model and make sense of these data to generate and test hypotheses. The massive increase in capacity to capture data from all research areas means skills development in integration and modelling of different data types is essential for One Health research.

How this support has developed from a strong base in quantitative epidemiology and expanded to encompass new ways of working with data from the 'omics revolution is explained in REF5b. New appointments made during REF2021 have expanded institutional dedicated support, which proved so successful in REF2014. These investments have enriched our environment and improved the quality and impact of our research. We see these investments continuing over the next 20 years to ensure the College achieves the following strategic objectives:

- Develop as a world-leading veterinary institution studying the genetics of complex diseases in companion animals supporting personalised medicine
- Provide academic leadership in genomic epidemiology, developing tools and pipelines necessary for national/international surveillance, rapid detection/prediction of and response to disease threats to animals (wildlife, livestock and pets) and people (emerging zoonoses)
- Develop tools, skills and partnerships to utilise VetCompass™ data to monitor and detect disease patterns that warn of environmental threats to public health

The final over-arching principle underpinning our research strategy is the need to understand how solutions we develop will be used and whether they will gain societal acceptance. Thus, involving policy makers, social scientists, industry and private practitioners at the appropriate stage of the research is important. Expertise in social sciences has been accessed through partnership, primarily within the London Centre for International Development (LIDC) with London School of Hygiene and Tropical Medicine (LSHTM), SOAS and UCL Institute for Education providing wide-ranging expertise. Partnerships with Government agencies (Animal and Plant Health Agency, and Food Standards Agency in particular) provide access to scientists experienced in translating science into policy.

RVC research falls under two themes, both embracing the One Health philosophy and encouraging multidisciplinary approaches. These are Comparative Physiology and Clinical Sciences (CPCS) and Integrated Research into Livestock and Food Systems (IRLFS) encompassing research relevant to companion and food producing animals respectively.

Comparative Physiology and Clinical Sciences (CPCS)

A major societal goal as longevity increases is that people age healthily. There is a focus on chronic degenerative ageing problems, particularly within the musculoskeletal, cardiovascular and central nervous systems and in identifying novel ways of slowing degenerative processes. The strategic areas of focus (which reflect these system-based ageing problems) and key appointments made to develop CPCS are outlined in REF5b.

As companion animals share our lifestyles, are exposed to the same environmental factors and age faster than people, we encourage appropriate companion animal use as models for human disease. Experimental animal model use is facilitated through provision of biological service units on both sites catering for many species. Access to veterinary patient data at scale is through VetCompass™. Dedicated clinics within our referral hospitals recruit patients, with extremely well characterised phenotypes, supported by our Clinical Investigation Centre (CIC). This resource is essential for genomic studies of complex diseases, knowledge we need to achieve our future goal of providing personalised medicine.

RVC is committed to supporting ethical animal use as an important step in translation of basic research into medical and/or veterinary practice. As an openness concordat signatory since its inception, we comply fully with its principles. RVC is one of 13 organisations awarded leader in openness designation (2019-2021; Understanding Animal Research) and in 2018 was awarded the openness award for Media Engagement. In 2019, Dominic Wells, CPCS research programme lead was recognised for his work to support openness on animal research and we were invited to host (with UCL and LSHTM) an NC3Rs Programme Manager to assist us in replacing, refining and reducing animal use in research.

Professor Wells is our Academic lead for Research Improvement and Integrity on the UK Reproducibility Network (UKRN). RVC is one of the first 10 Institutions to join UKRN. All member institutions aim to support each other in upholding a positive research culture, to enhance the quality of research through improvement of its reproducibility. Wells oversees College-wide training initiatives designed to achieve this goal, sharing best practice with other members and accessing their networks and expertise.

Designing experiments which are reproducible and ensuring all factors leading to variability are minimised and reported is particularly important when using experimental animals. Because *in vivo* experimentation is an important aspect of RVC's research, we are active members of the London Animal Welfare and Ethical Review Board (AWERB) Hub, which co-ordinates training events on experimental design.

The disciplined study of veterinary patients with naturally-occurring disease, where necessary under the Animals (Scientific Procedures) Act 1986 (ASPA), is a strategy we have adopted to limit experimental animal model use. In some cases, these animals are acquired and bred for experimental study. Other projects are undertaken on client-owned animals under ASPA, allowing collection of additional samples (with owner-informed consent) for research rather than clinical purposes. Archiving samples (blood, urine, tissue, DNA) form phenotypically well-characterised patients is an important strategy making our clinical caseload a unique and highly valuable resource, particularly where longitudinal data documenting disease progression are available. With the development of techniques for inducing pluripotent stem cells and the introduction of disease-associated gene mutations (by gene editing), study of the impact of disease on cellular function

becomes feasible and tractable systems can be established using clinical patient material. Thus, strategies followed since RAE2001 in taking an institutional-level approach to co-ordinating research using our clinical caseload are starting to pay off.

Mathematical modelling of body systems, how they interact and feedback to controllers (CNS or endocrine system), is an underlying principle of 'systems biology'. Applying systems biology approaches and modelling to whole tissues or organisms rather than isolated cells is what RVC's musculoskeletal biologists excel at. This approach reduces animal use. Their collaborations with engineers, physical scientists and mathematicians have led to successes in bioinspired robotics (see REF5b).

High-level strategic goals for CPCS scientists over the next decade include:

- Establishment of a joint clinical and research translational medicine centre using large experimental animal models and veterinary patients to accelerate development of novel regenerative medicine approaches
- Use the knowledge of locomotor control systems to inform robotics design

Integrated Research into Livestock and Food Systems

Threats to food safety, food security and human health from (re)-emerging infectious diseases of animals, particularly in low-and-middle income countries (LMIC), are major global challenges. These, combined with the global problem of antimicrobial resistance have shaped our strategic research into animal-source food production, which aligns with the global visions of UKRI-BBSRC, FAO, OIE and WHO. We aspire to contribute solutions to challenges faced by a growing world population with increasing demand for animal-source protein in the face of climate change, and to generate future leaders who can contribute to society globally by addressing these issues.

In response to the BSE crisis in 1990s and FMD outbreak in 2001, RVC built capacity in veterinary epidemiology under Dirk Pfeiffer's leadership. Pfeiffer's vision was to build a group of scientists with knowledge of livestock and food systems capable of leading collaborative research programmes with microbiologists, mathematical and social scientists in partnership with scientists and animal health professionals in LMIC. This has provided a platform on which to develop One Health leaders. Key appointments and development of leaders within the IRLFS programme are detailed in REF5b together with external collaborative partnerships, which underpin our success. Our leadership of major interdisciplinary research programmes indicates success, initially through the Zoonoses and Emerging Livestock Systems (ZELS) programme (cross-Council, 2014-2020) and The Bloomsbury SET (Research England, 2018-21) and thereafter, the UKRI Global Challenges Research Fund (GCRF) Hubs (2019-2024). ZELS was a cross-Research Council and DFID initiative, which funded 11 major research programmes, three of which RVC academics led. Success in running these with LMIC partners and ensuring their outputs impact positively on the lives of some of the world's poorest people, led to RVC being awarded the UKRI GCRF One Health Poultry Hub, a GBP20,000,000 interdisciplinary research programme. RVC is also a partner in the UKRI GCRF Action Against Stunting Hub, led by Claire Heffernan, Director of LIDC, a joint RVC and LSHTM appointment.

To be leading a competitive interdisciplinary programme of this scale and playing a significant role in another, when just 12 of 240 applications for UKRI GCRF Hubs were funded, demonstrates how far RVC's research has progressed since 2000. The One Health Poultry Hub provides an opportunity to expand our expertise across all aspects of poultry research and to apply similar approaches to other emerging agri-food areas, including aquaculture. Early and mid-career scientists working within the IRLFS programme will be supported by the Hub to become future leaders in livestock systems research, enabling them to contribute significantly to global challenges of food security, antimicrobial resistance and zoonotic disease. Our aspirational strategic goal over the next two decades is to undertake research which:

- Informs safe, sustainable and ethical protein production (with increasing focus on fish, chicken and insects) for human consumption
- Develops and commercialises vaccines for animal endemic diseases using novel delivery systems that harness the innate immune system and facilitate mass immunisation
- Leads the ethical debate on using gene editing in animal-source food production

3. People

RVC's staffing strategy is to attract, develop and retain the most talented academics committed to pursuing our strategic research goals. As an institution focused on science that underpins advancement of veterinary practice, public health and food-producing livestock systems, it is important we nurture qualified veterinarians to work in academia alongside scientists from a range of fields. Most of our undergraduates are female (82%) and are from increasingly diverse backgrounds. They need role models who inspire some to follow research careers. Thus, promotion of the leadership potential of female academic staff is a key strategy. Furthermore, increasing diversity in our researchers will provide the broad range of perspectives needed to address more effectively the complex global issues we aim to tackle. We recognise these staffing challenges, and are addressing them through initiatives described below.

Having equal numbers of women and men collectively setting the strategic direction for research will ensure the approaches taken appeal to all researchers. In 2014, RSC had 11 members, three of whom were women and none from a BAME background. In 2020, RSC has 16 members, eight of whom are women and two of whom are of BAME background. In addition, the two major research networks (UKRI GCRF Hubs) are led by female RVC professors. This is positive progress. We expect more women and people from BAME backgrounds to take up top management positions in REF2026. To facilitate that, the following are Equality and Diversity Action plan (2020-2024) objectives:

- Conduct an Equality Impact Assessment for each recruitment process stage ensuring removal of potential barriers for BAME applicants
- Investigate and provide positive action initiatives to increase the profile of women and BAME staff within senior grades
- Continue to promote family leave and flexible working policies including support available

In response to the Black Lives Matter campaign, RVC has established a Race Equality Task Group to consider and address issues (both actual and perceived) undermining race equality institutionally. This will lead to recommendations in the form of an action plan by April 2021.

Specific initiatives during REF2021 to improve female researcher representation in senior grades and leadership positions included:

- Overhaul of our academic promotions and progression process ensuring progression requirements are clearly measurable, tailored to (individual) career pathways (ICPs) to which academics are allocated according to their strengths
- Supporting female staff up to Senior Lecturer level to attend the Advance HE Leadership Development (Aurora) programme (2018-20; 16 to date).

However, women are still significantly under-represented in the professorial grade (Grade 9), with 2.2 males to every female professor (similar to REF2014). Nevertheless, there has been a four-fold increase in women at Associate Professor/Reader grade since REF2014, indicating ICPs are having an effect. We expect this to feed through gradually to gender equality at professorial level but recognise Covid-19 has impacted women's careers more than men. Overall, our staffing strategy has led to the appointment of more female academics (45/70) such that the male-to-female ratio in REF2021 is 1 to 1 compared to 1.67 to 1 in REF2014.

Encouraging veterinarians to consider research careers is important to our One Health strategic goals. Sixty-one percent of our REF-eligible staff are veterinarians and 38% engage in clinical service provision. Equally important is attraction of basic scientists to work alongside veterinarians and apply their skills to solve animal health issues. We work hard to promote RVC's scientific quality, which is as high as our neighbouring medically-focused institutions. Of the 70 appointments made during REF2021, 28 are basic scientists, 43% of whom were recruited from prestigious medical institutions: Kings College (2), UCL (4), QMUL (1), Imperial (2), and Oxford (3) showing we offer an attractive alternative for basic scientists.

Nurturing leading clinician scientists is also a challenge. We have developed a pipeline of research active clinical specialists through combined clinical specialist/PhD training and, most recently, post-doctoral clinical fellowships. Of the 42 new veterinary appointees in REF2021, 62% (26) were RVC-trained (wholly/partly). The quality of our clinical specialist training is recognised worldwide and is hugely over-subscribed, enabling us to select and develop research-motivated trainees into PhD scientists who maintain their clinical specialism. This long-term strategy has succeeded but we recognise the need for additional post-doctoral training and have created a fellowship scheme that enables clinician scientists sufficient off-clinic time to develop their research skills and networks whilst maintaining their clinical skills.

RVC's approach to doctoral training is described in REF5b. As a specialist institution, to develop interdisciplinary training and ensure access to resources for social and physical sciences requires partnership. RVC is a member of three multi-institutional partnerships: (1) BBSRC London Interdisciplinary Doctoral Training Programme (LIDo DTP; awarded 2012, renewed in 2015 and 2020); (2) UKRI Partnership for Sustainable Food Future (PSFF) – CDT (2021-27); and (3) the Bloomsbury Colleges PhD Studentships (2007 onwards). Cross-institutional co-supervision provides access to multiple learning environments. The LIDo DTP is highly rated by BBSRC for its approach to doctoral training. To assist with the skills needed to translate science into policy, at RVC's introduction APHA and FSA became LIDo and PSFF CDT associate partners.

Post-doctoral scientists, through the Researcher Association (RA), input into RVC decision-making committees. RA officers work closely with HR to tailor training to their needs, create a feeling of a research community and shape RVC's action plan for the HR Excellence in Research Award. Those who aspire to academic careers are supported by inclusion as researcher co-investigators on applications, guidance for fellowship applications, access to funds for pilot data generation and recognition as PhD student co-supervisors where merited. Opportunities to gain experience working with industry and Government partners are supported through HEIF funding (see REF5b). Opportunities for contract researchers to move into REF-eligible independent researcher positions are regularly provided. Twenty-five percent (11/43) of our new appointees occupying non-clinical positions during this REF period undertook a period of RVC post-doctoral research training.

When appointed to independent researcher positions, we provide support through institutionally-funded PhD students and running costs to establish their research team. This enables generation of pilot data and integration into the most appropriate research group through co-supervision with experienced researchers. Reflection on these approaches is provided in REF5b. Research environment viability/sustainability depends upon us maintaining a balance between experienced researchers and new talent. Thus, 11.4% of our new appointees during REF2021 were professorial, providing leadership for junior staff. Identifying and supporting pathways for progression of all staff is important to the vibrancy and sustainability of all our missions. The improvement to academic promotion and progression through the ICP system discussed above is a key enabler.

4. Income, infrastructure and facilities

We aim to have a balanced research funding portfolio across five main funder categories, RCUK, Charities, UK-Government, Industry and EU-Government. EU-Government funding acquisition during REF2021 have grown substantially, by securing European Research Council Investigator awards (x4) and Proof-of-Concept grants (x2), hosting Marie Sklodowska-Curie Innovative Training Networks (x3), Individual Fellowships (x2) and participating in Collaborative awards. We are adapting our approach to access alternative sources for large collaborative programmes. Our focus is on GCRF and Industrial Strategy Challenge funds (ISCF) as key future streams that will, if necessary, replace or complement EU-Government funding.

RCUK funding remains our major competitive funder averaging 26% (20-34%) of our portfolio. GCRF Hub spending began in February 2019 and represents a major opportunity for us to build our international networks around One Health, levering funds from previously new (to RVC) major funders, such as Gates Foundation, World Bank, NIH and USAID as well as private industry.

Industry funding has grown annually since 2015-16, averaging 20.2% of our total spend throughout REF2021, reaching 26% in 2018-19 (nearly double the 2013-14 value) before reducing slightly in 2019-20 due Covid-19's effects on progress. The increases have been due to collaborative research with big Pharma interested in medical applications [text removed for publication]. Work with these partners involving large animal models continues and further opportunities in collaboration with medical schools will develop with the Translational Research Centre, opening in 2022. The launch of the Herts LEP-funded Veterinary Vaccinology and Cell Therapy Hub, with SME space is an opportunity to develop new industry partnerships focusing on vaccine development and regenerative medicine translational research involving cell and gene therapy. Closer collaborative working with Stevenage Biosciences Catalyst within the UK Government's designated Life Sciences Opportunity Zone will facilitate partnerships with local companies aligned to our One Health strategy. Accessing Innovate UK funding and strategic use of our increased HEIF funding will help build these important partnerships. Recent investments in staff with skills to support partnership building and in infrastructure needed for translational research will facilitate exploitation of funding streams designed to foster these collaborations.

Major facilities and equipment supporting research are subject to rolling replacement programmes. Capital investments over REF2021 are substantial and ongoing. Refurbishment of experimental animal facilities on both sites (GBP3,700,000; 2016-2018) means these exceed Home Office requirements. Upgrading of large animal theatres, experimental dog unit and infectious disease challenge facilities align with current and future translational research needs. Investment in Camden (GBP865,250; 2016-2018) has allowed more effective zoning of activity, creating a Bone Biology suite of co-located laboratories and write-up areas. Renewal of >50% of the laboratory infrastructure at the Hawkshead Campus is ongoing (2019-2022), a GBP22,000,000 investment which will create two research laboratory hubs, one for work with pathogens, another for high quality cell and molecular biology work. The first phase has been co-funded by the Herts LEP (GBP7,000,000) and Wolfson Foundation (GBP1,250,000). This will transform the Hawkshead Campus research environment bringing SMEs onto site for the first time, building on the success of the London Biosciences Innovation Centre (LBIC, Camden). These developments have been accompanied by purchase of new equipment (3-Tesla MRI scanner) and upgrading of existing equipment (see REF5b).

***Facilitating Impact**:* The strategic approach to ensure effective knowledge exchange (KE) maximises the impact of our research is overseen by RSC. It is supported by RVC Business, External Relations, Widening Participation and Community Engagement, and co-ordinated by professional staff within the Research Support Office. The VPR-I chairs the Innovation Partnerships Group

overseeing KE activities which follow our HEIF strategy (2016-2021) and align with our Corporate Research and Innovation strategy (2014-2019 – extended to 2021).

Institutional-level partnerships with stakeholders are key to effective KE pathways. Ensuring two-way processes with feedback from stakeholders, informing knowledge gaps improves the chances of research generating impact. Key strategic partnerships are briefly outlined below. How these align with our research strategy is described in REF5b.

Partnership for KE with clinical practice – VetCompass™, an RVC-devised system for accessing data from UK general practices has >1800 partner practices who share their data, allowing us to mine it, answering clinical research questions for many stakeholders.

Partnerships to inform policy: International policies are needed to protect human and animal health against transboundary diseases. Through a well-established formal partnership with FAO (Reference Centre for Veterinary Epidemiology), the World Organisation for Animal Health (OIE – collaborating Centre for Risk Surveillance and Modelling joint with APHA) and the World Health Organisation (through academic advisory committee membership [text removed for publication] KE is effectively delivered. APHA provides a national strategic KE partner with joint appointments in epidemiology and virology.

Partnerships with Industry and Enterprise: LBIC (wholly owned by RVC) recruits companies aligned with RVC science and brokers their use of RVC facilities and academic expertise. RVC is in the heart of London's Knowledge Quarter (KQ), an organisation that aims to promote the collective knowledge generation potential of the King's Cross area. RVC is very active in KQ, leading the Government-commissioned Science and Innovation Audit (2018). The Herts LEP have provided funding for our Vaccinology and Cell Therapy Hub (GBP7,000,000) and Translational Research Centre (GBP2,127,000). Both will be accessible to local businesses when they open. Encouraged by the Herts LEP, we are building relationships with the Stevenage Bioscience Catalyst and the Cell and Gene Therapy Catapult Manufacturing Centre, both close to the Hawkshead Campus. [Text removed for publication].

Partnerships for KE with local Universities and Research Institutes: In 2018, Research England offered Connecting Capability Funding (CCF) to encourage English universities to work together on KE and commercialisation activities. RVC leads one CCF project (GBP5,600,000; The Bloomsbury SET) with LSHTM, SOAS and LSE as partners, and is a partner in a second CCF (GBP5,000,000; MedTech Super-Connector) led by Imperial College. Bloomsbury SET2 is a 2-year GBP4,000,000 Research England-funded extension connecting this consortium with Infection Innovation Consortium led by Liverpool School of Tropical Medicine and providing excellent KE opportunities for UKRI GCRF Hub science outputs.