Institution: University of Edinburgh and Scotland's Rural College

Unit of Assessment: 6

a. Context

The University of Edinburgh and SRUC (Scotland's Rural College), the HEI partners in this submission, in addition to competitive research grants, also receive core strategic funding, in the form of Institute Strategic Programme Grants (ISPGs) from BBSRC and as a Main Research Provider to Scottish Government. The Roslin Institute was requested by BBSRC in 2013 to produce an Economic Impact assessment of its research activities for the Department of Business, Innovation and Skills. This assessment by Biggar Economics estimated that year-on-year, the Institute alone produces £320M GVA in the UK economy, approximately £12.7 for each £1 spent (http://edin.ac/13Fajyp). More than 75% of the submission is involved in industry-associated projects. Impact activities have been recognised by the Praxis Unico Award (2012) and Innovator of the Year award (2013). The University of Edinburgh and The Roslin Institute won the UK-wide BBSRC-sponsored 2013 Activating Impact Competition. Similarly, we estimate that in 2010/11 SRUC generated§ £181M GVA, and contributes extensively to outcomes of the Scottish Government's National Performance Framework (http://goo.gl/Tp4sle).

Our strategic funding is linked to on-going outcomes and impact. Our collaborations have been especially strong in genetic and welfare improvements in the UK livestock sectors and in disease pathology and epidemiology. Our association is strengthened by the co-location of much of our research in a new £60M state-of-the-art research facility at the Easter Bush Campus. There is also extensive development of infrastructure described in REF5, notably the construction of a new Innovation Centre allowing colocation of industry partners and spin-out companies.

The major impacts of the partners in this submission will continue to be in the areas of: **Food and Environmental Security, and One Biology/One Health.**

b. Approach to Impact

Our strategy to achieve impact takes distinct approaches to target four key audiences (below). In addition, the unique association with a leading medical school (through the University of Edinburgh College of Medicine and Veterinary Medicine) with a longstanding and strategic commitment to the concept of One Medicine/One Health also enables the translation of expertise and knowledge into human medicine (UoA1) and *vice versa*.

Four Key Audiences:

- **Animal health/biosciences/agri-food companies and the veterinary profession**
- **Farm and land-based industries**
- **Policy makers**
- **The public**

During the period 2008-2013 we established a vibrant shared environment in which knowledge exchange, commercialisation and innovation (KECI) are seen as integral to our research effort. The KECI managers are well known, highly visible, available and knowledgeable. Two KECI staff, as well as legal support staff, are funded within The Roslin Institute; these staff in turn have access to the resources of Edinburgh Research and Innovation, the University's commercialisation unit. In SRUC, three FTE staff develop and deliver the KECI strategy, managing the interaction with key end-users (policy-makers, farm and land-based industries, public, scientific and commercial users), funders and other providers. SRUC recently established a new Centre for Research, Enterprise and Commercialisation to focus KECI support.

Addressing the four audiences:

1.Animal health/biosciences/agri-food companies/veterinary profession: The industrial sector in which we operate usually involves high turnover and low margin businesses, a large number of microbusinesses, or small market size and does not commonly lend itself to spinout companies, high value and large royalty streams. Our approach to achieve impact emphasises relationship building from the earliest stages of research activity. Our close association with the Biosciences Knowledge Transfer Network helps in this regard. It is co-located with us at Easter Bush, the Roslin Director (Hume) serves on its board and senior Roslin and SRUC staff (Archibald, Simm) sit on its Animal Sector Strategy Committee.

We look for strategic partnerships with small, medium and large commercial partners built around shared resources and genuine joint development of intellectual property, often across a broad

portfolio of opportunities. These partnerships have been fostered through targeted interactions, visits and a series of open days in which representatives from potential end users of our research are invited to interact with researchers, exchange their ideas and discuss possible future collaborations. For example, in April 2009, we held our first industry-focused Research Showcase. This was followed in 2010 by our second event, *One Medicine: From Farm to Pharmaceuticals*, and in 2011 we held our third event, *Relocate, Innovate*, associated with the opening of our new building. Also in 2011 we held our Innovation showcase for SMEs in the food and drink industry focusing on *Environment and Efficiency* in the livestock sector. In late 2012, we held *Feed, Breed and Succeed* (www.roslin.ed.ac.uk/industry/feed-breed-succeed/) and in 2013 a workshop on *Trust in Food Supply chains* for SMEs involved in the tourist industry. The success of this approach is evident from the development of the EBRC-Zoetis Programme Platform Partnership worth £1.5M over five years, a similar partnership with the Cattle/Pig Genetics company Genus worth £1.5M and another with Cobb-Vantress, the poultry breeding company, worth £1M. We also have a ten-year partnership agreement with Morrisons supermarket supporting sustainable production systems and we are members of Farming Futures (previously the Centre of Excellence for UK Farming and Food Supply), which brings together many of the major companies in the agri-food sector and academic partners to maximise KECI in the food supply chain. There are also numerous funded research relationships with most major companies/actors in the Animal Health and Breeding sectors (e.g. Aviagen, DairyCo, EBLEX, JSR, Hendrix, Hyline, Cherry Valley and Scotbeef) and Multi-national Pharma involved in animal health (e.g. Merck Animal Health, Novartis Animal Health, Merial, CEVA), along with many smaller companies. We host many company visits and in the past year these have including: Zoetis, Merial, Idexx, Genus, Waitrose, Marks and Spencer, Life Technologies, Cobb, Aviagen, EW group, Cherry Valley Farms, CEVA, Hendrix, MV Diagnostics, Westpoint Vet Group, 2 Sisters Group and Gene+. Our interactions with the veterinary profession occur at many levels including professional bodies such as RCVS, our networks of associated veterinary clinics and numerous CPD courses (www.ed.ac.uk/schools-departments/vet/studying/cpd; http://www.sruc.ac.uk/info/120381/cpd_for_vets).

These relationships provide opportunities for both translation and intelligence about industry needs and opportunities. A primary means of engagement is through collaborative research, including through research co-funding schemes such as BBSRC Industry Partnership Awards, BBSRC industry clubs, Industry LINK, CASE Studentships, Technology Strategy Board and EU programmes. In 2012-2013, we attracted research funding from industry of £5.1M, providing matching funds towards grants with a total value of £18.3M, including twenty five BBSRC CASE studentships, seven TSB grants, four BBSRC Link, five BBSRC IPA awards and fourteen EU FP7 collaborative projects. We were also supported in 2013 through five grants from the Animal Health Club. The key to all of these relationships has been development of pragmatic approaches to joint intellectual property that give companies a degree of confidence that they will have freedom to operate whilst ensuring that appropriate commercial benefits flow back to our organisations in due course.

We also aim to generate impact indirectly through enabling activities. The publications and annotation of livestock genomes, transcriptomes and variomes, together with novel analytical tools, is absolutely required for progress in livestock breeding. The assembly, curation and distribution of “big data”, for example data linking genotypes with phenotypes, are also crucial enabling activities. We aim to participate actively in the KECI centres, envisaged in the UK Agri-tech Strategy (2013). We also generate and distribute research tools such as software programmes (e.g. Biolayout Express^{3D}, www.biolayout.org) and novel avian lines through the National Avian Research Facility and promote developments directly to industry, for example the *Across Breed Genomic Selection* workshop for the livestock breeding industry held in 2013. These resources and the associated skill base attract inbound commercial investment into the UK Research Sector. It is also relevant to consider the delivery of human resources as an impact. Together, we are a major centre for postgraduate training in Animal Sciences at PhD and Masters level in the UK, especially in the areas of Quantitative Genetics and Animal Welfare. We have trained many of the technical leaders in major breeding companies or agencies (e.g. Koerhuis, Avendaño (Aviagen); Walling (JSR Genetics); Tinch, (Landcatch) and Winters, (DairyCo)), and many of our current graduate students are supported by industry-supported scholarships from BBSRC (25 new CASE studentship in 2012-2013) and other sources. Many of our graduates from outside the UK are also now industry collaborators. Many of our animal welfare graduates hold senior positions in government

departments or industry (e.g. Simmons (Defra) and Fox, (Scottish Government). We consider the provision of trained personnel to be one of our most important impacts.

2.Farm and land-based industries: SAC Consulting (a Division of SRUC) (http://www.sruc.ac.uk/info/20005/sac_consulting) is a £20M p.a. turnover consulting business delivering consulting services for agri-business in the UK and beyond. It also provides veterinary disease surveillance programmes for the Scottish Government, offers the leading farm animal health monitoring schemes in the UK (Premium Cattle Health Scheme, Sheep and Goat Health Scheme) and delivers commercial diagnostic services. There are over 12,000 clients, including 70% market penetration in Scotland's farming sector. Many of the services offered by SAC Consulting are rooted in research from the partners in this submission, especially those relating to animal health and welfare, livestock genetic improvement, greenhouse gas mitigation in agriculture and reducing the environmental impact of farming. SAC Consulting provided support to the farming industry that resulted in £189M in Common Agricultural Policy support for clients, and between 2009 and 2012 supported successful Scottish Rural Development Programme applications worth £229M. Both activities are informed by our research. In addition to commercial consultancy activities, our 'Success Through Knowledge' programme delivers annually around 30-40 major events with annual attendance of >3,000. Our research farms are an important platform for KECI and public engagement, as evidenced by 2013 Farmers Weekly Dairy Farmer of the Year Award to our Dairy Research Farm Manager (McClymont). We also have specialist research-led service units intended to facilitate knowledge exchange and maximise research impact. Edinburgh Genetic Evaluation Services (EGENES) was formed in 2005 to provide research-led genetic evaluation services for the livestock sector. EGENES is contracted by UK levy boards (DairyCo, EBLEX) and breed societies to provide UK-wide dairy and sheep genetic evaluations, and evaluations for several beef breeds. These services underpin multi-million pound annual returns in the sectors concerned. Similarly, research-led whole body scanning services for livestock breeders, and crop disease diagnostic services provide direct routes to this sector of the market for our research.
Our Carbon Management Centre was created to provide a 'one stop shop' for carbon-related research, consulting and education activities. The centre has been central to the growth of policy- and industry-relevant research in this area, including the launch of a PAS2050 accredited carbon calculator for use on farms and in supply chains and membership of the consortium which won the contract from UK levy boards for developing a UK-wide standard carbon calculator for use in all sectors of agriculture.

3.Policy makers: We participate actively in numerous organisations and networks that contribute to policy development. The Rural Policy Centre (www.sruc.ac.uk/info/120069/rural_policy_centre) was initiated to create a stronger focus and liaison point for exchanging knowledge between research providers and policy agents. The Centre also provides the secretariat for the Cross Party Group in the Scottish Parliament on Rural Policy. We won the research category of the Green Gown Awards in 2010 and 2012, for work on informing government policy on greenhouse gas mitigation options in agriculture (see individual impact case study) and for our GreenCow facility for measuring greenhouse gas emissions from livestock, and international KECI relating to this. (http://www.eauc.org.uk/green_gown_awards).
Our work is closely linked to UK initiatives on Living with Environmental Change and Global Food Security. Strategic research programmes have at least 5% of the embedded activity devoted to KECI. We have leading roles in the Centres of Expertise, notably the Centre of Expertise in Animal Disease Outbreaks (EPIC, SRUC-led), Centre of Expertise on Climate Change (CxC) and Farming Futures. KECI relating to the Scottish Government programme is stimulated by a wide range of tailored events, including briefings, 'call down' responses on specific policy questions, workshops, and a dedicated website www.knowledgescotland.org. We influence Scottish, UK, EU and other international policy via provision of evidence from policy-relevant research, through membership of committees advising on policy (e.g. the UK Government Foresight project on the Future of Food and Farming, the Farm Animal Genetic Resources Committee, the EFSA Animal Health and Welfare panel, the Veterinary Products Committee, the Advisory Committee on Releases into the Environment, the Defra Scientific Oversight Group on cattle TB vaccination and the Scottish Government's Land Reform Group). We were instrumental in the creation of the EU Animal Task Force, an organisation created to influence EU policy, and foster innovation for a competitive livestock sector in Europe.

4.The public: The partners have an active involvement in public engagement in science. In the current REF period, this includes: annual 'Open Doors' events at The Roslin Institute Building; annual exhibitions at the Royal Highland Show – one of the best attended public engagement events in the UK showcasing innovation in agriculture (>177,000 attendees) and similar events UK-wide; regular involvement in events at the annual Edinburgh International Science Festival, and other science festivals, regular participation in the annual 'Open Farm Sunday' event and other farm open days and school visits, joint activities with other main research providers at Royal Botanic Gardens Edinburgh and numerous public lectures, notably the annual series Our Changing World (www.ocw.ed.ac.uk) and Edinburgh Medical Detectives Lecture Programme and many media contributions. Many of the lectures (e.g. Medical Detectives) can also be accessed through YouTube or via our websites. As part of the development of the new Innovation Centre at Easter Bush, we will establish the Midlothian Science Centre, which provides both a static exhibition space and teaching laboratory to engage secondary students and teachers from the Edinburgh area. This will not only help to inspire and inform the public, it will provide our own graduate students and staff with experience in public engagement.

The public includes the owners of companion animals who are the clients in our hospitals and clinics. Over the past 3 years, R(D)SVS has opened its doors on the STV series Vet School (programmes.stv.tv/vet-school) and Junior Vets (http://www.bbc.co.uk/cbbc/shows/junior-vets), on CBBC, particularly in the context of widening participation. The epidemiology project DogsLife (http://www.dogslife.ac.uk/) has engaged 4,047 Labrador owners UK-wide. A massive open online course (MOOC) on equine nutrition (http://www.mooc-list.com/course/equine-nutrition-coursera) attracted 28,000 registrants in 2012. The Jeanne Marchig International Centre for Animal Welfare Education (http://www.ed.ac.uk/schools-departments/vet/jeanne-marchig-centre) is at the centre of a large network of international organisations that promote public awareness of animal welfare.

c. Strategy and plans

Strategic focus.

Our strategy over the next five years is to understand further the needs of, and enhance the impact of our research in, the four audience groups identified above. The University of Edinburgh was selected in the first round of the £500K BBSRC Excellence with Impact competition (http://www.bbsrc.ac.uk/business/impact-incentive/excellence-impact.aspx) and many of our KECI activities in 2014-2015 were outlined in our first stage submission. We have integrated the KECI teams of our two organizations to produce joint strategies targeting these 4 groups as follows:

1) Animal health/biosciences/agri-food companies/veterinary profession: We will strengthen infrastructures for working with industry and other partners; increase the current large number of industry interactions, especially strategic partnerships; generate valuable intellectual property (IP) and realize a royalty stream from that IP. Our future KECI Strategy will be expedited by the availability of a £25M, 6500m^2 Innovation Centre currently under construction on the Easter Bush Campus. Roslin BioCentre will provide fully serviced research space for partners and spin-out companies immediately adjacent to the infrastructure and expertise of UoE and SRUC research in The Roslin Institute Building. The BioCentre will itself be managed as a spin-out company and income from rentals will be used to provide seed funding for commercialisation activities.

We will continue the successful Industry Open Days and structured visits from specific companies, with the objective of creating long-term strategic relationships built around synergies. We will continue to create viable spin-out companies, either alone or as joint ventures. Also, we will continue to lead and/or engage with interdisciplinary and multi-centre partnerships and innovation centres, for example the newly-formed SFC-funded Aquaculture Innovation Centre led by University of Stirling, KECI hubs for International Development, Smart/Precision Farming, Agroforestry and others as opportunities arise.

We will continue to develop tools, resources and services with impact across multiple KECI audience groups (annotated genomes and transcriptomes and tools including transgenic animals, monoclonal antibodies and recombinant cytokines. The National Avian Research Facility will distribute transgenic reporter and inbred chicken lines, and will support preservation of primordial germ cells. The TSE Resource Centre distributes materials to support research on these diseases. Edinburgh Genomics provides next generation sequencing, genotyping and informatics services to academia and industry. We expect that some of these activities will eventually reach a scale that would justify spin-out as service companies. An example of such an outcome in the REF period was Roslin Cells, (http://roslincells.com/), which was established initially to produce and distribute

clinical grade human ES cells.

2) Farm and land-based industries: We will accelerate translation of research developments into farming and food supply chain practice. SAC Consulting, a >£20M per annum commercial KECI business for the land-use sectors, will continue to be a major vehicle for our knowledge and know-how delivery. Its (confidential) business development plan will expand the scope of delivery over the next REF period. SAC Consulting services will be informed increasingly by our research. This will be promoted by the intended relocation of the SRUC headquarters, including SAC Consulting, to Easter Bush, and the development of farming industry-orientated KECI hubs at SRUC campuses.
Our role in the innovation centres and Centres of Expertise mentioned above will be equally important in engaging further with this KECI audience group. We are actively researching behaviour and innovation systems in the farming and land-based industries, with partners in New Zealand, Netherlands and Ireland, with a view to enhancing future KECI.

3) Policy makers: We will continue to seek opportunities to influence government policy in fields related to our core expertise. We will do so via the Centres of Expertise mentioned above, and by advising government on policy on rural development, infrastructures and communities, land use, animal welfare, biodiversity, genetic resources, transgenic animals and crops, tuberculosis, transmissible spongiform encephalopathies, food safety and other animal and crop health and breeding issues. Influence and involvement in these areas will be through ongoing advice to, or membership of policy panels of the relevant bodies including: FAO, European Food Standards Agency (EFSA), the Food and Environment Research Agency, Advisory Committee on Dangerous Pathogens, Spongiform Encephalopathy Advisory Committee (SEAC), World Organisation for Animal Health (OIE), the Farm Animal Genetic Resources Committee, Farm Animal Welfare Committee, the Animal Task Force and the European Farm Animal Breeding and Reproduction Technology Platform. Our Rural Policy Centre provides a vehicle for focusing policy information in economic, sociological and environmental contexts as well as technological ones.

4) The public: We will continue to increase public awareness of our activities and promote science education. Within the innovation centre there will be a teaching laboratory and education centre - *Midlothian Science Centre* – to support high school student, teacher and public outreach. The vision is to engage our own students and junior researchers in this outreach activity. We will seek to increase public engagement through new channels including greater use of social media, and further engagement with Scottish Science centres. Our KECI outlook is international, and in each of the audience groups we engage internationally. We recently appointed a Professor of International Development (Peters) to enhance our existing engagements with major government (e.g. Department for International Development) and third sector agencies (e.g. Bill and Melinda Gates Foundation)

d. Relationship to case studies

Our portfolio of impact cases illustrates many of the ways in which we address each of our target audiences. Some case studies have significance for multiple audiences.

1) Animal health/biosciences/agri-food companies/veterinary profession: The ultimate impact of our work is to support innovation in the animal health industry and to translate basic research into clinical and animal health practice. Impact cases that illustrate the outcomes include:
1a) Bovine Neonatal Pancytopenia (BNP), a newly recognised disease of calves, is caused by colostral transfer of cross-reactive alloantibodies induced in dams by PregSure Bovine Viral Diarrhoea (BVD) vaccine.
1b) Dolly the sheep – the first cloned adult animal leading to multiple cloning business enterprises
1e) Marker-Assisted Selection to breed for resistance to Infectious Pancreatic Necrosis in Salmon
1f) The development of genomic selection and application through optimal contribution theory in livestock breeding
1g) Widespread removal of muesli-style diets from retail outlets and changes to feeding policy following the identification that they are detrimental to rabbit health.

2) Farm and land-based industries: The ultimate impact of our work is to improve the sustainability and profitability of farms and land-based industries through our endeavours in the areas of food and environmental security and One Biology/One Health. Impact cases that illustrate

the outcomes include:
1d) Breeding a scrapie resistant international sheep flock
1h) The Profitable Lifetime Index (£PLI) is a reliable basis for genetic improvement of dairy cattle productivity, health, welfare, longevity and environmental impact.
1k) Discovery that *Ramularia collo cygni* causes leaf spotting in barley and development of a diagnostic to target fungicide use, saving the industry £5.4M per annum.
1n) Control of bovine viral diarrhoea virus in livestock through evidence-driven behaviour changes on farms and through veterinarians.
1r) Visual evaluation of soil structure reliably assesses soil quality and has been adopted world-wide to enable soil improvement for enhanced crop yield.

3) Policy-makers: Because of the governance of agricultural regulations across the UK and EU, any translation of our research must inevitably address policy implications. Examples from our impact cases include several where there has been clear translation from research into policy:
1i) Eliminating trypanosome carriage in Ugandan cattle prevents sleeping sickness in humans, stimulating the formation of "Stamp Out Sleeping Sickness (SoS)" a Public Private Partnership that is eliminating the disease from Uganda.
1j) Controlling bovine TB in the UK by controlling badger numbers.
1l) Whole-house gassing improves the welfare of birds requiring culling during a major disease outbreak and is now adopted by Defra.
1m) Aerial perches improve the welfare of laying hens and are now recommended by the European Union.
1o) Quantifying the capacity for reducing greenhouse gas emissions from agriculture
1p) Minimising heat and other stresses during animal transportation improves animal welfare and has driven EU legislation.
1q) Recognising European farms as being High Nature Value (HNV) promotes conservation of fragile ecosystems and is now embedded in EU rural development policy.
1s) Loose-farrowing systems Improve the welfare of the sow whilst protecting the welfare of the piglet and have superseded the farrowing crate, now banned in three countries.

4) The Public: Many of the impact cases we have submitted have been highlighted in the public domain and have had a significant impact upon public consciousness, understanding and policy development, e.g:
1c) Promoting public and policy-maker understanding of the benefits of genetic modification (GM) technology in chickens; transgenic birds that do not transmit avian influenza.