Institution: Queen's University Belfast

Unit of Assessment: 6 - Agriculture, Veterinary and Food Science

a. Context - Agricultural, veterinary and food science has been a main focus of research at Queen's University Belfast for over 100 years. The research conducted during this time has changed dynamically, reflecting the continuous advances in science and technology and the different needs of consumers and the global agri-food industry. The Institute for Global Food Security (IGFS), which evolved from the UK's first Institute of Agri-Food and Land Use, is a multi-disciplinary ensemble that encompasses all academic staff within the University who conduct research with an agriculture-, veterinary- and food-related focus. IGFS currently comprises four inter-linking research themes designated: (i) Animal Health & Parasitology; (ii) Food Safety & Integrity; (iii) Human Nutrition & Health; (iv) Plant & Soil Sciences. Core to the ethos of IGFS is high quality research that has a significant impact on the integrity and competitiveness of the agri-food industry both locally and internationally. Locally, the agri-food sector generates over £5 billion for the Northern Irish economy and is its largest employer. Much of the research conducted within IGFS also has far-reaching, global impacts due to the ever-increasing complexities and associated challenges of 21st century food supply chains.

IGFS research-driven engagements and impacts are core to its activities. Productive, collaborative links with the agricultural community, related industries and local food companies are evident from the large numbers of Knowledge Transfer Partnerships (KTPs), PhD scholarships funded by industry and joint industry–academia projects supported by regional, national and international bodies. In the food safety and nutrition areas, these links range from small artisan food producers to multinationals such as Moy Park, one of Europe's largest poultry companies, Nestlé and many others. Further, animal health and parasitology researchers engage with diverse end-users ranging from multiple small veterinary practices to world-leading pharmaceutical companies with which they have developed multi-faceted links. Many licensing agreements between industry and the University generate research income for the Institute to conduct translational research, exemplified by the agreement with Merial which markets the world's most successful animal vaccine ever (global sales ~£300 million per annum) for porcine circovirus 2 (PCV2). Another key impact of IGFS has been the generation of high quality scientific jobs for local graduates and young researchers across Europe.

b. Approach to impact - IGFS has a broad research portfolio. Much of it has had a significant economic and societal impact, reflecting our understanding of the complexities and often confounding issues relating to the production of economically viable food, balanced against the need for a safe and assured global supply of food, which does not impact negatively on our environment. IGFS has widespread engagement with many industrial partners in the UK and internationally, from multinational agricultural corporations to food, pharmaceutical, biotechnology, diagnostics and technology companies. Having senior representatives from Nestlé, the world's leading nutrition and health company (Professor John O'Brien), and Shore Capital (Dr Clive Black), one of London's leading independent investment businesses, as members of our Industrial Advisory Board (IAB) highlights the importance placed on working with industry. Funding obtained by IGFS through IAB membership contributions is channelled towards supporting research that has the strongest likelihood of delivering future beneficial economic and societal impact. Members of the IAB and IGFS Steering Committee are responsible for the allocation of these funds.

The formation of a biotechnology spin out company in 2013 (Xenobia) to exploit the Institute's successful research in food safety and integrity is another clear indication of the importance placed on creating high value, scientific jobs. To support all IGFS related research a £3m technology centre, **the ASSET Technology Centre,** was opened in 2009 to provide cutting edge analytical capabilities supporting the production of assured, safe and traceable food. Due to the success of this initiative a further £6 million was secured in 2012 to advance, substantially, the capabilities of the Centre. Within the REF period, over 40 agriculture, food and technology companies (national and international) have engaged with the centre and view it as an essential partner in ensuring the integrity and competitiveness of their industries in the global food supply chain. This highly successful industry–academia partnership, the *'Food Fortress',* is used as an exemplar by many of

our partner companies selling their produce into international markets. Linkages with global suppliers of feed and food, developing research partnerships to help deliver safe products of high integrity, are actively being sought. Successful missions to Brazil, Thailand, China and India have been undertaken within the REF cycle and a trip to Indonesia is planned for early 2014.

With respect to Policy, academic staff engage with, and advise, government at all levels: locally (Department of Agriculture and Rural Development), nationally (Department of Food and Rural Affairs, Food Standards Agency), EU (DG SANCO, ICES, DG TRADE) and internationally (US Food and Drug Agency, International Agency for Cancer Research, United Nations Food and Agricultural Organisation). An IGFS Stakeholders' Forum is underway to support researchers' ability to interact with these key organisations and help shape the impact agenda of the Institute.

c. Strategy and plans - The overarching strategy of IGFS is to have a major, beneficial impact on the global agri-food economy as it strives to enable the provision of the world's population with more food and food of a higher integrity, and provide chronic disease sufferers with a better quality of life. Critically, this global outlook also encompasses an important regional element within the Institute's efforts.

Institutionally, QUB has a strong track record in delivering impact. For example, when measured against sector standard metrics, captured through the annual Higher Education Business and Community Interactions Survey, QUB is consistently ranked in the top ten amongst UK universities. IGFS staff involvement in impact activities is encouraged formally through the use of key performance indicators, built around impact / end-user engagement and used within staff appraisal. Looking forward, the award in 2013 of four new Invest NI proof-of-principle grants to develop novel translational research ideas demonstrates IGFS staff engagement in impact development.

The sustainability and continued growth of the **ASSET Technology Centre** are core to the strategy of IGFS. The provision of cutting edge technologies across systems biology to enable all staff to undertake the highest calibre translational research is a key goal. In 2013 an agreement with a global technology provider was signed to support the Centre through the provision of free access to advanced mass spectrometry, technical support and funding streams. The Institute is only one of five global centres of excellence in food analysis to be awarded the status of 'Collaborating Centre' with Waters Corporation, a multi-billion dollar global technology provider.

ASSET has been built around the provision of cutting edge sensor, spectroscopy and spectrometry platforms with more than 30 different technologies available to staff and their research groups. The future plans are to enlarge the scope of the provision to include state-of- the-art, core genomics and bioinformatics facilities to allow the large and growing number of molecular biologists within IGFS to further develop their fundamental and translational research activities. Thus the clear strategy is to have within IGFS a world-leading systems biology technology centre to facilitate high-quality, sector-leading research of the highest calibre.

The Institute's current director, Elliott, has driven the development of an Agri-food Competence Centre (**Agri-food QUEST**), which has secured over £5 million of funding over a five-year period from the European Union to facilitate joint industry–academia research. This has been a key success in securing the medium- to long-term funding base of the ASSET Technology Centre. **Agri-food QUEST** will join the growing networks of food related competence centres across Europe and will play a key role in securing substantial Horizon2020 funding.

The Animal Health and Parasitology research theme centres on improving the productivity of animal-based agricultural systems and involves extensive collaborations with major pharma and other research end-users. The development of vaccines for major livestock pathogens has been a core facet of the animal health research activity with porcine circovirus (PCV2) vaccines and diagnostics having global impacts. Ongoing work funded by an Advanced ERC award and through a substantial academia-industry partnership is developing first-generation vaccines against liver fluke, a major, growing burden on global animal production systems. The development of reverse genetic technology platforms for several key parasites by IGFS staff has provided the first opportunities to validate novel drug and vaccine targets and has resulted in sustained collaboration with the multi-national animal health pharmaceutical company, Merial.

The development and exploitation of new technology platforms to exploit the accumulating parasite genomic datasets remain a key focus and will continue to meet industrial needs in this area.

Animal welfare advice, emanating from research in IGFS (O'Connell) on pig housing density and pig feeder types, has been distributed via the devolved government (DARDNI). It is being adopted by the pig industry and is already having financial impacts on local pig production systems (annual savings estimated at >£200k per year by DARDNI).

The focus of the nutrition group is in delivering innovative food products, in partnership with industry, which are healthier and not compromised in their organoleptic properties. Nutritional-based therapies (e.g. medicinal foods) for specific health complaints such as diabetes and neurological disorders are also under investigation. IP is currently being sought for neutraceutical compounds that have been shown to be deficient in sufferers of aging related illnesses. These will be developed in partnership with major food companies as ground-breaking health products.

A key focus of the newly formed Plant & Soil theme within IGFS is to address the sustainability of arable food production, specifically by addressing the major problem that global phosphorus (P) supplies are now outstripped by demand. This is addressed, for example, through employing state-of-the-art next generation sequencing approaches to identify genes in wild progenitors that enhance plant P acquisition and use.

d. Relationship to case studies - IGFS has greatly impacted on pig health and economics globally. Postweaning multisystemic wasting syndrome (PMWS) is a pig disease with a massive negative economic impact on this industry. Allan isolated and characterised the causative agent, a new virus of swine (porcine circovirus 2 [PCV2]). This fundamental research was the foundation stone for the academia-industry (IGFS-Merial) collaborative development of PCV2 vaccines. The introduction of these vaccines has facilitated a major reduction in the use of antibiotics in swine around the world; the societal impact of reducing the development of antibiotic resistant pathogens is huge. Developing the world's best-selling animal vaccine has provided a substantial impetus in the area of vaccinology within IGFS. Major FP7 and ERC funding streams underpin the on-going development of first generation liver fluke vaccines. The development of reverse genetic technology platforms for parasite control has attracted sustained collaboration and funding from major pharma, including a 2013 BBSRC-LINK award with Merial. Further, through BBSRC-CIDLID funding these technologies are being used in India with a view to providing validated vaccine targets for the tropical liver fluke to biotech companies within south Asia. The use of drugs in farm animal rearing has proved to be a major problem for global trade and food safety. Elliott has been the pioneer in developing high sensitivity and reliable biosensor screening and mass spectrometric confirmatory means of detecting illegal drug residues in many foods. These methods are now used across the world as commercially available diagnostic test kits or as instrumental techniques. The development of commercial partnerships with a wide range of diagnostic companies based globally was key to the success in this area. Translational research in IGFS to develop further food safety and animal health diagnostics is on-going with the support of FP7, commercial partners though studentships, KTPs and post-doctoral research contracts.

Kennedy's work on nitrofurans is an exemplar of uncovering a global problem and delivering a solution that had a huge impact on global trade and consumer safety. Basic research showed that the illegal use of nitrofuran drugs could be detected by measuring bound residues and led to the development of analytical tests that are now being used worldwide by industry and regulatory authorities. The massive and devastating impact on Bangladesh of incorrect nitrofuran analysis by a laboratory in Belgium was uncovered. Without the intervention of Kennedy their entire aquaculture industry would have collapsed. Kennedy and Elliott are currently pursuing the use of detection of other bound drug metabolites to track the illegal global use of nitroimidazoles.

Prodöhl's work on the genetic and fitness impact of farmed fish releases and the use of farmed fish for stocking of wild salmon and brown trout populations has shaped government policies and advice given to fish farmers in this area. The offspring of farmed, first and second generation hybrids, and backcrosses both to wild and farmed salmon showed reduced survival compared with wild salmon, so repeated escapes can reduce the biological fitness of vulnerable wild populations potentially leading to their extinction. Ongoing work on wild lobster stocks in collaboration with the North-East Lobster Fisherman's Co-operative Ltd. is using genetics to monitor the V-notching scheme, aimed at ensuring the long-term stability of lobster stocks. Interest from other lobster fishing communities is such that IGFS is currently extending the scheme to other areas in NI, Scotland and the Republic of Ireland.