

BBSRC Veterinary Vaccinology Strategy

2015-2020



1. INTRODUCTION

Vaccines represent a highly cost effective intervention for disease prevention and eradication, and are an important tool in the fight against infectious diseases. Veterinary vaccines are routinely used to control infections both in the UK and globally for the major livestock species¹. Vaccination enhances animal welfare and sustainably improves livestock production to meet global food security challenges both in terms of volume of food production and nutritional quality. Veterinary vaccines enhance food safety and also reduce the usage of antibiotics and other drugs. In addition, veterinary vaccines reduce and/or prevent transmission of zoonotic diseases thereby protecting public health.

One of the greatest successes for veterinary science is the successful vaccination campaign which led to the global eradication of rinderpest; this is estimated to save the economies of Africa around US\$1 billion per year² with a benefit:cost ratio of 85:1³. Effective vaccines were probably the most important single factor enabling the Norwegian aquaculture industry to grow from

57,000 tonnes in 1987 to 1,250,000 tons in 2012. By the introduction of reliable vaccines, the Norwegian aquaculture industry reduced its use of antibiotics in trout and salmon by 99.8% compared to the 1987 level⁴.

Despite past successes using vaccines, losses due to new diseases (e.g. Schmallenberg), incursions of exotic diseases (e.g. avian influenza), and re-emerging diseases (e.g. porcine respiratory and reproductive syndrome) have highlighted the need to re-think vaccine development methods.

The UK strength in veterinary science and advances in biotechnology and new technologies (such as next generation sequencing, synthetic biology and systems biology) offer a great opportunity for co-ordinated multidisciplinary vaccinology research to address the need for new and improved veterinary vaccines and to improve vaccine development efficiency.

2. WHAT ARE WE AIMING FOR IN OUR STRATEGY?

This document details a high-level strategy to guide BBSRC's future investment priorities for veterinary vaccinology research in the UK.

Within the context of the BBSRC's Strategic Plan⁵, the aim of this document is to set out the key current drivers, opportunities and challenges for delivering impact from existing and future BBSRC investments in world class vaccinology research and how we will address them.

The main focus for the strategy is on animals (including fish) farmed for food production in the UK (and where appropriate, in the international context) but it is also relevant to other domesticated animals of importance to the UK economy.

3. BBSRC VETERINARY VACCINOLOGY VISION

BBSRC Veterinary Vaccinology Vision

World-leading BBSRC-supported bioscience research will transform the development and translation of next generation veterinary vaccines to improve animal health and welfare, reduce the impact of zoonoses on public health and strengthen the UK as a centre of excellence for veterinary vaccine research and development

4. STRATEGIC DRIVERS FOR VACCINES RESEARCH

Food security. It is estimated that world population will increase from the current 7 billion to 9.1 billion by 2050. The Food and Agricultural Organization of the United Nations (FAO) estimates that in order to feed this projected world population overall food production will need to increase by 70% between 2007 and 2050. In addition, there has been increasing pressure on the livestock sector to meet the growing demand for high-value animal protein as real income grows in the emerging economies. Annual meat production is projected to increase from 218 million tonnes in 1997-1999 to 376 million tonnes by 2030⁶. Vaccines that protect animal health and welfare and improve sustainable production are important components in meeting this need.

Climate change mitigation. Improving animal health through vaccination, and thereby increasing lifetime productivity, is an effective approach for enhancing animal production efficiency^{7,8}. This reduces greenhouse gas emissions per unit of product, and has been suggested as one measure for climate change mitigation in the livestock sector⁹.

Control of emerging animal diseases.

Emerging, (re)-emerging and exotic animal diseases pose a growing threat to animal

health and welfare. In addition, the effect of climate change¹⁰ on disease ecology and transmission dynamics may lead to changes in host (e.g. vectors) distribution, density and their availability to existing pathogen may translate into disease emergence in animals, humans and at the animal-human interface¹¹. The ability to respond rapidly with efficacious interventions is vital for efficient disease control.

Improving public health through control of zoonotic diseases. Approximately 60% of pathogens with the potential to harm people have their origin in animals^{12,13}. Vaccines to control zoonotic diseases in food animals, companion animals, and wildlife have had a major impact on reducing the incidence of zoonotic diseases in people e.g. rabies vaccine for domestic animals has helped control human rabies in developed countries¹⁴. The use of a vaccine in poultry in the 1990's was a significant factor in reducing cases of human salmonellosis, particularly *Salmonella* Enteritidis PT4¹⁵. In addition, the development of new technologies for veterinary vaccine production could also be translatable for developing human vaccines under a One Health agenda.

Food safety vaccines: vaccines that reduce shedding. There is an urgent need for vaccines that help reduce the faecal shedding of pathogens that cause food-borne diseases.

Less reliance on antimicrobials including anthelmintics. Veterinary vaccines reduce the need for antimicrobials and anthelmintics to treat infections in food producing and companion animals. Reducing reliance on antimicrobials is a key component of our strategy to reduce the impact of antimicrobial resistance on human and animal health.

Economic drivers. An outbreak of foot and mouth disease (FMD) in the UK in 2001 cost an estimated £8 billion. The impact study conducted by the Pirbright Institute estimated that mitigating an outbreak of FMD using vaccination would save £244 million in livestock value and £172 million in export market value and would thereby protect approximately 9,000 jobs¹⁶.

Growing market for vaccines. The global animal vaccines market (including companion animals) is in a growth phase and was

estimated to be worth \$5.8 billion in 2013. It is expected to grow at a healthy Compound Annual Growth Rate (CAGR) of 8.1% to reach \$8.6 billion by 2018¹⁷.

Social impact. Mass slaughter of livestock in an effort to control the spread of infectious diseases (as was the UK's response to the 2001 outbreak) is becoming unacceptable to society and the lobby for a 'vaccinate to live' policy is gaining strength. Prevention of disease through vaccination would reduce the need for such measures.

Supporting national and international eradication programmes. UK science has made major contributions to the global eradication of rinderpest and is making a major impact on controlling FMD and Peste des Petits Ruminants. The latter may be a feasible target for global control and eradication. Improved vaccines will allow other diseases to be considered for elimination and/or eradication.



5. CURRENT STATUS

The development of BBSRC's veterinary vaccinology strategy is informed by a global veterinary vaccinology survey which was conducted by BBSRC under the auspices of Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses (STAR-IDAZ)¹⁸, to map the current research activities and identify gaps in veterinary vaccinology, by a survey of UK veterinary vaccine research needs¹⁹ and by analysis of the BBSRC veterinary vaccinology portfolio analysis.

The analysis shows that even though vaccine research is mostly done in the context of a particular disease, there are generic vaccinology research areas/gaps that would benefit from coordinated research efforts. There is a need for improved understanding of immunology, and development of novel tools and technologies for producing new and/or improved vaccines.

The three main long-term research challenges identified globally and in the UK are:

- **Immunology:** with focus on the need for better understanding of the host immune response, protective immunity, and immunogenetics.
- **Technologies:** the need for 'omics technologies, delivery systems, novel vaccine development technologies, scale-up and production technologies.
- **Tools:** with focus on developing species-specific immunological reagents, novel adjuvants, vectors and alternative animal models.

In addition, the UK survey also highlighted: large gaps of knowledge in the basic **epidemiology** of some diseases; need for **identifying new antigens/immunogens, understanding antigen/immunogen structures** and their ability to induce protective immune responses including structural vaccinology underpinned by 'omics and bioinformatics; the need for a **joined up approach to vaccinology across industry and academia** within the UK; the need to embrace a **One Health concept** to enable switching between human and animal applications, transferability of expertise and regulatory regimes; the **lack of social science and economics** in vaccinology; the need to ensure there is **capacity and capability** within the UK; and good understanding and engagement with **regulatory aspects** of vaccine development.

BBSRC's current veterinary vaccinology investments

Veterinary vaccinology research builds on BBSRC's existing portfolio and the strengths of the UK research base in immunology and veterinary science. BBSRC is one of the largest UK public funders, along with the Department for International Development (DFID) and the Department for Environment, Food and Rural Affairs (Defra), of veterinary vaccine research and has a unique role in supporting fundamental, strategic and applied vaccinology research along with training and capacity development.

In the two fiscal years 2010/11 and 2011/12 BBSRC invested approximately £8 million and £14 million per annum in vaccine research and research underpinning vaccinology respectively, including continued support for developing species-specific immunological tools/reagents.

BBSRC's past investment in immunological tools has led to commercialisation of a number of immunological reagents. Examples of recent

BBSRC supported research advances are outlined in the boxes.

New foot-and-mouth vaccine signals huge advance in global disease control

BBSRC funded science has developed a new methodology to produce synthetic vaccines made up of tiny protein shells **designed to trigger an optimum immune response** and does not rely on growing live infectious virus. This new approach to making and stabilising vaccines could also facilitate development of vaccines to related human viruses, including polio.

<http://www.bbsrc.ac.uk/news/food-security/2013/130327-pr-new-foot-and-mouth-vaccine.aspx>

One health approach to vaccine against RSV infection in children

A vaccine developed by expressing a string of conserved Respiratory Syncytial Virus (RSV) proteins in viral vectors, and evaluated for its ability to protect calves against bovine (B)RSV will soon go into a Phase-I clinical trial in humans to treat RSV. The exploitation of BRSV infection in the natural host, calves, to evaluate an RSV vaccine being developed for use in children, **highlights the value of the One Health approach of uniting research in veterinary and human medicine in the development of vaccines.**

<http://www.jenner.ac.uk/one-health-approach-development-vaccine-against-rsv-infection-children>

6. OUR STRATEGY

This document focuses on veterinary vaccinology from a BBSRC strategic perspective, reflecting the Council's mission, remit and areas of influence. However, many of the research challenges articulated in this document will also be of interest to other UK and international funders. In delivering its key objectives BBSRC acknowledges the need for **collaborative links to other Research Councils, key national and international funders and wider stakeholders including industry, NGOs, regulators and policy makers.**

BBSRC's vaccinology strategy builds on UK strengths, and BBSRC's investment in animal science and immunology. **The strategy will**

aim to move the focus away from a disease-focussed approach, which potentially creates silos in vaccine research, to foster research applicable across diseases. The strategy acknowledges that gaps in vaccine research, as identified by Discontools²⁰, are common across diseases e.g.

- Lack of effective vaccines for many important disease such as African swine fever (ASF), Bovine tuberculosis (bTB), sea lice in Atlantic salmon, white spot in shrimps, tick-borne diseases, campylobacteriosis;
- Limited efficacy of current vaccines against heterologous pathogen strains (e.g. FMD);

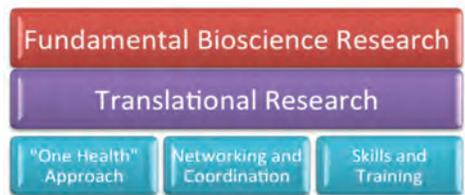
- Slow onset and short duration of immune response e.g. bTB, avian, swine and equine Influenza (ASEI);
- Need for safer, cost effective adjuvants: ASEI, blue tongue;
- Poor vaccine stability (e.g. FMD);
- Inability to distinguish between vaccinated and infected animals (e.g. bTB, African horse sickness, ASEI, FMD, Peste des Petits Ruminants, Koi herpesvirus (KHV));
- Limitations of vaccine delivery mechanisms (e.g. ASEI, bTB).

The strategy focuses on **three main goals in vaccinology research and deployment that will enable prevention/eradication of diseases and maintenance of disease free status to sustainably increase productivity and address welfare issues.**

- **To address current ‘unmet’ needs** by developing vaccines for both endemic and exotic diseases which are not yet controlled by vaccination through advancement in underpinning bioscience knowledge;
- **To improve current vaccines** by developing novel tools and technology platforms that will help produce vaccines that approach the “ideal” as closely as possible;
- **To prepare for future threats** by empowering the research community with innovative technological and immunological platforms to deliver a step change in vaccinology research, enabling a rapid response to emerging threats.

BBSRC acknowledges that along with vaccines, strict application of disease-prevention management techniques and hygienic practices on the farm are of fundamental importance in minimising the risk of disease introduction.

BBSRC’s vaccinology strategy will have two main pillars, **Fundamental bioscience research and Translational research**, that will support research across the vaccinology research pipeline from fundamental laboratory research through to translational research including deployment in the field. These two main pillars will be underpinned by three cross-cutting themes: **One Health approach: coordinated efforts of medical and veterinary sciences for mutual benefit; networking and coordination; and skills and training.**



Fundamental bioscience research

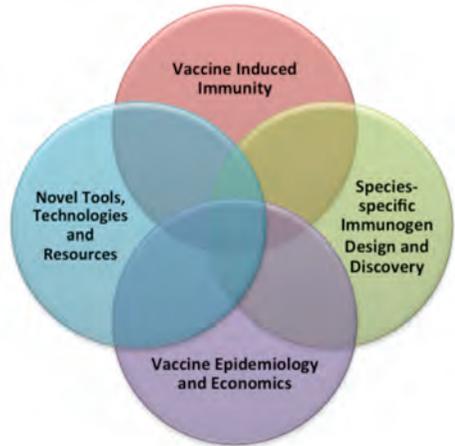
UK excellence in basic bioscience research is essential to underpin the strategic aims of BBSRC’s veterinary vaccinology strategy and to provide the foundation for the development of next generation vaccines. To meet the future challenges in vaccine research the following will be prioritised. An **integrated approach** encompassing all these priorities will be required to make a step change in vaccinology research. See box for some relevant funding mechanisms.

Vaccine Induced Immunity

One of the major barriers in vaccinology research is the **lack of knowledge of correlates of protective immune responses**.

Without this it is difficult to know exactly what class of immune response a vaccine needs to induce to provide protection or how to assess the efficacy and effectiveness of vaccines.

A clear understanding of the correlates of protection will help vaccine developers, regulatory officials and public health officials to make informed decisions about candidate vaccines.



Species-specific Immunogen Design and Discovery

The availability of genomic, proteomic and transcriptomic datasets (of both host and pathogen) has shifted the paradigm of vaccine development from microbiological to technological approaches. However, it is not yet clear how to effectively translate raw data into candidate vaccines. Approaches that cross the traditional boundaries of genomics, molecular biology, cell biology, immunology and computer science, along with deep understanding of **host-pathogen interactions**, would facilitate

potential *in silico* approaches for antigen **discovery and selection** and solutions to the rational design of next generation vaccines.

Novel Tools, Technologies and Resources

One of the major impediments to producing next generation vaccines is **the development and application of novel tools** (e.g. immunological (monoclonal antibodies, cytokines etc.), adjuvants, vectors, and models) **and technologies** (e.g. omics, thermostabilization, delivery).



Vaccine Epidemiology and Economics

Understanding the **epidemiology and economics** of infectious diseases is essential for evaluating vaccine efficacy and effectiveness. Assessing the need for/feasibility of a vaccine requires an understanding of everything from pathogen diversity to vaccine coverage and performance in the field. The potential financial

return on investment for the development of a vaccine (benefit: cost ratio) is the key consideration in the design and deployment of a new vaccine for industry and farmers. Engagement with social scientists, economists and industry throughout the development pathway will ensure cost effectiveness and uptake of vaccines.

Current Activities: Fundamental Bioscience Research of Relevance to Vaccine Development

Strategic Longer and Larger Grants:

Veterinary vaccinology was one of the areas highlighted for 2014/15 with the focus on multidisciplinary approaches and generic technologies for producing vaccines; novel tools and technologies; and/or diseases which constitute major threats to animal health where there is a lack of an effective vaccine. <http://www.bbsrc.ac.uk/funding/grants/lola/lola-priority-areas.aspx>

Tools and Resources Development Fund:

This fund can pump prime the development of tools and technologies for making the next generation vaccines. <http://www.bbsrc.ac.uk/funding/opportunities/2014/tools-and-resources-2014-call1.aspx>

Animal Health and Disease and Veterinary Immune Reagent Call: A

BBSRC-NIFA collaboration funded research on emerging diseases and/or diseases

of agriculturally relevant animals of high economic consequence in both the US and UK; alternatives to current antimicrobials and anthelmintics used to treat disease in agricultural animals and development of publicly accessible immunological reagents for agriculturally-relevant animal species. <http://www.bbsrc.ac.uk/funding/opportunities/2014/animal-health-veterinary-immune-reagents.aspx>

Multidisciplinary Synthetic Biology Research Centres (Call 1&2):

BBSRC established six centres that will offer a strong collaborative culture; provide essential state-of-the-art equipment, facilities, trained researchers and technical staff; drive advancement in modern synthetic biology research; and develop new technologies. <http://www.bbsrc.ac.uk/funding/opportunities/2013/synthetic-biology-research-centres.aspx>

Translational research²¹

BBSRC will work with other funders, industry, policy makers and regulators to support the translation of its basic research into new vaccines²² and to facilitate knowledge exchange within the veterinary vaccinology community.

Working with Business

BBSRC will seek to understand the most critical challenges facing industry and create opportunities for **effective links and engagement between academia and industry**. Promoting a joined up approach to vaccinology across academia and industry will help address disconnect between research and commercial need within the UK.

BBSRC will seek to fund **collaborative and pre-competitive research** through existing funding mechanisms such as the Industrial Partnership Awards, and Stand-alone LINK grants. In addition, **working in collaboration with Innovate UK (formerly the Technology Strategy Board)** and using other support mechanisms (such as Follow-on Funding, Follow-on Pathfinder, Rainbow Seed Fund), BBSRC will ensure that there is a seamless route for translating candidate vaccines into products, policy and practice.

Building on the success of the Animal Health Research Technology Club²³, BBSRC will **work with Industry to explore challenges in the translation of veterinary vaccinology research into new vaccines and identify**

opportunities to address these challenges. BBSRC will explore the possibility of developing an Innovative Medicines Initiative – like programme in veterinary vaccinology in conjunction with other funders across Europe.

Working with the Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK, BBSRC will support novel tools, platform technologies and engineering solutions needed for **scale up, bioprocessing and biomanufacturing of vaccines**. Development of innovative methods for vaccine testing as well as methods that improve efficacy, extend shelf life and reduce production costs will also be encouraged.

Current Activities: Translational Research

Animal Health Research Club: The aim is to bring together industry and the research community to support research that improves understanding of resistance to pests and diseases in farmed animals. <http://www.bbsrc.ac.uk/business/collaborative-research/industry-clubs/animal-health/animal-health-index.aspx>

Agri-Tech Catalyst: The aim is to support businesses and academia in developing innovative solutions to challenges in the agri-tech sector. <http://www.bbsrc.ac.uk/business/collaborative-research/tsb-competitions/agri-tech-catalyst.aspx>

Sustainable Agriculture and Food Innovation Platform: This Innovate UK programme was launched in October 2009 to help UK businesses to develop innovative technologies, production systems and supply chain solutions to increase the productivity of the agri-food sector while reducing its

environmental impact. <http://www.bbsrc.ac.uk/business/collaborative-research/tsb-competitions/saf-ip.aspx>

Replacing Animal Models for Studying Bovine Tuberculosis: BBSRC-NC3Rs call to develop novel systems, that can be used to study TB infection, pathogenesis, virulence and host-pathogen interactions, such as: *in vitro* models; *ex-vivo* models; tissue engineered systems; lab-on-a-chip / microfluidic model; *in silico*, mathematical and systems biology approaches and other appropriate innovative models. <http://www.nc3rs.org.uk/news/replacing-animal-models-studying-bovine-tuberculosis>

A 'one health' approach

A One Health approach - coordinated efforts of medical and veterinary science for mutual benefit, is a key component of the strategy. Complementary and harmonised approaches in humans and animals to better understand mechanisms of infection, protection, persistence and transmission will enable rational design of vaccines.

Advances in veterinary vaccinology research typically rely on novel technologies developed in laboratory animal models or human research, but vaccine development per se can generally proceed much faster in the veterinary sector than in the human medicines sector, due to the different regulatory environment, particularly in relation to early phases of development, and the ability to test vaccines in controlled infection studies. **Working in collaboration with the Medical Research Council (MRC), BBSRC will promote a One Health approach in vaccinology research** by increased and

integrated collaboration between human and animal health sectors **to address important infections of animal and humans including zoonotic diseases.** This will exploit synergies in human and veterinary vaccine design and development, and provide critical mass of a more broadly based research community.

Current Activity: a 'One Health' Approach

Zoonoses and Emerging Livestock

Systems: A joint DFID, DSTL and Research Councils' programme which aims to reduce the impact of zoonoses on poor people and their livestock by making a step change in the evidence available to decision makers to minimise the health risks associated with the rapidly changing nature of livestock production systems in developing countries. <http://www.bbsrc.ac.uk/funding/opportunities/2012/zoonoses-emerging-livestock-systems.aspx>



Networking and coordination

Networking and coordination are important to foster a multidisciplinary community that is able to meet the needs of veterinary vaccinology, to establish closer collaboration with industry and to engage effectively with policy makers and regulators.

BBSRC has established a new **multidisciplinary veterinary vaccinology network** that draw together major UK research players and enhance the uptake of

new technologies in order to design, develop and deliver safe and effective next-generation vaccines against new and (re)-emerging diseases. The **Veterinary Vaccinology Network**²⁴ will advance the field by sharing resources, encouraging collaboration between experts in veterinary and medical sciences, and establishing links with industry.

In addition, BBSRC has supported, through STAR-IDAZ, establishment of a number of disease-specific global networks to address vaccine research challenges.

Current Activities: Networking and Coordination

UK Veterinary Vaccinology Network:

BBSRC funded multidisciplinary network to address the unmet needs in veterinary vaccinology, establish closer collaboration with industry and engage effectively with policy makers and regulators. <http://www.bbsrc.ac.uk/funding/opportunities/2013/uk-veterinary-vaccinology-research-network.aspx>

Global African Swine Fever Research

Alliance (GARA): A global partnership that will generate knowledge and tools to contribute to the successful prevention, control and where feasible eradication of African Swine Fever. <http://www.ars.usda.gov/GARA/>

Global Foot and Mouth Disease (FMD)

Research Alliance (GFRA): A global alliance of scientists producing evidence and innovation that enables the progressive control and eradication of FMD. <http://www.ars.usda.gov/gfra/>

Global Peste-des Petits Ruminants

Research Alliance: This alliance aims to facilitate research and information exchange that contributes to the progressive global and regional control of PPR. <http://www.globalppresearchalliance.org/>

OFFLU: The OIE-FAO global network of expertise on animal influenza working to reduce the negative impacts of animal influenza viruses by promoting effective collaboration between animal health experts and with the human health sector. <http://www.offlu.net/>

Global Research Alliance in Bovine

Tuberculosis (GrabTB): A coordinated global research alliance enabling improved control of bTB.

Skills and training

BBSRC will ensure that the best talent is appropriately developed across the UK research base that underpins veterinary vaccinology research and will provide opportunities for training, retraining and retaining expertise at different career stages and will **actively seek to attract more veterinary graduates into research** at both doctoral and post-doctoral level. Creative use of the available career development mechanisms is required to ensure that the **UK attracts new talent, and maintains appropriate skills and capacity in veterinary vaccine research across the entire vaccinology research pipeline from pathogen biology and immunology to bioprocessing, production and evaluation.** BBSRC acknowledges there is a lack of career path for veterinary vaccinologists and there is a need for support across the skills pipeline

from post graduate training to junior and senior fellowships in veterinary vaccinology.

BBSRC will evaluate the need for training and skills in veterinary vaccinology to ensure the next generation of bioscientists has the appropriate skills and knowledge to tackle challenges in veterinary vaccinology. BBSRC will specifically evaluate skills gaps in basic science (entomology, vector biology, virology, and parasitology) and aim to address the lack of disease- and species-specific expertise.

There will be a need to bring together those institutions that are able to work in different parts of the vaccine research pipeline (from target identification/immunology through to delivery systems/adjuvants and then onto clinical trials and interaction with industry) while also incorporating the One Health concept.

Current Activities: Skills and Training

Doctoral Training Partnerships: This is the main mechanism by which BBSRC provides funding for **PhD training** along with **professional development** training opportunities to enhance students' capability and develop the world-class, highly skilled workforce the UK needs for its future.

Flexible Interchange Programme: The aim is to provide flexible opportunities for individuals ("the interchangers") moving between different organisations, disciplines and sectors at all stages in their career beyond the PhD (or equivalent). <http://www.bbsrc.ac.uk/business/people-information/flexible-interchange-programme.aspx>

Anniversary Future Leadership Fellowships: The fellowship will provide support for early career researchers wishing

to undertake independent research within a host and gain leadership skills. <http://www.bbsrc.ac.uk/funding/fellowships/anniversary-future-leader-fellowship.aspx>

In vivo Strategic Skills Awards: Awards provides additional funding towards the high-costs of in vivo training. <http://www.bbsrc.ac.uk/funding/studentships/strategic-skills.aspx>

Translational Fellowships: Aimed at early career researchers from academia or industry who have demonstrated potential and wish to establish an independent career focused on the translation of fundamental bioscience research. <http://www.bbsrc.ac.uk/funding/fellowships/translational-fellowships.aspx>

7. DRIVING IMPACT

Effective knowledge exchange will be essential to obtain impact from BBSRC's investments. Improved and early engagement with users (industry, policy makers and regulators) will ensure that there is effective innovation, knowledge exchange and commercialisation of outputs from research investments and will better inform the research community of users' needs, drivers, constraints and challenges.

Socio-economic

The adoption and use of vaccines depends on the perceived and actual costs and benefits to individuals and society. BBSRC recognises that there is a **lack of data on the economic impact of infectious diseases of livestock and the benefits of various intervention strategies**. BBSRC encourages researchers to engage with social scientists and economists, at an early stage in research projects, to ensure that societal needs are met in the translation of basic research into products.

BBSRC will work with the Economic and Social Research Council (ESRC) and Defra to ensure research on **social acceptance and uptake of vaccines**, including genetically modified vaccines, is considered during the translation process. This would include understanding of motivations, engagement with the public, industry and policy makers, and developing financial models to encourage farmers to adopt vaccines.

Regulatory

Researchers will be expected to consider **regulatory requirements** and will be encouraged to work within the Veterinary Medicines Directorate guidelines for production and regulation of vaccines.

Legislation

Researchers will be expected to consider legislation requirements. Various international, European and national regulatory bodies are involved in controlling the manufacture and use of vaccines against livestock disease. International bodies such as the World Organisation for Animal Health (OIE) and the European Commission stipulate the time period required to regain disease-free status following an outbreak of an exotic disease. European legislation restricts the use of vaccines for some diseases.

The European Commission has adopted a revised law on veterinary medicines and medicated feed to improve the health and wellbeing of animals, to tackle antimicrobial resistance and to foster innovation²⁵. With its proposal, the Commission aims to tailor legislation on veterinary medicines to the needs of the veterinary sector whilst continuing to ensure a high level of public and animal health and a safe environment. This legislation will impact on the use of vaccines as there will be increased pressure on prudent use of veterinary medicines.



8. INTERNATIONAL COLLABORATION

BBSRC will seek to maximise the UK's veterinary vaccinology interests both in the European Union (by influencing Horizon 2020 priorities) and worldwide by fostering international relations and links with counterpart organisations. We will ensure that, in accordance with the BBSRC International Strategy, UK researchers are able to participate in key international activities through schemes such as International Partnering Awards and can collaborate effectively with researchers in other countries, ensuring a flow of the best international skills and expertise and promoting the sharing of resources and facilities. In addition to **strengthening existing links with the USA, India, Africa and Europe**, BBSRC

will consider opportunities to establish new international links with partners with expertise in vaccine research in other countries, such as China, Korea, Taiwan, South Africa and Brazil, which between them add value in fish, poultry and cattle immunology and challenge studies.



Current Activities: International Collaborations

Europe: ERA-Nets (Animal Health and Welfare ERA-Net and new proposed Sustainable Livestock Production ERA-Net), Horizon 2020.

The Joint Research Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI): Its Implementation Plan highlights “Developing novel vaccination methods and breeding for robustness (to infectious diseases) in livestock and aquaculture” species as an area for investment and where there is a need for common European efforts and developing research through collaborative projects, new ERA-NETS or infrastructures. Special attention will be paid to emerging animal diseases in the context of climate change. <https://www.facejpi.com/Document-library/First-Biennial-Implementation-Plan-2014-2015>

Farmed Animal Disease and Health: A joint BBSRC-DBT India programme for collaborative research to develop tools and control measures to combat diseases of farmed animals and improve their health, welfare and productivity. <http://www.bbsrc.ac.uk/funding/opportunities/2013/farmed-animal-disease-health.aspx>

Animal Health and Disease and Veterinary Immune Reagent Call:

A BBSRC-NIFA collaboration to fund research on emerging diseases and/or diseases of agriculturally relevant animals of high economic consequence in both the US and UK; alternatives to current antimicrobials and anthelmintics used to treat disease in agricultural animals in both the US and UK; and development of publicly accessible immunological reagents for agriculturally relevant animal species. <http://www.bbsrc.ac.uk/funding/opportunities/2014/animal-health-veterinary-immune-reagents.aspx>

Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses (STAR-IDAZ):

A global network to address the coordination of research programmes at international level in animal health and infectious animal diseases, including zoonoses.

<http://www.star-idaz.net/>

Workshop sponsored by the UK Government’s Science and Innovation Network to explore US-UK links in veterinary vaccinology and antimicrobial resistance.

9. CAPACITY AND CAPABILITY

The success of this veterinary vaccinology strategy will depend upon having internationally competitive capacity and capability across the broad bioscience research base that underpins vaccine research. In order to expedite vaccine research and innovation, the research base must be able to respond flexibly to strategic opportunities and challenges and to changing research opportunities and demands. It must have appropriate access to the necessary tools and resources, and interact effectively with stakeholders to ensure maximal knowledge exchange and impact from research.

Infrastructure for Research and Innovation

The STAR-IDAZ survey highlighted issues with four types of facility that are limiting vaccinology research: livestock research, containment level 3, scale-up and containment level 4. The issue with livestock research and containment level 3 facilities - is not simply a lack of facilities and limited capacity for future needs but **lack of access and affordability**. Although access/availability of facilities is restricted for legal or political reasons in some cases, in general the cost of maintaining and running these facilities is an impediment.

BBSRC is supporting the development of world-class containment facilities for animal health research in two of its strategically funded Institutes. The Phase 1 development of the **Pirbright Campus has concluded** and will include a state-of-the-art containment level 4 laboratory complex undertaking research on highly contagious viruses. In 2011, a further investment of £100 million+ was made to include new containment level 2 laboratories due for completion in **late 2015**. A new **Biological Resources Facility** for in-vivo work at various levels of containment is in the planning stage and is **scheduled for completion in 2018**.

The National Avian Research Facility

(NARF)²⁶ at the University of Edinburgh's Easter Bush Campus, funded by BBSRC, the University of Edinburgh, Roslin Foundation and the Wellcome Trust, is a resource for both UK and international researchers studying chicken health and disease.

In addition, where possible, BBSRC, through its input to the European Strategy Forum for Research Infrastructure (ESFRI)²⁷, will **facilitate coordination of large animal and containment facilities across the European Union, encourage collaboration with countries where diseases are endemic and work in partnership with the National Centre for Replacement, Refinement & Reduction of Animals in Research (NC3Rs)** to reduce reliance on high level containment facilities and thereby reduce the cost of animal research at all stages of vaccine research and development.

BBSRC acknowledges that the lack of facilities/farms for vaccine trials is a major limitation given that trials cannot be performed on commercial farms due to Home Office regulations, and issues of public acceptance. Also, infrastructure for pilot studies and small-scale production of vaccines is limited in the UK.

The BBSRC is working with the Home Office, Defra, The Royal College of Veterinary Surgeons and the Wellcome Trust to try to address issues limiting field trials in the UK, including those of vaccines, which may increase the availability of field trial sites and facilities.

10. KEY TARGETS TO DELIVER STRATEGY

BBSRC responsive mode research grants will be a key funding mechanism to support veterinary vaccinology research. The schematic below summarises targets over the coming years.



FOOTNOTES

- ¹ <http://www.noah.co.uk/issues/briefingdoc/22-vaccfarmanimals.htm>
- ² <http://www.nib.ac.uk/publications/downloads/the-pirbright-institute.pdf>
- ³ http://r4d.dfid.gov.uk/PDF/Outputs/AnimalHealth/DFID_impact_case_study_Rinderpest_April2010%5B1%5D.pdf
- ⁴ <http://www.pharmaq.no/products/antibiotic-in/>
- ⁵ http://www.bbsrc.ac.uk/web/FILES/Publications/strategic_plan_2010-2015.pdf
- ⁶ http://www.who.int/nutrition/topics/3_foodconsumption/en/index4.html
- ⁷ Gill, M. Smith, P and Wilkinson, J. M. Mitigating climate change: the role of domestic livestock. *Animal* **4**, 323-333 (2010).
- ⁸ Hristov, A. N. et al. *Mitigation of Greenhouse Gas Emissions in Livestock Production. A Review of Technical Options for non-CO₂ Emissions*. FAO Animal Production and Health Paper, No. 177. Rome (2013)
- ⁹ Herrero, M., Conant, R.T., Havlík, P., Hristov, A.N., Smith, P., Gerber, P., Gill, M., Butterbach-Bahl, K., Henderson, B. & Thornton, P.K. Greenhouse gas mitigation potentials in the livestock sector. *Nature Climate Change* [in revision]
- ¹⁰ IPCC Assessment Report 5 - Food Security and Food Production Systems <http://www.ipcc.ch/report/ar5/wg1/>
- ¹¹ <http://www.fao.org/docrep/017/i3084e/i3084e05.pdf>
- ¹² <http://www.oie.int/en/for-the-media/press-releases/detail/article/oie-at-the-european-parliament-to-raise-awareness-on-animal-diseases-and-risks-for-public-health/>
- ¹³ <http://www.who.int/foodsafety/zoonoses/en/>
- ¹⁴ <http://web.oie.int/boutique/extrait/34arechigaceballos311321.pdf>
- ¹⁵ O'Brien, 2013 – Clinical Infectious Disease, 56 pp705
- ¹⁶ <http://www.pirbright.ac.uk/ecosoc/docs/Foot-and-Mouth-Case-Study.pdf>
- ¹⁷ <http://www.researchandmarkets.com/research/gcksr4/animalveterinary>
- ¹⁸ <http://www.star-idaz.net/>
- ¹⁹ <http://www.bbsrc.ac.uk/funding/opportunities/2013/uk-veterinary-vaccinology-research-network.aspx>
- ²⁰ <http://www.discontools.eu/>
- ²¹ Read this section in conjunction with Section 7: Driving impact
- ²² Translational research can be described as a process to narrow the gap between basic science and its application to product and process innovation
- ²³ <http://www.bbsrc.ac.uk/business/collaborative-research/industry-clubs/animal-health/animal-health-index.aspx>
- ²⁴ <http://www.vetvacnet.ac.uk/>
- ²⁵ http://europa.eu/rapid/press-release_IP-14-987_en.htm
- ²⁶ <http://www.narf.ac.uk/>
- ²⁷ http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri

