Government Office for Science

Department for Environment Food & Rural Affairs

Animal and Plant Health in the UK: Building our science capability

Government Office for Science
Department for Environment, Food and Rural Affairs

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Foreword

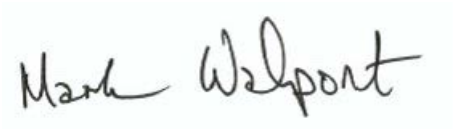
Government cares about the health, wellbeing, resilience, and security of its citizens, as well as the economy and the environment which are vital for society. Science matters to all of these areas.

Diseases in animals and plants can have significant impacts on the economy, the environment and society. Government has therefore been working on building ever more effective systems of prevention, surveillance and response supported by the best science.

The burden of threat is increasing in all areas, as illustrated by the recent increase in the introduction of new damaging tree pests and diseases. We need to build on our current work, through improved coordination and collaboration, to maximise our ability to predict threats, detect and stamp out disease outbreaks, and minimise their effects when they become endemic. This can be achieved effectively and efficiently through a strengthened partnership across UK government, the Devolved Administrations, academia, industry and the charitable sector, and coordinated use of the full range of scientific capability.

The UK's science capability to build resilience to threats from animal and plant disease is maintained by a wide range of bodies from the public, private and charitable sectors. The scientific capability spans everything from understanding public concerns, ensuring a discovery pipeline of new diagnostics, treatments and vaccines, through to the real-time epidemiology used to respond to disease outbreaks, disease response planning, and risk-based cross-border surveillance.

The current institutional structures have evolved for very sound reasons and many aspects of the current disease control systems work well. If these organisations were more coordinated, we could have a more effective and efficient system, which would deliver improved science capabilities to benefit society.



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- Professor Paul Boyle, Chief Executive, ESRC
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- Professor Louise Heathwaite, Chief Scientific Adviser, Rural Affairs and Environment, Scottish Government
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- Professor Nicola Spence, Chief Plant Health Officer, Defra

We are particularly grateful to the large number of experts from across the animal and plant health science landscape who generously gave up their time to participate in project interviews and workshops. Their expert input, views and advice have been invaluable to this project.

Finally, we acknowledge the dedicated work of the members of the Project Team from the Government Office for Science, Defra, Defence Science & Technology Laboratory (DSTL) and the Biotechnology and Biological Sciences Research Council (BBSRC). Under the joint leadership of Dr. Gemma Harper and Andrea Garman, they worked tirelessly to provide the Steering Group with the high quality support needed: Lisa Smith, Andrew Cotterill, Scott Sellers, Dr. Elspeth Steel, Neil Lindsay, Alastair Johnson, Mirzet Sabirovic, Alice Milner, Jef Grainger, Gregory Vaughan, David Lawrence, Neel Naik, Elizabeth Lewis, Claire Drurey and Robbie Moore.

Executive summary

In December 2013 the UK Government Chief Scientific Adviser, Sir Mark Walport, and Defra's Chief Scientific Adviser, Professor Ian Boyd, started a study to determine the UK's future needs for capability in the provision of research, evidence and laboratory services to underpin best practice management for animal and plant health during the next 10-15 years.

Agriculture, forestry, fisheries, aquaculture and the equine/racing industries matter to the UK. They are valuable to the economy, society and the environment. The annual economic contribution by these industries, measured using Gross Value Added (GVA), is estimated to be over £10bn[1]. The wider agri-food industry "from field to fork" contributes around £97bn to national GVA each year[2]. The social and environmental value of forestry, in so far as this can be quantified financially, is estimated to be around £1.8bn each year[3].

This study was performed because of **four key scientific issues** that, if not tackled, could impair the UK's capacity to handle and minimise the costs and consequences of animal and plant diseases. These are:

1. The need to ensure that the UK maintains appropriate capacity to predict, detect, understand and respond to animal disease threats that pose a national risk, some of which have zoonotic potential (that is the ability to transfer between vertebrate animals and humans);

2. Evidence of mounting risks to crops, trees and native plant species from pests and diseases, which threaten food security, forest productivity and biodiversity;

3. Concerns about fragmentation of the infrastructure that delivers the scientific capability for the UK; and

4. The science capability to predict, detect and respond to animal and plant pests and disease is shared among different parts of the UK government and the Devolved Administrations and there is no overall mechanism for coordination.

A Steering Group of experts from the UK government, the Devolved Administrations, the Research Councils, industry and academia guided this project. The evidence collection phase consisted of a programme of workshops and interviews with the Steering Group and a wide range of experts from across the animal and plant health science landscape.

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[1] Food Statistics Pocket Book, Page 12, Defra (National Statistics), 2013 sources GVA for agriculture and fishing of **£9bn** per year: www.gov.uk/government/statistics/food-statistics-pocketbook-2013. The UK Forestry direct GVA value of **£0.8bn** per year is based on ONS statistics for logging and sawmilling/planing. The 2014 ONS Annual Business Survey (Section A) sources GVA for aquaculture at just under **£0.2bn** per year. GVA for the horse racing sector is estimated at around **£0.5bn** (including activities relating to racecourses, horse owners, breeders and media) see pages 10-11 of www.britishhorseracing.com/wp-content/uploads/2014/03/EconomicImpactStudy2013.pdf, and there will be additional value associated with the equestrian sector (upkeep and care of horses and riders' and horses' equipment and consumables). £10bn is 0.6% of Gross Domestic Product www.ons.gov.uk/ons/rel/naa2/quarterly-national-accounts/q2-2014/stb-quarterly-national-accounts--q2-2014.html

[2] The agri-food sector contributed £97.1 bn to national Gross Value Added in 2012: Food Statistics Pocket Book, Page 8, Defra: www.gov.uk/government/statistics/food-statistics-pocketbook-2013

[3] The Tree Health Management Plan, Defra, 2014: Pages 4-5, estimates the social and environmental value of forestry at around £1.8bn per year: www.gov.uk/government/publications/tree-health-management-plan

The first phase of workshops brought together experts to explore the Current Evidence Landscape, Risk and Emerging Technologies. The second phase of workshops focussed on developing proposals for improvements.

This study builds on recent progress in animal and plant health science. It has been shaped by developments in risk assessment, research partnerships and contingency and control plans. It also takes account of developments arising from the UK Strategy for Agricultural Technologies[4]. Through extensive consultation with experts, the study has assembled evidence from these and other sources, to form *for the first time* a strategic approach to animal and plant health across the UK, involving cooperation and collaboration across government departments, the Devolved Administrations and the Research Councils. The study has already created a programme of work that will increase our capability to tackle growing threats from animal and plant diseases.

The **key findings** are as follows:

Key finding 1: There are many animal and plant disease threats to the UK that could have important consequences for society. Some of these are likely to be felt most in the parts of the UK where there is the greatest reliance for growth in the sectors of farming and forestry.

Key finding 2: There is a substantial amount of science being funded by the UK government and the Devolved Administrations across animal and plant health and some good examples of coordination and collaboration. However, the science landscape is too complex and distributed to self-organise effectively.

Key finding 3: With little evidence of a coordinated UK level vision for animal and plant health science and no agreed set of priorities to incentivise collaboration and cooperation, there is too much scope for duplication (costly) and gaps (risky) in science infrastructure, skills and evidence generation, all of which may reduce the cost-effectiveness of government investment.

Key finding 4: The absence of unified, strategic oversight of animal and plant health science in the UK reduces the extent to which interdisciplinary capabilities in natural science, social science and economics are effectively deployed.

Key finding 5: While capability is sustainable in some areas, there is a range of scientific areas where the UK is currently experiencing skills shortages.

Key finding 6: Current risk assessment is primarily driven by known pests and pathogens. Further consideration needs to be given to wider risks and the need to take more of a whole-system view. Work is in place to establish a prioritised risk register across animal and plant health.

Key finding 7: There is further potential for the science and expertise from academia, industry, non-governmental organisations (NGOs) and the charitable sector across the UK and internationally to contribute to the UK's science capability and to stimulate innovation.

[4] A UK Strategy for Agricultural Technologies: Industrial Strategy: government and industry in partnership, HM Government, July 2013. Available from: https://www.gov.uk/government/publications/uk-agricultural-technologies-strategy

The case for change is based on the need to build on current good practice and improve efficiency and effectiveness in animal and plant health science through better coordination and strategic planning. Achieving this will continue to help deliver efficiency benefits that will help to protect and enhance the £10bn of additional yearly economic value (plus additional social and environmental value) across a number of key sectors.

The project has demonstrated a need for a new UK level **vision** for animal and plant health science. We propose that this should be:

An improved culture of coordination, collaboration and sharing of good practice across plant, animal and human health science capabilities is needed to deliver this vision. This can be realised through the establishment of a new **UK Science Partnership for Animal and Plant Health** which will set the overarching strategic direction and priorities for animal and plant health science and ensure that the UK has the science capability that it needs during the next 10-15 years.

Recommendation 1: Establish a new 'UK Science Partnership for Animal and Plant Health' to develop a more integrated, whole-system approach to animal and plant health science.

Building on existing coordination mechanisms and good practice, this new science partnership will help drive culture change and increase the efficiency and effectiveness of science delivery by:

- Further connecting science and expertise across the UK government, the Devolved Administrations, academia, industry, NGOs and the charitable sector.
- Increasing use of international expertise.
- Further exploitation of the potential of emerging technologies.
- Rationalising overlaps and alleviating gaps in UK infrastructure, skills and evidence generation.

In the longer term, the success of this new science partnership will be measured by its ability to:

- Deliver improved value for money by minimising duplications and filling strategically important evidence gaps (thereby increasing effectiveness).
- Deliver improved innovation by making better use of emerging technologies and cutting-edge scientific techniques.
- Strengthen emergency preparedness and coordinate the national deployment of interdisciplinary science capabilities in times of emergency response.

- Protect and augment animal and plant health science skills and capabilities within the UK.
- Enhance engagement between public and private sectors across the UK and internationally.

Viewed in this light, any additional costs of establishing and supporting this new science partnership are small in comparison and will make up only a small fraction of one per cent of the annual value of benefits delivered.

Progress towards a UK level vision and formation of the new UK Science Partnership for Animal and Plant Health will involve significant change in both practice and culture. The Steering Group has therefore agreed that a stepwise approach should be taken to creating this partnership including immediate work on a set of high priority issues.

Recommendation 2: To deliver rapid progress, the project Steering Group should become an interim Implementation Group to drive forward immediate work on priority actions as the first step in progress towards a new UK Science Partnership for Animal and Plant Health.

This will deliver rapid progress in the short term and provide a tangible demonstration of the value of this new science partnership. The proposal is that in the interim:

- The current Steering Group becomes an Implementation Group chaired by the Government Chief Scientific Adviser (GCSA);
- The Implementation Group will oversee work to take forward the four priority actions described below and to develop an action plan for establishing the new science partnership;
- Independent science advice and expertise will be provided to the Implementation Group by Defra's Science Advisory Council, the Scottish Science Advisory Council, and the Science Advisory Council for Wales; and
- Groups will be convened to work on each of the four priority actions. Members of the Implementation Group will lead each group.

Implementation plan

The Implementation Group will oversee work on four areas identified by the project as priority actions for immediate attention:

Action 1: Develop a UK level strategy for animal and plant health science that identifies the key priorities and scientific questions, defines the role for government and others, and sets out an action plan with accountabilities for delivery.

Action 2: To strengthen the evidence base for maximising the value from public investment in animal and plant health science across government.

Action 3: Propose an integrated and rational strategy for the maintenance of high containment laboratory capability for analysis of viral animal pathogens (including those which are transmissible to humans), recognising the longer term need to ensure an integrated UK approach to analysis of all viral animal pathogens.

Action 4: Generate a plan for developing appropriate plant health skills and career pathways.

Alongside work on the priority actions, the Implementation Group will develop an action plan for establishing the new UK Science Partnership for Animal and Plant Health.

Chapter 1: Introduction

This chapter sets out the rationale for the project, its scope and how it was conducted.

1.1 The importance of animal and plant health science

The health of animals and plants in the UK affects our rural and urban communities and our ability to champion the UK's food and its environment. Agriculture, forestry, fisheries, aquaculture and the equine/racing industries matter to the UK. They are valuable to the economy, society and the environment. The annual economic contribution by these industries, measured using Gross Value Added (GVA), is estimated to be over £10bn[5]. The wider agri-food industry "from field to fork" contributes around £97bn to national GVA each year[6]. The social and environmental value of forestry, in so far as this can be quantified financially, is estimated to be around £1.8bn each year[7].

This productivity hinges on the health of the animals and plants that form the basis of these industries. When this health is affected, the economic, social and environmental consequences can be significant. Disease outbreaks, and the measures used to control them, carry wide and costly consequences for society, the economy and the environment. For example, the total costs to the economy of the outbreak of foot and mouth disease in 2001 were in the region of £3-4bn[8], involved the slaughter of millions of animals, and affected animal owners, rural businesses and the tourism industry.

While economic considerations are a key driver for the maintenance of animal and plant health in the UK, so is the health and wellbeing of the public, including the risk of zoonotic diseases. Many of the current emerging diseases, such as, avian influenza type H5N1, are zoonotic. Plants and animals are also integral to our green and blue (water) spaces and are essential to the wellbeing of the population[9]; societal wellbeing, and its valuation, is critical to understanding the value to society of plants and animals as part of the ecosystem[10].

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[5] Food Statistics Pocket Book, Page 12, Defra (National Statistics), 2013 sources GVA for agriculture and fishing of **£9bn** per year: www.gov.uk/government/statistics/food-statistics-pocketbook-2013. The UK Forestry direct GVA value of **£0.8bn** per year is based on ONS statistics for logging and sawmilling/planing. The 2014 ONS Annual Business Survey (Section A) sources GVA for aquaculture at just under **£0.2bn** per year. GVA for the horse racing sector is estimated at around **£0.5bn** (including activities relating to racecourses, horse owners, breeders and media) see pages 10-11 of www.britishhorseracing.com/wp-content/uploads/2014/03/EconomicImpactStudy2013.pdf, and there will be additional value associated with the equestrian sector (upkeep and care of horses and riders' and horses' equipment and consumables). £10bn is 0.6% of Gross Domestic Product www.ons.gov.uk/ons/rel/naa2/quarterly-national-accounts/q2-2014/stb-quarterly-national-accounts--q2-2014.html

[6] The agri-food sector contributed £97.1 bn to national Gross Value Added in 2012: Food Statistics Pocket Book, Page 8, Defra: www.gov.uk/government/statistics/food-statistics-pocketbook-2013

[7] The Tree Health Management Plan, 2014, Pages 4-5, estimates the social and environmental value of forestry at around £1.8bn per year: www.gov.uk/government/publications/tree-health-management-plan

[8] "Economic costs of the foot and mouth disease outbreak in the UK in 2001" OIE's Revue Scientifique et Technique 2002, 21(3), p675-687.

[9] See for example the Beyond Greenspace blog which describes the progress of a research project based at the University of Exeter. Beyond Greenspace uses secondary ecological, socioeconomic and health data to deepen our understanding of relationships between nature, health and wellbeing: http://beyondgreenspace.wordpress.com/

[10] One of the key findings from the National Ecosystem Assessment Follow On (NEAFO) is that 'combining monetary and non-monetary, deliberative and interpretive methods can deliver a more comprehensive

Government has therefore been working on building ever more effective systems of prevention, surveillance and response supported by the best science. In the last year, Defra has consolidated operational delivery by bringing together animal and plant health inspection functions in the new Animal and Plant Health Agency (APHA), increasing our flexibility and resilience to respond to emergencies, and overhauled its approach to the escalation and assessment of risk. A new risk assessment approach has been introduced across the whole of the Defra network to enable animal and plant health risks to be escalated quickly and assessed (in terms of their impact on the UK and the likelihood of the risk happening). The approach is led by the Chief Veterinary Officer and Chief Plant Health Officer and prioritises action based on the risks posed to the economy, environment and society. Defra has a new forum where risks are escalated directly to the Secretary of State and Ministers (the Monthly Biosecurity Meeting), and implementation activities and capabilities across animals, plants, bees, fish and invasive non-native species are discussed.

Maintaining the Plant Health Biosecurity Strategy for Great Britain and the Plant Health Risk Register are also key priorities alongside the development of specific contingency plans against known pests and diseases at England, Wales and Scotland levels.

Defra and the Welsh Government recognise in the recent evidence strategy[11] that government investment in strategic evidence has an important role in helping society and business respond to current and long-term challenges. The strategy identifies a set of key issues for evidence in order to support the delivery of policy:

- Enhanced competitiveness and environmental performance in the environmental, food and rural sectors.
- Natural resources managed sustainably and equitably to promote economic growth, public health and healthy ecosystems.
- Greater resilience through well managed risk, and better contingency planning and mitigation of risks associated with the natural environment.

Welsh Government

Animal health is given high priority by the Welsh Government as demonstrated by the establishment of an Office of the Chief Veterinary Officer for Wales and the announcement of a 10 year Welsh Government framework for animal health and welfare, with a strong emphasis on protecting public health and evidence based policy making.

Scottish Government

The Scottish Government's purpose is to focus government and public services on creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth. The food and drink sector (including agriculture

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valuation of ecosystem services' (NEAFO Synthesis Report, key messages, page 5). The NEAFO has developed the Balance Sheet Approach, which recommends a broader range of evidence and methods is used as the environmental context becomes more complex and dynamic. In highly complex and dynamic contexts, the approach indicates that techniques such as multi-criteria analysis and group-based deliberative methods can help ensure a full range of values, ethical issues and fairness are taken into account (NEA Synthesis Report, Section 1.3 What are the advances in our ability to make better decisions, pages 15-16).

[11] Making the most of our evidence: A strategy for Defra and its network, Defra, June 2014. Available from: www.gov.uk/government/publications/evidence-strategy-for-defra-and-its-network

and fisheries) has been identified as one of the major areas for growth by the Scottish Government. **Scotland's Rural Affairs, Food and Environment Research Strategy (2016-2021)** and current portfolio of research (2011-2016)[12], set the framework for investment in scientific research to underpin Scotland's rural communities and businesses; the productivity and profitability of the agricultural sector; the sustainable use of natural resources; and the prevention and effective management and control of animal and plant diseases. Additionally, the Science and Innovation Strategy for Forestry in Great Britain[13], delivers Scotland's forestry research and has a strong focus on biosecurity. Through both strategic research programmes and Centres of Expertise, founded on the principles of multi-disciplinary and collaborative working, the level of preparedness, coordination and resilience to animal and plant health risks is enhanced. However, like the rest of the UK institutions, they do not have the capacity to cover all threats.

Department of Agriculture and Rural Development Northern Ireland

The Department of Agriculture and Rural Development Northern Ireland (DARD NI) has highlighted the importance being given to growing a sustainable, profitable and integrated Northern Ireland agri-food supply chain. This will be achieved through promotion of high quality, safe food with an emphasis on provenance from family farms operating to high standards of animal and plant health, husbandry, hygiene and integrity. The current DARD NI animal and plant health operational priorities are to improve animal health and welfare and protect the food chain; and control of diseases affecting trees, horticulture and arable crops. DARD NI is also committed to enhancing the arrangements for animal and plant health on an 'all-Island' basis by working with the Department of Agriculture, Food and the Marine (DAFM). The North South Ministerial Council Agriculture meetings between respective Ministers direct and note the progress of the **All-Island Animal Health & Welfare Strategy**[14] and **Surveillance Strategy**[15] in addition to the **All-Ireland Chalara Control Strategy**[16] and **strategic plant health and pesticides work programme** all are vehicles to ensure effective, on-going institutional cooperation across the island of Ireland for mutual benefit.

Europe

From a European perspective, the 'Smarter Rules for Safer Food' package of measures presented by the European Commission (May 2013)[17] will transform the European regulatory landscape in the animal and plant health fields. It proposes to repeal more than forty existing Regulations and Directives, and will provide a single, simplified regulatory framework for animal and plant health.

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[12] The Scottish Government's Rural and Environment Science and Analytical Services Division Strategic Research Portfolio 2011-16: www.scotland.gov.uk/Topics/research/about/ebar/strategicresearch/future-research-strategy

[13] Science and Innovation Strategy for Forestry in Great Britain, Forestry Commission, 2014.

[14] See the following link to the Press Release for the launch of the All-Island Animal Health & Welfare Strategy in March 2010: www.northernireland.gov.uk/news-dard-310310-all-island-animal

[15] The Surveillance Strategy is yet to be published but its precursor was the All-Island surveillance report. See: www.afbini.gov.uk/all-island_animal_disease_surveillance_report_2011reduced.pdf

[16] All-Ireland Chalara Control Strategy, NI Executive, 2013.

[17] Animal and Plant Health Package: Smarter rules for safer food, European Commission, May 2013.

1.2 Project objectives and scope

This study was performed because of **four key scientific issues** that, if not tackled, could impair the UK's capacity to handle and minimise the costs and consequences of animal and plant diseases. These are:

1. The need to ensure that the UK maintains appropriate capacity to predict, detect, understand and respond to animal disease threats that pose a national risk, some of which have zoonotic potential;
2. Evidence of mounting risks to crops, trees and native plant species from pests and diseases, which threaten food security, forestry productivity and biodiversity;
3. Concerns about fragmentation of the infrastructure that delivers the scientific capability for the UK; and
4. The science capability to predict, detect and respond to animal and plant pests and disease is shared among different parts of the UK government and the Devolved Administrations and there is no overall mechanism for coordination.

Guided by the need to address these issues, the Government Chief Scientific Adviser, Sir Mark Walport and Defra's Chief Scientific Adviser, Professor Ian Boyd, started a study in December 2013 to determine the UK's future needs for capability in the provision of research, evidence and laboratory services to underpin best practice management for animal and plant health during the next 10-15 years. The project terms of reference are set out in Annex 1.

This project focused on the generation, management and collation of all sources of evidence relating to the challenges to plant and animal health (and welfare) from pests or disease. This includes the diseases of pollinators, fish disease in aquaculture, zoonotic diseases as well as endemic and exotic diseases of plants and animals. Nutritional and some environmental (for example, non-native species) challenges related to animal and plant health were out of scope.

The project covered the natural and social sciences including economics, technology and engineering.

In this report, the term 'evidence' refers to the outcome of research, analysis, monitoring and surveillance, which underpins scientific knowledge, and, in turn, informs strategy, policy and delivery.

1.3 Project approach and methods

A Steering Group of experts from the UK government, the Devolved Administrations, the Research Councils, industry and academia guided this project. This group structured its work around two phases of activity: evidence collection; and the assessment and diagnosis of the problems of delivering effective UK science capability to prevent and respond to animal and plant disease.

The evidence collection phase of this project consisted of a programme of workshops and face-to-face interviews with the Steering Group and a wide range of experts from across the animal and plant health science landscape.

The first phase of workshops brought together experts to explore:

- The Current Evidence Landscape
- Risk
- Emerging Technologies

The second phase of workshops focussed on developing proposals for improvement.

Annex 2 provides further details of the methods used in this project and of the issues explored in these workshops.

This project has taken account of several recent developments including the report from the **Tree Health and Plant Biosecurity Expert Taskforce**[18] (and the government response to this), publication of the **Plant Biosecurity Strategy for Great Britain**[19], the **Tree Health Management Plan**[20], which describes how government is implementing the Plant Biosecurity Strategy for pests and diseases of trees in England, and the **House of Commons Environment, Food and Rural Affairs Committee's report on Tree Health and Plant Biosecurity**[21].

The project has also taken account of the **UK Strategy for Agricultural Technologies**[22], **The Strategy for achieving Officially Bovine Tuberculosis Free status for England**[23], the **UK Five Year Antimicrobial Resistance Strategy 2013 to 2018**[24] and **The National Pollinator Strategy: for bees and other pollinators in England**[25]. It also builds on the work of the **Global Food Security Programme**[26], the **Food Research Partnership**[27], the Scottish Government's **Rural Affairs, Food and Environment Research Programme**[28], the recently published **Science and Innovation Strategy for Forestry in Great Britain**[29]

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[18] Tree Health and Plant Biosecurity Expert Taskforce Final Report, Defra, May 2013.
[19] Protecting Plant Health: A Plant Biosecurity Strategy for Great Britain, HM Government, April 2014.
[20] The Tree Health Management Plan, Defra, 2014.
[21] Tree Health and Plant Biosecurity, House of Commons Environment, Food and Rural Affairs Committee Tenth Report of Session 2013-14, March 2014.
[22] A UK Strategy for Agricultural Technologies: Industrial Strategy: government and industry in partnership, HM Government, July 2013. Available from: https://www.gov.uk/government/publications/uk-agricultural-technologies-strategy
[23] The Strategy for achieving Officially Bovine Tuberculosis Free status in England, Defra, April 2014. Available from: www.gov.uk/government/publications/a-strategy-for-achieving-officially-bovine-tuberculosis-free-status-for-england
[24] UK Five Year Antimicrobial Resistance Strategy 2013 to 2018, HM Government, 2013. Available from: www.gov.uk/government/publications/uk-5-year-antimicrobial-resistance-strategy-2013-to-2018
[25] The National Pollinator Strategy: for bees and other pollinators in England, Defra, 2014. Available from: www.gov.uk/government/publications/national-pollinator-strategy-for-bees-and-other-pollinators-in-england
[26] Global Food Security programme: The UK's main public funders of food-related research and training are working together through the Global Food Security programme to meet the challenge of providing the world's growing population with a sustainable, secure supply of safe, nutritious, and affordable high-quality food using less land, with lower inputs, and in the context of global climate change, other environmental changes and declining resources www.foodsecurity.ac.uk/programme/
[27] The Food Research Partnership (FRP) brings together key public sector funders of food-related research with senior representatives from the research community, non-governmental organisations and the agri-food industry to promote cross-sector dialogue and to jointly deliver enhanced leadership in addressing key strategic issues for food research and innovation.
[28] See the Scottish Government Rural Affairs and Environmental Strategic Research programmes at the following link: www.scotland.gov.uk/Topics/Research/About/EBAR/StrategicResearch/future-research-strategy/Themes
[29] Science and Innovation Strategy for Forestry in Great Britain, Forestry Commission, 2014.

and Defra's new **Evidence Strategy 'Making the most of our evidence'** which sets out how evidence will help to deliver advice and support to policy and operations in Defra[30]. Notably, this latter strategy states that Defra will support the co-design and co-funding of research with other parts of government.

Chaired by Sir Mark Walport, Government Chief Scientific Adviser, the Project Steering Group included Professor Ian Boyd, Defra's Chief Scientific Adviser and Deputy Chair, the Chief Veterinary Officer, Defra's Chief Plant Health Officer and senior representation from the Scottish, Welsh and Northern Ireland Governments, the Department of Health (DH), the Department for Business, Innovation and Skills (BIS), the Biotechnology and Biological Sciences Research Council (BBSRC), the Economic and Social Research Council (ESRC), and three independent experts: Professor Rob Fraser, Professor of Agricultural Economics, University of Kent; Professor Quintin McKellar, Vice Chancellor, University of Hertfordshire; and Mike Bushell, Principal Scientific Adviser, Syngenta. Details of the Steering Group are included at Annex 3.

[30] Making the most of our evidence: A strategy for Defra and its network, Defra, June 2014. Available from: www.gov.uk/government/publications/evidence-strategy-for-defra-and-its-network

Chapter 2: Assessment and diagnosis

This chapter summarises the funding of UK animal and plant health science, the range of institutions and organisations involved in its delivery, and provides a high level assessment of the current science landscape. It draws extensively on the outputs of the workshops with experts as well as interviews with the Steering Group and a wide range of experts from across the animal and plant health science landscape.

2.1 UK investors in animal and plant health science

The UK invests significant amounts of money in plant and animal (including welfare) health science. This includes funding from public, private and the charitable sectors.

UK government investment in animal and plant health science is estimated to be in the region of £200-£250m annually (this includes spend by Defra, BIS, DFID, BBSRC and other Research Councils, the Forestry Commission, Innovate UK and the Devolved Administrations - see Annex 4 for further details). By way of comparison, total government investment in research activities was £9.7bn in 2012[31].

The Defra network

Defra and its network of agencies including the Food and Environment Research Agency (FERA) the Animal and Plant Health Agency (APHA)[32], the Veterinary Medicines Directorate (VMD), and the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), invest in science activities to support government policy in relation to:

- predicting risk;
- prioritising areas for intervention;
- disease protection measures;
- building resilience and resistance; and
- disease management.

Much of Defra's current evidence spend in this area is on statutory obligations for evidence and on short-term applied research priorities. The recently published Defra evidence strategy 'Making the Most of our Evidence[33] sets out how Defra and its network bodies will improve the way it addresses both applied and strategic evidence needs for the future by working together as one business: prioritising needs, coordinating evidence activities, sharing best practice and improving the quality and management of information.

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[31] UK Government Net Expenditure on R&D (including expenditure by government departments, Research Councils and Higher Education Funding Councils and the indicative UK contribution to EU R&D expenditure) in 2012 (current prices) was £9.7bn. Source: UK Government Expenditure on Science, Engineering and Technology, 2012 Statistical Bulletin, Office for National Statistics, July 2014.

[32] On 1 October 2014, a new agency 'The Animal and Plant Health Agency' (APHA) was launched. This agency joined four functions of FERA (Bee Inspectorate, the Plant Health and Seeds Inspectorate, the Plant Variety and Seeds Group and the GM Inspectorate) with the Animal Health and Veterinary Laboratories Agency (AHVLA).

[33] Making the most of our evidence: A strategy for Defra and its network, Defra, June 2014. Available from: www.gov.uk/government/publications/evidence-strategy-for-defra-and-its-network

Devolved Administrations

Animal health and welfare research portfolios are held and administered by Defra on a GB basis, in recognition that animal industries and diseases operate in the epidemiological unit of GB, and for economies of scale. Defra holds the research budget for plant health on behalf of England and Wales; Scotland and Northern Ireland hold separate research budgets for plant health. Through the Science and Innovation Strategy for Forestry in Great Britain[34], the Forestry Commission GB funds research on tree health issues and associated knowledge exchange with additional resources allocated to tree health statutory work, surveys and control of outbreaks, as necessary.

Additionally the devolved budgets are used to support animal health and welfare issues.

DARD NI has a separate animal health and welfare research budget which funds evidence gathering to support both policy development and the local agri-food sector in relation to animal disease control. DARD NI also provides funding for postgraduate research studentships which focus on the mechanisms of animal disease and on their control.

In Scotland, the Scottish Government funds a veterinary surveillance programme to collect information on diseases and infections in animals and undertakes specific surveys to measure the prevalence of certain diseases. The Scottish Government funds an extensive research portfolio in Rural Affairs, Food and the Environment at the Scottish research institutes (which includes research in livestock and crop health and disease), Science and Advice for Scottish Agriculture (SASA) and Marine Scotland Science (MSS). The Scottish Funding Council provides funding for research at Higher Education Institutions in Scotland which also covers animal and plant health related work as does the Higher Education Funding Council for England and the Higher Education Funding Council for Wales.

UK Government Departments (other than Defra)

Other UK Government Departments such as the Food Standards Agency (FSA), the Department for International Development (DFID), the Department for Business, Innovation and Skills (BIS) - through its funding of science and research, Innovate UK (formerly the Technology Strategy Board (TSB)) and the Science and Research Budget - and the Department of Health (DH) (including Public Health England), fund evidence activities that contribute to UK capability to support animal and plant health. For example, although DH does not directly fund research on animal health, some of its human health research relates to zoonotic diseases and often has implications for animal health, such as, through the development of diagnostics for *E.coli* 0157 and *Campylobacter*. FSA funds research on *Campylobacter*, *Salmonella*, *E.coli* 0157, *Trichinella*, Q fever and Transmissible spongiform encephalopathy (TSEs).

The UK government recently invested £160m to strengthen existing, and to develop innovative new collaborations among policy makers, funders, industry and academia to accelerate innovation by UK food and farming businesses. This includes an agri-tech catalyst, set up by Innovate UK, BBSRC and DFID with £70m investment to provide a single fund for projects from laboratory to market and £90m of UK government funding for Centres of Agricultural Innovation. Innovate UK has also recently announced a £16.5m grant support thematic call for animal and crop disease solutions under Innovate UK's sustainable agriculture and food innovation platform.

[34] Science and Innovation Strategy for Forestry in Great Britain, Forestry Commission, 2014.

Research Councils

The UK government invests in fundamental underpinning research in animal and plant health through the Research Councils (notably BBSRC, ESRC and the Natural Environment Research Council (NERC)).

Under the strategic priority of Agriculture and Food Security, BBSRC funds significant research in animal health and crop sciences, including research into *Chalara fraxinea* and bovine tuberculosis. It also provides strategic funding to various animal and plant health institutions, for example, The Pirbright Institute which conducts research on viral diseases of farm animals and viruses that spread from animals to humans, and the John Innes Centre (Reducing Crop Losses programme).

NERC funds basic and strategic environmental research and monitoring though Higher Education Institutes and its centres at the population, local and global scales. These studies help better understand the threats, responses, and mitigation opportunities of ecosystems, and their plants and animals, to natural challenges and man-made activities. Through this whole-system knowledge, NERC informs responsible management of the environment.

ESRC funds research on the food system, including animal and plant health considerations. The Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre brings together social and natural scientists to carry out research across the areas of food and agriculture, health and disease, water and sanitation and energy and climate change to generate new thinking and practical solutions. ESRC has also identified an interconnected set of social science challenges related to energy, environment and food security – the Social Science of the Nexus – from which ESRC, working with a range of partners, is taking forward a programme of research and capacity building.

Other funders

Commercial organisations, NGOs and charities invest significant resources in animal and plant health science. Charitable organisations, including the Bill and Melinda Gates Foundation, the Gatsby Charitable Foundation and the Wellcome Trust, make significant investment in research that addresses global health and development issues, including agriculture and infectious diseases. The agri-tech and animal health industries traditionally invest in near market research and product development to aid disease control and improve agricultural productivity. The agricultural and horticultural levy boards also contribute toward applied research and invest significantly in knowledge transfer.

2.2 Providers of UK animal and plant health science

A wide range of institutions and organisations generate animal and plant health science for the UK. This is illustrated in Annex 5, which maps the range of bodies involved in delivering animal and plant science.

These institutions and organisations include:

- Government agencies, for example: FERA, APHA, VMD, CEFAS, Science and Advice for Scottish Agriculture (SASA) and Marine Scotland Science (MSS) - that are part of the Scottish Government - and Forest Research (a delivery agency of the Forestry Commission).
- Executive non-departmental public bodies, for example: Royal Botanic Garden Edinburgh, Kew Gardens and the Agri-Food and Biosciences Institute (AFBI) that operate at an arm's length from sponsor departments.
- Institutions such as The Pirbright Institute, Rothamsted Research, The Roslin Institute and the John Innes Centre that receive strategic funding from the BBSRC, and The Sainsbury Laboratory which is based on the Norwich Research Park and is closely linked to the Gatsby Charitable Foundation, University of East Anglia, BBSRC and the John Innes Centre.
- Institutes that receiving funding from other Research Councils such as The Centre for Ecology and Hydrology (CEH), funded by NERC.
- Institutions such as The James Hutton Institute, Scotland's Rural College and the Moredun Research Institute that receive strategic science funding from the Scottish Government.
- Higher Education Institutions that provide significant capability, for instance, Scotland's Rural College, Harper-Adams University and the Royal Agricultural University and Schools of Veterinary Medicine throughout the UK.
- Industry, which often provides co-funding for research projects, and funds applied research for product development. Examples include agri-tech and animal health companies and independent institutes in their own right (ADAS[35], East Malling, red meat levy bodies).
- NGOs and the charitable sector, for example, Animal Health Trust, Royal Horticultural Society, National Trust, Woodland Trust and the Royal Society for the Protection of Birds (RSPB).
- International institutions, both at the EU level and further afield, for instance reference laboratories in other countries and research carried out by the World Health Organisation (WHO) on zoonoses.

[35] ADAS Ltd – formerly the Agricultural Development Advisory Service.

UK institutes and university departments are at the forefront of areas of research vital to agriculture and related technologies[36]. Animal and plant health science in the UK is high quality and has internationally recognised centres of expertise, for example:

- The Kew Fungarium is the largest and most comprehensive in the world, containing an estimated 1.25 million specimens.
- The Millennium Seed Bank Partnership at Kew is the largest *ex situ* plant conservation programme in the world.
- FERA hosts the National Collection of Plant Pathogenic Bacteria, one of the most important plant pathogen collections in the world.
- The Royal Botanic Garden Edinburgh herbarium has nearly 3 million specimens representing half to two thirds of the world's flora. Around 11,000 new specimens are added annually.
- The James Hutton Institute holds the internationally important Commonwealth Potato Collection.
- Scottish Government (SASA) maintains over 700 commercial potato varieties in tissue culture as well as unique cereal and field vegetable seed collections.
- The Pirbright Institute is the reference laboratory for Foot and Mouth and other diseases and provides diagnostic and surveillance capability for ten viral exotic diseases (including Foot and Mouth Disease, African swine fever and Bluetongue) for Defra and for the Scottish Government, and internationally to the UN's Food and Agriculture Organisation (FAO), The World Organisation for Animal Health (OIE) and the European Union.
- APHA's central laboratory at Weybridge acts as the national, european and international (FAO, WHO and OIE) reference laboratory for more than 25 exotic and zoonotic notifiable or reportable diseases, including bovine tuberculosis, brucella, antimicrobial resistance, avian influenza and rabies.
- CEFAS Weymouth laboratory is the national reference laboratory and OIE Collaborating Centre for Aquatic Animal Diseases and is designated by the European Commission as the European Union Reference Laboratory (EURL) for monitoring bacteriological and viral contamination of bivalve molluscs. It is also the EURL for crustacean diseases.
- AFBI is a DARD NI Non Departmental Public Body responsible for carrying out high technology R&D, statutory, analytical and diagnostic testing in relation to animal health and welfare, and plant health.

The high quality of science fosters links with research programmes around the world and provides opportunities for increased collaboration in the future. Several initiatives exist to support collaboration between providers of research and between research fund managers. Within the EU, ERA-NETs[37] on both plant and animal health provide tools for coordinating transnational funding. The EU also supports collaborative research directly, funding international networks through the Framework and Horizon 2020 programmes. A further

[36] A UK Strategy for Agricultural Technologies: Industrial Strategy: government and industry in partnership, HM Government, July 2013. Available from: https://www.gov.uk/government/publications/uk-agricultural-technologies-strategy

[37] European Research Area Networks (ERA-NETs):
Animal Health and Welfare ERA-NET (ANIHWA) www.anihwa.eu/
Phytosanitary ERA-NET (EUPHRESCO) www.euphresco.net/

initiative with respect to animal health - STAR-IDAZ[38] - seeks to build a global network of research funders to address shared priorities, increase research capacity and make better use of resources.

In addition, international standards adopted under the framework of the International Plant Protection Convention provide guidance for official plant health services on phytosanitary measures and are recognised under the World Trade Organization's Sanitary and Phytosanitary Agreement as standards that should be taken into account in international trade of plants and plant products.

The European Plant Protection Organization (EPPO) provides a forum for information exchange across Europe on quarantine pests, for example on diagnosis, distribution, pest risk analysis (risk assessment and management) and control measures.

2.3 Governance and collaboration

The number and variety of organisations and institutions across the public, private, NGO and charitable sectors that contribute to animal and plant health science capability in the UK is welcome and provides a rich and diverse environment.

There are some good examples of coordination and collaborative activity, for example, the Tree Health and Plant Biosecurity Initiative (see Case study 1), the Insect Pollinators Initiative[39], the Scottish Government's Centre of Expertise in Animal Disease Outbreaks ('EPIC') (see Case study 2), the Zoonoses in Emerging Livestock Systems (ZELS) research initiative (see Case study 3), and Defra's recent consolidation of operational delivery by bringing together animal and plant health inspection functions in the new Animal and Plant Health Agency (APHA). This new Agency will enable joined up working on plant and animal diseases and pests, and increase our resilience and flexibility to respond to emergencies.

However, there is a need for ever more improved coordination and communication across this complex landscape to ensure effective and efficient sharing of data and knowledge, greater access to biobanks (stores of biological samples for use in research), to help remove potentially costly duplication of infrastructure and activities, and to help identify and fill strategically important evidence gaps.

[38] Strategic alliances for the coordination of research on the major infectious diseases of animals and zoonoses (STAR-IDAZ) www.star-idaz.net/

[39] In 2010, the Insect Pollinators Initiative (IPI) funded nine research projects with the aim of promoting innovative research aimed at understanding and mitigating the biological and environmental factors that adversely affect insect pollinators. The initiative was funded by BBSRC, Defra, NERC, the Scottish Government and the Wellcome Trust, under the 'Living With Environmental Change' Partnership. See: https://wiki.ceh.ac.uk/display/ukipi/Home

Case study 1

The Tree Health and Plant Biosecurity Initiative (THAPBI) is funded by BBSRC, NERC, ESRC, Defra and the Welsh Government, Forestry Commission and the Scottish Government. It aims to address long term needs in improving biosecurity and resilience to pests and diseases. This £9.6m initiative, under the auspices of the Living with Environmental Change (LWEC) Partnership, draws upon the wide research base in the UK, and is building the national science capability and capacity in this area. Projects have focused on areas including; identifying new approaches for the early detection of problems; increasing resilience against tree disease outbreaks; and finding genetic clues to better tree health.

Case study 2

The Scottish Government created the Centre of Expertise in Animal Disease Outbreaks ('EPIC') in 2011. The virtual centre is made up of a consortium of Scottish research institutes and universities and is led by Scotland's Rural College (SRUC). EPIC has two main roles. First, it carries out a programme of research to further understanding of exotic animal diseases in the Scottish context, including looking at the risks of disease spread via animal movements, and comparison of potential disease control options. Second, in the event of an exotic disease outbreak, the Centre provides emergency scientific advice and analyses to the Chief Veterinary Officer (Scotland). EPIC is considered to be a good model of how to secure the best available scientific advice to inform government policy on reducing the impact of animal disease outbreaks. The science-policy interchange process is described in a recent paper: Lisa Boden *et al*. (2014). Working at the science-policy interface. *Veterinary Record*. 174:7 165-167.

Case study 3

Zoonoses in Emerging Livestock Systems (ZELS) is a joint research initiative between the Department for International Development (DFID), four Research Councils (BBSRC, ESRC, Medical Research Council (MRC), NERC) and DSTL, with Defra as an observer. Its purpose is to make a step change in the research evidence available to inform decision makers on how to minimise the health risks associated with the rapidly changing nature of livestock systems in developing countries, focusing on those risks which have impact on livelihoods and people's health. ZELS key aims are to:

- reduce the impact of zoonoses on people and their livestock. The initiative recognises that priorities for endemic, new and/or (re)-emerging zoonotic diseases may vary from region to region. It will address the problem of zoonoses by generating high quality research in technical and policy areas;

- forge mutually beneficial inter- and multi-disciplinary partnerships between researchers in the UK and developing countries that create trans-national added value through meaningful intellectual collaboration, and enhance the scientific capabilities of southern partners for the longer term.

Animal and plant health issues often cross geographical and political borders, so it is essential that priorities among the four nations of the United Kingdom are aligned, that each of the four nations of the UK are appropriately represented in the collaborative effort to tackle pests and disease and that we build upon existing examples of good practice evident in each nation.

During disease outbreaks different parts of the network of delivery bodies tend to combine forces to provide the capability needed to respond. This happened during 2012 when ash dieback was detected in the UK. There was significant scientific uncertainty across Europe about what was happening due to taxonomic issues in identifying the causal agent. In addition, the practice in the trade of exporting seed for growing abroad was not widely recognised, particularly for unregulated species such as ash, and it took time to mount a coordinated response. The 2014 House of Commons Environment Food and Rural Affairs (EFRA) Committee Report into Tree Health and Plant Biosecurity[40] received evidence that the ash dieback outbreak exposed a lack of definition of the roles and responsibilities of plant health authorities in the UK but welcomed the appointment of the new Chief Plant Health Officer role to ensure measures are in place to manage such risks, minimise their impact and remove previous uncertainty over roles and responsibilities.

It is also important to maximise the economic and societal impact of the research supported by the Research Councils without losing any of their independence. Much of this can be achieved by ensuring there is an appropriate level of coordination among the Research Councils, and government departments and their agencies, to ensure that opportunities are exploited where they exist, but without undermining the important functions of the Research Councils to support fundamental research.

Additional traction can be gained by working in partnership with other funders, including Innovate UK, the Higher Education Funding Council for England, the Scottish Funding Council, the Higher Education Funding Council for Wales, industry, NGOs and charitable organisations.

However, there is currently no formal overarching mechanism for identifying science needs and no agreed set of strategic priorities at a UK level to incentivise improved coordination. Previously there has been a strong focus on evidence to support statutory and applied policy needs. More recently, initiatives such as the Defra Network Evidence Strategy are advocating the need to balance statutory, applied and strategic evidence needs and sustain critical capabilities over the longer term. This requires a collective focus or consideration of the infrastructure and skills required to deliver national capability into the future in order to avoid duplication in science infrastructure and inefficiencies that are not making the best use of resources (see Case study 4). The economic losses associated with inefficient delivery of capability in this field may impact on the costs of sustaining the research capability, and the innovation pipeline, needed to reduce risk. The economic impacts of ignoring this need could be greatest in economies that have signalled their reliance on growth of the food and drink sector, especially in Scotland but also in Northern Ireland.

[40] This chronology is described in the Tree Health and Plant Biosecurity, House of Commons Environment, Food and Rural Affairs Committee Tenth Report of Session 2013-14, March 2014.

Case study 4

In Surrey, the UK maintains two separate animal health laboratories. They operate at the highest level of containment required to protect against escape of viral pathogens. One is located at Defra's agency APHA, Weybridge, and the other at The Pirbright Institute, a charity funded by BBSRC (details of APHA's and The Pirbright Institute's research activities are provided in Annex 5).

Both institutes have vital roles to play in responding to an animal health national emergency and have demonstrated their importance in the past. There is a high degree of complementarity within science across the two organisations and some good collaborations driven by strategic resource and critical mass needs. The Pirbright Institute and APHA operate, respectively, at the more fundamental and applied ends of the spectrum. Several reviews have recommended that the two institutions are combined into a single 'National Institute of Excellence' [41], but implementation of this vision remains challenging and concerns have also been expressed over the requirements for new governance, funding arrangements and whether the spend on the fundamental science end of the spectrum will be at risk in times of financial pressure.

During the course of this review a workshop of experts concluded that the interface between government, industry and academia is critical to solving some of the problems currently facing the UK and that there is further potential for the science and expertise from these sectors to contribute to the UK's animal and plant health science capability.

Increased opportunities to exchange and share data, knowledge, research and evidence, through networks, co-production, use of technology, and the need for effective communication across different research cultures were identified in this workshop as enablers to achieve this, while acknowledging commercial constraints.

This project also mapped the current governance and leadership arrangements for animal and plant health science in the UK (see Annex 6). A range of boards, bodies and strategies have a role in governance and leadership of the animal and plant health science landscape, for example, the Plant Health Strategic Evidence Group, the Food Research Partnership, the Strategic Oversight Board for Animal Health and Welfare Evidence, and the CAMERAS Board (Coordinated Agenda for Marine, Environment and Rural Affairs Science).

However, these tend to focus on specific issues or are geographically focussed; there is no single body or organisation that has a comprehensive overview of the UK's requirements for animal and plant health science or that has unified strategic oversight of animal and plant health science across this landscape. This means that there is scope for the UK government and the Devolved Administrations to make better use of the entirety of the UK science base and to deploy national science resources more effectively against disease threats.

[41] Infectious diseases in livestock, The Royal Society, 2002. Available from: https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2002/9935.pdf; Appraisal of the options for the future relationship between the Veterinary Laboratories Agency and the Institute for Animal Health: A report for BBSRC Council and Defra Management Board, January 2007. Available from: www.bbsrc.ac.uk/web/FILES/Reviews/070129_preston_report.pdf

2.4 Current skills

A wide range of scientific, analytical and surveillance skills are needed to provide the science that underpins and supports animal and plant health. The current skills that we have in the UK are accepted world-wide as being of a high standard, as evidenced by the high reputation of UK animal and plant health science.

During the course of this review, experts highlighted a range of areas where there are current skills shortages, and where skills are sub-optimal, or on a decreasing trajectory, and that may therefore become future gaps in strategically important areas:

- Although there has been an improvement since the recommendations of the independent Tree Health and Plant Biosecurity Expert Taskforce, experts identified that in the light of increasing risks of disease, more attention is needed to the plant sciences. In particular, consideration is needed in traditional **skills in plant pathology**, which cannot, as yet, be replaced by diagnostic tools, including **forestry and tree health** (see Case study 5).

Case study 5

A recent report[42] by the UK Plant Sciences Federation found that the UK ranks second in the world for plant science publication impact. The UK has a world-leading fundamental plant science research base within universities and research institutes. Of the five countries with the highest plant science publication impact, the UK is the most efficient. This is true whether expressed as publication impact per capita, or as a function of gross domestic product (GDP). Despite these strengths, 96% of the respondents from a range of UK public, private and third sector research institutions expressed concerns about gaps in plant science skills within their own organisations. The majority of UK students beginning biological science courses at university show little interest in plants and this has contributed to a decline in the number of UK Higher Education Institutions offering specialist plant science degree courses. This decline is reinforced by the findings of a review in 2012 by the British Society for Plant Pathology[43].

- The need to inspire and create a pipeline (from training through to employment) of a new generation of **taxonomists** to help in the diagnosis of new, exotic pests and diseases. Concerns were expressed by experts that the UK has lost taxonomy skills in some areas, for example, mycology.
- Vulnerabilities in invertebrate biology, in particular, a need for more expertise in exotic zoonotic parasites (**parasitologists**) that may increase due to climate change and global trade, and plant parasitic nematodes, an important crop pest with acute skills shortage.
- A gap in traditional **entomology skills** and expertise to deal with increasing vector-borne diseases of animals and plants.
- Vulnerabilities in skills needed for surveillance of pests and pathogens of plants and livestock, including the need for expertise in **antimicrobial resistance**.

[42] UK Plant Science: Current status and future challenges. A report by the UK Plant Sciences Federation: Available from: www.societyofbiology.org/images/pdf/UK_Plant_Science-Current_status_and_future_challenges.pdf

[43] Plant pathology education and training in the UK: An Audit, British Society for Plant Pathology, 2014. Available from: www.bspp.org.uk/society/docs/bspp-plant-pathology-audit-2012.pdf

- Vulnerabilities in **computational modelling approaches to epidemiology** and the need for people with transferable skills to apply knowledge, understand the likely spread of diseases and to predict and take account of risk factors.
- There is also a need for experts with **social science and economics** skills to help understand what motivates and constrains individuals and groups, to understand behaviour during emergencies, and to strengthen policy appraisal and evaluation.
- The observation was also made that approaches tend to be **multidisciplinary** whereas there is also a need for **interdisciplinary skills**[44].

These tend to be areas where key people are reaching retirement or where the incentives for young people to pursue such careers are not as attractive as they used to be. Research in these areas is not attractive to high impact research journals and career opportunities are limited.

Further work is needed to prioritise these skills shortages in the context of the UK's needs and strategic priorities. The UK needs to determine what can be 'bought in' from Europe and internationally and to identify the role and potential for gaps to be filled by making increasing use of expertise in publically funded institutions and universities, and in industry, NGOs and the charitable sector.

2.5 Current approach to risk assessment

Defra and the Devolved Administrations use a wide range of evidence sources to inform the operational management of risk, including targeted and scanning surveillance, diagnostics, epidemiology, economic and social science.

In recent years, Defra has taken steps to strengthen the arrangements for managing threats to animal and plant health. The approach to the escalation and assessment of risk has been overhauled, and a new risk assessment approach introduced across the whole of the Defra network to enable animal and plant health risks to be escalated quickly and assessed (in terms of impact on the UK and the likelihood of the risk happening). The approach is led by the Chief Veterinary Officer and Chief Plant Health Officer (CPHO). The CPHO post had functions added in 2013 enabling prioritised actions based on the risks posed to the economy, environment and society.

Current risk assessment is primarily driven by known pests and pathogens. Workshop participants highlighted that certain wider risks relating to the interplay between pathogens, hosts and the environment, and our inability to influence particular high risk pathways, also need consideration. There is a need for a whole-system view to be taken, especially in relation to risks that do not simply focus on existing or known pathogens.

The workshop participants considered that further public engagement is required on the type and level of potential strategic risks and their broad-ranging impacts. It is important to

[44] Where social, economic, and environmental values are at stake, taking an interdisciplinary approach means natural and social science disciplines working together from the start of the process to frame the problem(s), co-design the research questions and co-produce the scientific knowledge required to address those questions.

consider wider issues, such as socio-economics, the implications of climate change, increasing global trade and new ways to import pathogens (e.g. soil-borne), the growth in livestock production in developing countries which brings risks in those countries but potentially also increases risks in the UK, the emergence of new diseases and novel or unexpected pathogens.

Quantifying the costs and benefits of managing risk is challenging, and in some cases requires innovative thinking to assess the impacts of management actions, including by learning from other fields, for example, medicine, safety, development studies, and defence.

2.6 Emerging technologies

Participants at the 'Emerging Technologies' workshop identified the UK as having a strong animal and plant health science research base. However, they also identified the UK as being weak at translating this into practical solutions to problems and commercially successful products or business.

Workshop participants identified a wide range of emerging technologies with the potential to make an important difference to animal and plant health science capability during the next 10-15 years including developments in genomics, sensors for detecting and diagnosis, and exploiting data and bioinformatics (see Annex 7).

Workshop participants concluded that the UK needs:

- To improve sharing of ideas across all sectors and the entire supply chain (plant and animal breeders, academics, industry, NGOs and the charitable sector), across disciplines, and at an early stage of the innovation process.
- Open innovation approaches to allow companies, academics, and the public sector to work together on a particular challenge in a pre-competitive way.
- Improved interaction and coordination between policy makers, funders, industry and academia.
- An improved ability to exploit the wealth of new information being generated and to encourage new ways to share biological information.
- Improved public engagement on the social and cultural impacts of emerging technologies, which can be key to the successful exploitation of all technology; early involvement of social science expertise is crucial.

These findings echo those in the government's Agri-tech Strategy which provides an opportunity to rectify some of these problems with £160m of investment. The **UK Strategy for Agricultural Technologies** (the 'Agri-tech Strategy') identified the need for a new partnership between government, the science base and the food and farming industries across the UK to help contribute to the challenges being faced by the food industry, such as the increasing demand for locally produced organic food and the need to feed a growing population with dwindling resources[45]. The projects supported to date cover a wide range of innovation from reducing fertiliser use to producing an organic sustainable pesticide for use

[45] A UK Strategy for Agricultural Technologies: Industrial Strategy: government and industry in partnership, HM Government, July 2013. Available from: https://www.gov.uk/government/publications/uk-agricultural-technologies-strategy

in agriculture and gardens. New land management systems like agroforestry, may also help to improve coordination between the forestry and farming sectors with associated benefits for disease management. We need to ensure the UK has a vibrant sector developing a wide range of innovations across the supply chain whether using organic, novel or conventional techniques. The aim is to integrate the UK's excellence in science and progressive food and farming businesses with government's support for trade, investment and international development to help unlock a new phase of global leadership in agricultural innovation.

2.7 Key findings

Evidence gathered in the workshops and interviews with experts has led to the following **key findings**:

Key finding 1: There are many animal and plant disease threats to the UK that could have important consequences for society. Some of these are likely to be felt most in the parts of the UK where there is the greatest reliance for growth in the sectors of farming and forestry.

Key finding 2: There is a substantial amount of science being funded by the UK government and the Devolved Administrations across animal and plant health and some good examples of coordination and collaboration. However, the science landscape is too complex and distributed to self-organise effectively.

Key finding 3: With little evidence of a coordinated UK level vision for animal and plant health science and no agreed set of priorities to incentivise collaboration and cooperation, there is too much scope for duplication (costly) and gaps (risky) in science infrastructure, skills and evidence generation, all of which may reduce the cost-effectiveness of government investment.

Key finding 4: The absence of unified, strategic oversight of animal and plant health science in the UK reduces the extent to which interdisciplinary capabilities in natural science, social science and economics are effectively deployed.

Key finding 5: While capability is sustainable in some areas, there is a range of scientific areas where the UK is currently experiencing skills shortages.

Key finding 6: Current risk assessment is primarily driven by known pests and pathogens. Further consideration needs to be given to wider risks and the need to take more of a whole-system view. Work is in place to establish a prioritised risk register across animal and plant health.

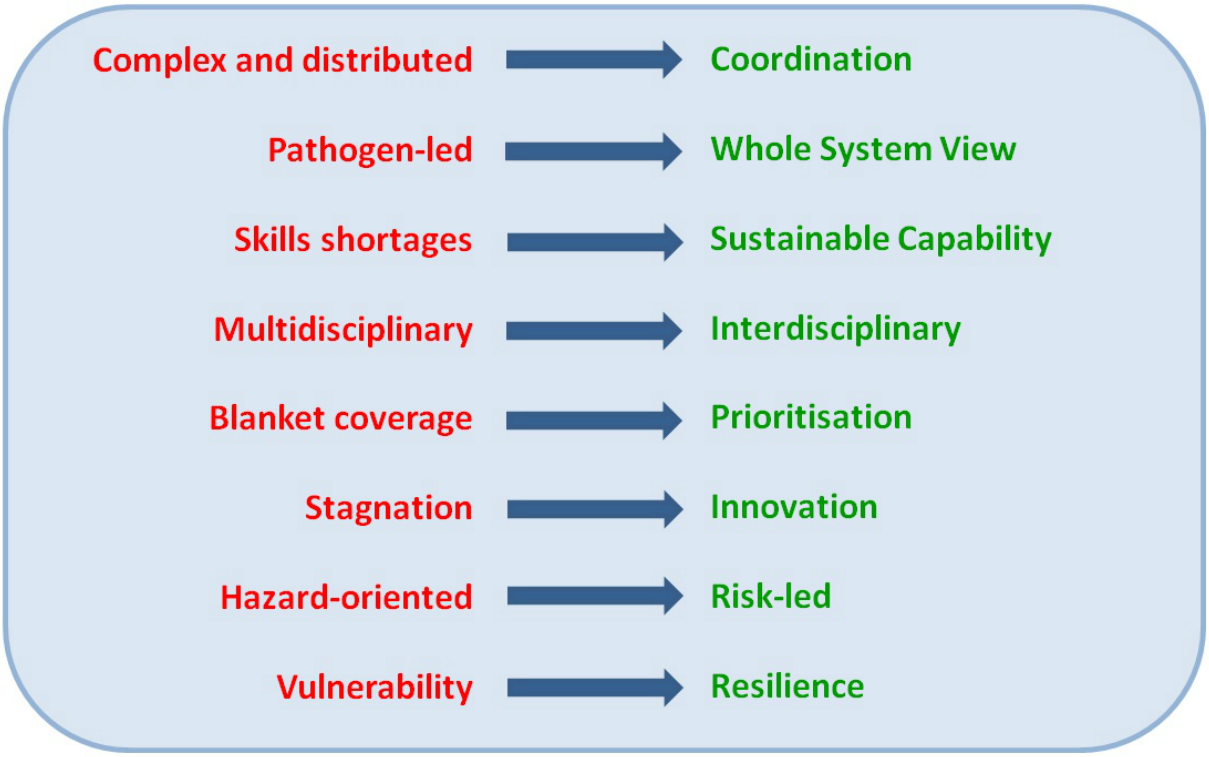
Key finding 7: There is further potential for the science and expertise from academia, industry, NGOs and the charitable sector across the UK and internationally to contribute to the UK's science capability and to stimulate innovation.

Figure 1: An overview of the characteristics of the system of delivery

Red: Characteristics of the system of delivery before intervention

Green: Characteristics of the system of delivery where they should be under a modified system of coordinated delivery

Depending on the sector, and the level of previous and current interventions, different elements of the system have already moved towards the green. These provide exemplars for future improvement activity.



2.8 Conclusions

The UK has faced some important animal and plant disease challenges in the recent past and there is a constant level of threat. The UK Plant Health Risk Register[46] lists over 700 individual threats. There has been a sharp increase in the introduction of new tree pests and disease in the last two decades and some of these have started to cause serious economic and environmental damage. This includes *Dothistroma pini* in Scotland, *Phytophthora ramorum* in Wales, and oak processionary moth in England. Endemic diseases like bovine tuberculosis and bovine viral diarrhoea reduce the competitiveness of major parts of our livestock industries and exotic animal diseases like porcine epidemic diarrhoea, African swine fever and avian influenza are a continuing threat. The huge growth in livestock production in developing countries not only brings risks in those countries, but potentially also increases risks in the UK. The outbreaks of foot and mouth disease in 2001 and 2007 caused considerable economic damage across the UK livestock farming industry.

[46] The UK Plant Health Risk Register: https://secure.fera.defra.gov.uk/phiw/riskRegister/

The best way to continue to protect the economically important food and drink sector of the economies of the four nations is to ensure that our best science and technology is applied to risk reduction. This requires well-coordinated action on a UK scale to build and sustain the science capability (infrastructure, expertise, networks and data) we need.

In summary, it is essential that the UK continues to build the required skills and processes to:

- Capture, integrate and use interdisciplinary science and to deploy the latest methodology to do so. Interdisciplinary working needs to be encouraged early on in careers. Social scientists can provide an understanding of the psychological, cultural, economic and social interactions with the biological, natural and physical systems that are studied by natural scientists.
- Ensure an effective flow of scientific evidence that supports decisions and the innovation needed to remain ahead of continuously evolving disease threats. Scientific knowledge needs to be structured and used to maximise impact.
- Embrace and exploit new technologies and develop people skilled enough to use them, for example, people who can handle and process 'big data' and explore opportunities to improve our surveillance systems using information from the EU Copernicus satellite programme.
- Deliver more modern cost-effective diagnostics that are deployed using risk-based methods surveillance techniques at home and abroad.
- Improve risk analysis and public engagement and dialogue on risks.
- Bring together epidemiology, statistical techniques, bioinformatics, the best data handling techniques, and use of web crawlers and citizen science to spot early warning signs of a disease or problem.
- Build a better fundamental knowledge of disease processes, how they evolve and what can be done to combat their modes of action, such as through the development of improved vaccines, prophylactic treatments and systems of treatment that lead to the reduced use of antimicrobials in livestock farming.
- Improve join-up across plant, animal and human health science, where there are synergies and benefits of doing so[47].
- Improve communication between academia, government, industry, NGOs and the charitable sector.
- Make better use of European and international capability.

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[47] Defra recently reviewed the infrastructure and expertise needed to capture, process and interpret observational evidence on plant and animal health. In this context, observational evidence can be defined as the information and data used to predict, monitor, manage and control biosecurity threats that is acquired by observation e.g. operational surveillance, rather than experiment. Each capability, structure or process was assessed as to whether, or to what extent, it must be delivered from within government or was similar enough to share across animal and plant health. The review concluded that there was extensive scope for sharing animal and plant health capabilities which translate information into knowledge, for example, modelling, study design, epidemiology, economic analysis, and social science analysis. There may also be the scope to look forward and create a culture of 'joint by default' for new initiatives, for example jointly funded animal and plant health information technology and diagnostics developments to support data capture in the field (e.g. handheld devices). If we are to realise a more optimal use of technical and interdisciplinary teams, resources and skills, it is important to recognise where there are synergies between plant and animal health and to build upon them. Observational Evidence Strategy for Animal and Plant Health (review available on request).

- Improve coordinated, long-term planning for the facilities, equipment and expertise needed to deliver national capability in animal and plant health science.

To deliver these aims the UK will need to make more cost-effective use of public investment in the future. An integrated, partnership approach is needed to ensure efficiency, cohesion and synergy across this complex, but crucial science landscape.

Chapter 3: The case for change

This chapter summarises the case for change in the way that UK science capability is delivered for animal and plant health. There are a number of reasons why elements of the current delivery system should be improved. This will help improve efficiency and effectiveness, and the value for money science capability delivers in protecting and enhancing the contributions animal and plant health make to society.

3.1 The case for change

A clear UK level strategy to support national science capability and its supporting infrastructure is required to help minimise the economic, social and environmental impacts of plant and animal disease on the UK.

One option would be to look to the private sector to provide this capability. However, there is little evidence that the private sector would be able to supply the research capability to deliver across all critical needs. The private sector typically funds science where there is an expectation of a financial return[48]. This depends on factors such as patents and market size which determine the existence and enforceability of property rights.

Even when a company retains the intellectual property rights of science, government support may still be needed because of market failure. However, in responding to this, government needs to also be aware that the technology and know-how developed from its investments may eventually have market value and be useful to international partners. Lack of private sector investment could also be due to an expectation of government investment; in which case there may be an element of government failure.

In the context of agriculture and the environment, the strong "public good" and "positive externality" characteristics of research and development expenditure unambiguously make the case for government funding of such expenditure[49].

[48] For instance, elements of science are likely to have characteristics that define them as a 'public good' (this is a market failure with the characteristics of non-excludability and non-rivalry). Non-excludability implies that once the scientific research is completed, no other company or organisation can be stopped from freely consuming it. Non-rivalry implies that if anyone uses the scientific knowledge, the amount available to other companies or organisations remains the same. Science with such characteristics may be under-provided by the private sector (as those who generate the scientific knowledge will not be able to retain the benefits), and so there is a case for government provision. A less extreme example of market failure may be a "positive externality" whereby innovation is stifled by the ability of followers to replicate the technologies of those leading the way in science –this ability to free-ride may lead to inadequate incentives to innovate and ultimately under-supply.

[49] See, for example, Alston, J. M. (2010), "The Benefits from Agricultural Research and Development, Innovation, and Productivity Growth", *OECD Food, Agriculture and Fisheries Papers*, No. 31, OECD Publishing (http://dx.doi.org/10.1787/5km91nfsnkwg-en) for evidence of returns to government R&D research in agriculture from public goods and "spillover" (i.e. externality effects).

However, there is also a case for changing our approach to the delivery of this nationally, and internationally, important science capability. The case for change can be summarised based upon three outcomes:

- **efficient delivery** - there is a need to build on the coordination of science funding within the UK and to ensure this funding is delivered with increased strategic prioritisation and within the wider context of disease surveillance and control at an international level;
- **rational infrastructure** - there is a need to balance financial efficiency with structural resilience by rationalising gaps and overlaps in infrastructure, capabilities and evidence generation across the UK, and by renewing ageing infrastructure using a strategic, planned approach to sustain national capability and evidence generation; and
- **partnership working** - there is a need to improve leverage of government investments to stimulate market behaviour, as well as the NGO and charitable sectors and wider society, to sustain a vigilant and effective system of disease prevention and control across the UK.

By addressing these issues, we can find a solution that improves effectiveness and efficiency in the delivery of government funded animal and plant health science capability.

3.2 Examples of efficiency benefits from change

The annual economic value, measured using Gross Value Added, of the UK's agriculture, forestry, fisheries, aquaculture and the equine/racing industries is estimated to be over £10bn, and the social and environmental value of forestry is estimated to be around £1.8bn each year.

As argued above, improved efficiency in the provision of science capability would be achieved through improved coordination, better alignment of incentives, and developing better understanding of industry motivations. This improved efficiency will help to protect and enhance the economic, social and environmental value from the UK's agriculture, forestry, fisheries, aquaculture and equine/racing industries.

Specific examples of these efficiency benefits are expected to include:

- At a programme level, minimising evidence gaps and duplications, when commissioning science (for example, when rapid coordination is required in commissioning research during periods of outbreak).
- At a capital expenditure level, removing overlaps in the functions of institutions and improving economies of scale (for example, high containment laboratory capability for analysis of viral animal pathogens).
- Improving animal and plant health science coordination to help prioritisation across these two areas to deliver the new UK level vision, share capabilities, particularly for emergency response, and share best practice.
- Using government funding to lever (including through encouragement and facilitation) additional research involvement and delivery through industry, NGOs and charities. Any additional research should demonstrate that it improves value for money in contributing to animal and plant health outcomes.

To achieve these efficiency benefits, a new UK Science Partnership for Animal and Plant Health is proposed in Chapter 4.

Chapter 4: The future of animal and plant health science in the UK

This chapter sets out a new UK level vision for animal and plant health science and the need for a new UK Science Partnership for Animal and Plant Health to deliver this vision. It also sets out the main recommendations arising from this review including work on four priority actions.

4.1 Vision

Animal and plant health is part of a complex, interacting system covering physical, natural, biological, social, economic and cultural systems. As described in Chapter 2, there are a number of active science funders and producers in this system but there is a lack of a coordinated UK level vision for animal and plant health science. The project has demonstrated a need for a new UK level **vision** and agreed that this should be:

4.2 A new UK Science Partnership for Animal and Plant Health

To realise this vision, there is a need for a new whole-system approach through the establishment of a new **UK Science Partnership for Animal and Plant Health**. This is about bringing together this complex, interacting system and facilitating coordination and collaboration to help ensure that the UK has the science capacity and capability that it needs for animal and plant health during the next 10-15 years. This science partnership will pursue alignment across the animal and plant health, or animal and human health sectors, where there are demonstrable benefits to be gained and where this is not to the detriment of within sector improvements.

Recommendation 1: Establish a new 'UK Science Partnership for Animal and Plant Health' to develop a more integrated, whole-system approach to animal and plant health science.

An assessment of how this new partnership will achieve the new UK level vision is described in Table 1.

Table 1: Assessment of how the new UK Science Partnership for Animal and Plant Health will achieve the UK level vision for animal and plant health science

Where we want to be:	How we will get there:
Coordination	The UK Science Partnership for Animal and Plant Health will drive a culture change of coordination.
Whole-System View	The UK Science Partnership for Animal and Plant Health will endeavour to ensure that investment in UK science capability (people, skills and infrastructure) is approached in a whole-system way.
Sustainable Capability	The UK Science Partnership, with input from Defra's Science Advisory Council, the Scottish Science Advisory Council, and the Science Advisory Council for Wales, will provide advice on skills gaps and how these should best be filled. It will help maintain a view across the animal and plant health science landscape to help defend against the loss of capability in critical areas.
Interdisciplinary	The UK Science Partnership for Animal and Plant Health will ensure that investment in UK science capability (people, skills and infrastructure) is approached in an interdisciplinary way. It will assess the science capabilities required to provide evidence on the interactions between the physical, biological, social, economic and cultural systems associated with protecting and enhancing animal and plant health.
Prioritisation	The UK Science Partnership for Animal and Plant Health will provide oversight and advice on priorities for science investment, targeting those capabilities that contribute most to maximising the benefits from animal and plant health. It will not be a budget holder but will provide advice on major investments.
Innovation	The Science Advisory Councils will provide advice to the new partnership on how to make better use of emerging technologies and cutting-edge scientific techniques. The UK Science Partnership will also draw upon private sector expertise.
Risk-led	The UK Science Partnership for Animal and Plant Health will set strategic science priorities for animal and plant health based on risk, and focusing on the contribution science can make to improve the effectiveness and value of current mitigations. The Science Advisory Councils will help improve efficiency by providing advice on research and evidence gaps and on duplications.
Resilience	The UK Science Partnership for Animal and Plant Health will develop a UK level strategy for animal and plant health science to ensure long term social, economic and environmental resilience.

Building on existing coordination mechanisms and good practice, the new UK Science Partnership for Animal and Plant Health will help drive culture change and increase the efficiency and effectiveness of science delivery by:

- Further connecting science and expertise across the UK government, the Devolved Administrations, academia, industry, NGOs and the charitable sector.
- Increasing use of international expertise.
- Further exploitation of the potential of emerging technologies.
- Rationalising overlaps and alleviating gaps in UK infrastructure, skills and evidence generation.

In the longer term, the success of this partnership will be measured by its ability to:

- Deliver improved value for money by minimising duplications and filling strategically important evidence gaps (thereby increasing effectiveness).
- Deliver improved innovation by making better use of emerging technologies and cutting-edge scientific techniques.
- Strengthen emergency preparedness and coordinate the national deployment of interdisciplinary science capabilities at times of emergency response.
- Protect and augment animal and plant health science skills and capabilities within the UK.
- Enhance engagement with public and private sectors across the UK and internationally.

Viewed in this light, any additional costs of establishing and supporting this new science partnership are small in comparison and will make up only a small fraction of one per cent of the annual value of benefits delivered.

4.3 Implementation plan

Progress towards a UK level vision and formation of the new UK Science Partnership for Animal and Plant Health will involve significant change in both practice and culture. The Steering Group has therefore agreed that a stepwise approach should be taken to create this partnership including immediate work on a set of high priority issues.

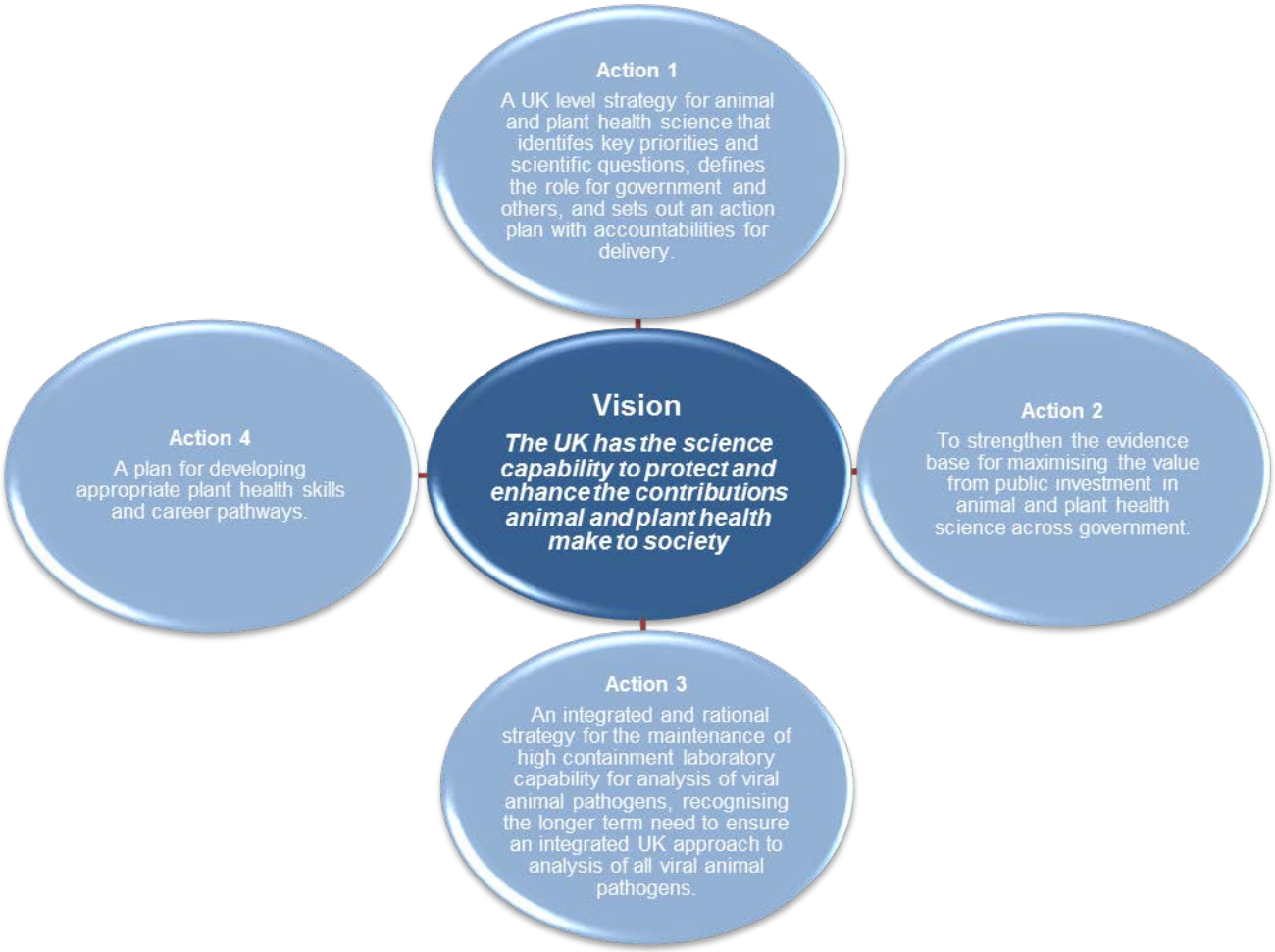
Recommendation 2: To deliver rapid progress, the project Steering Group should become an interim Implementation Group to drive forward immediate work on priority actions as the first step in progress towards a new UK Science Partnership for Animal and Plant Health.

This will deliver rapid progress in the short term and provide a tangible demonstration of the value of the new science partnership. The proposal is that in the interim:

- The current Steering Group becomes an Implementation Group chaired by the Government Chief Scientific Adviser (GCSA);
- The Implementation Group will oversee work to take forward the four priority actions described in Figure 2 and to develop an action plan for establishing the new science partnership;
- Independent science advice and expertise will be provided to the Implementation Group by Defra's Science Advisory Council, the Scottish Science Advisory Council, and the Science Advisory Council for Wales; and
- Groups will be convened to work on each of the four priority actions. Members of the Implementation Group will lead each group.

The four areas identified as priority actions for immediate attention are shown in Figure 2 below.

Figure 2: Four priority actions initiated to deliver progress towards the animal and plant health science vision



Alongside work on the priority actions, the Implementation Group will develop an action plan for establishing the new UK Science Partnership for Animal and Plant Health. This will include investigating existing coordination mechanisms, such as, the Office for Strategic Coordination of Health Research (OSCHR), created to develop a more coherent strategic approach to health research and the Marine Science Coordination Committee (MSCC), a high level decision making body driving forward effective delivery of the UK Marine Science Strategy. Further details of how these coordination mechanisms work are provided in Annex 8.

4.4 Conclusions

The health of animals and plants is important to the UK economy, the health and wellbeing of the public and our environment. Science is fundamental to all of this. The UK needs to maintain an appropriate science capability to predict, detect, and respond to animal and plant pests and diseases, and needs an appropriate mechanism in place to deliver this.

This project has identified a new UK level vision for animal and plant health science and the need to establish a new UK Science Partnership for Animal and Plant Health to deliver this. This new science partnership will set the overarching strategic direction and priorities for

animal and plant health science and will ensure that the UK has the science capability that it needs over the next 10-15 years. It will help drive an improved culture of collaboration and cooperation, sharing of good practice and improved connections across UK government, the Devolved Administrations, academia, industry, NGOs and the charitable sector. This will deliver a more effective and efficient science capability to deal with the risks facing UK and to protect and enhance the contribution made by animal and plant health to society.

Annexes

**Annexes 5 & 6 are attached separately*

Annex 1: Project terms of reference

Terms of reference

The terms of reference for this project were structured around: the risks to animal and plant health; the science capability currently available to manage these risks; and the science capability that will be needed in the future. They include the identification of important capability gaps and developing options for improvements to science capability delivery.

The project terms of reference were to:

1. Analyse at a strategic level what are the future risks to animal and plant health;

2. Describe the current and emerging technologies and methods that could be used to make a significant difference in the capacity to manage animal and plant disease;

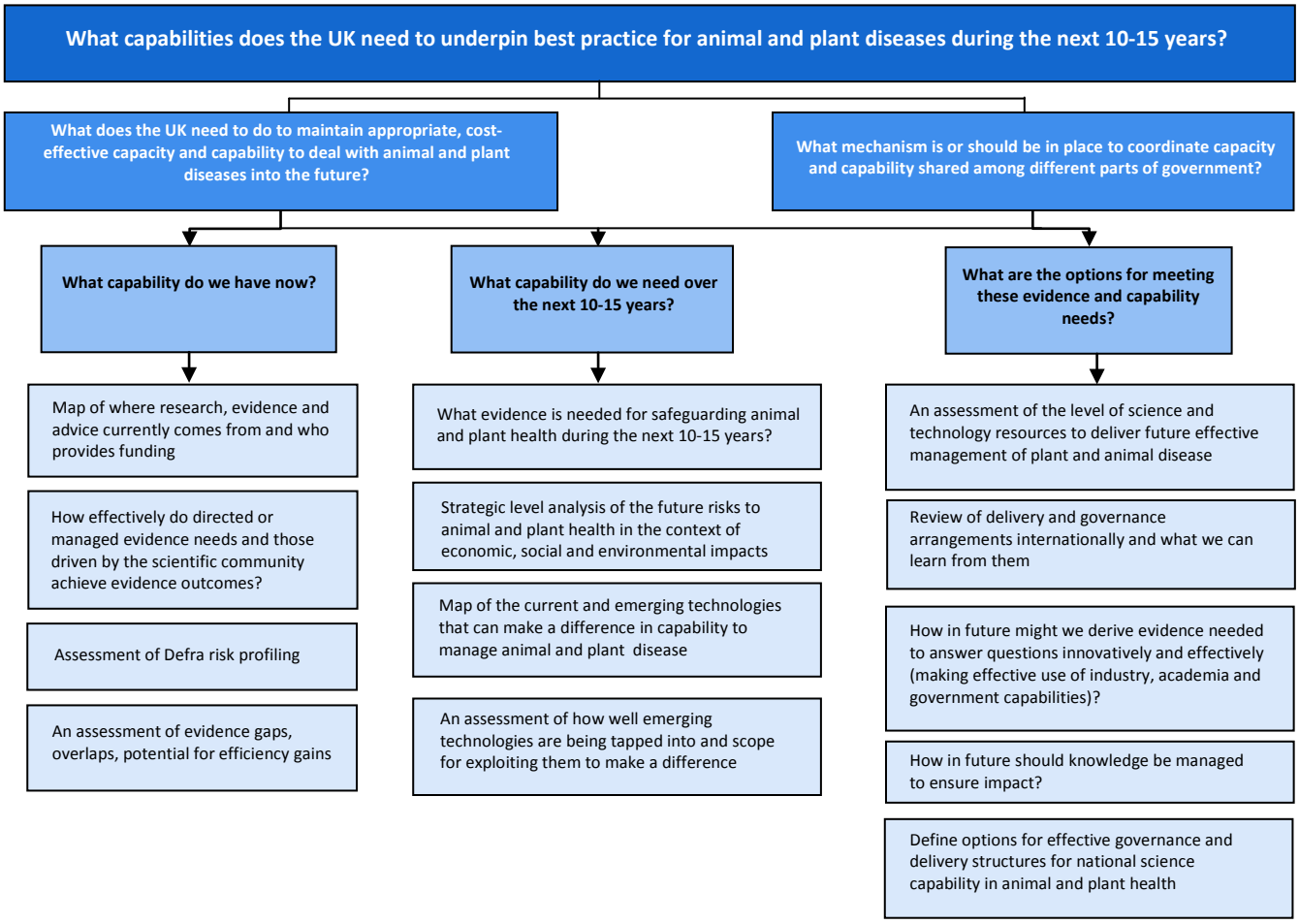
3. From a UK perspective, define evidence and knowledge management capability requirement and the areas where there is a need for further research investment, including links with other countries;

4. Provide an assessment of the level of science and technology resources, and the knowledge management needed to deliver future effective management of plant and animal disease at the level of the whole UK;

5. At a strategic level, define options for effective governance and delivery structures for national science capability in animal and plant health.

Issues tree

The figure below sets out questions explored by the project:

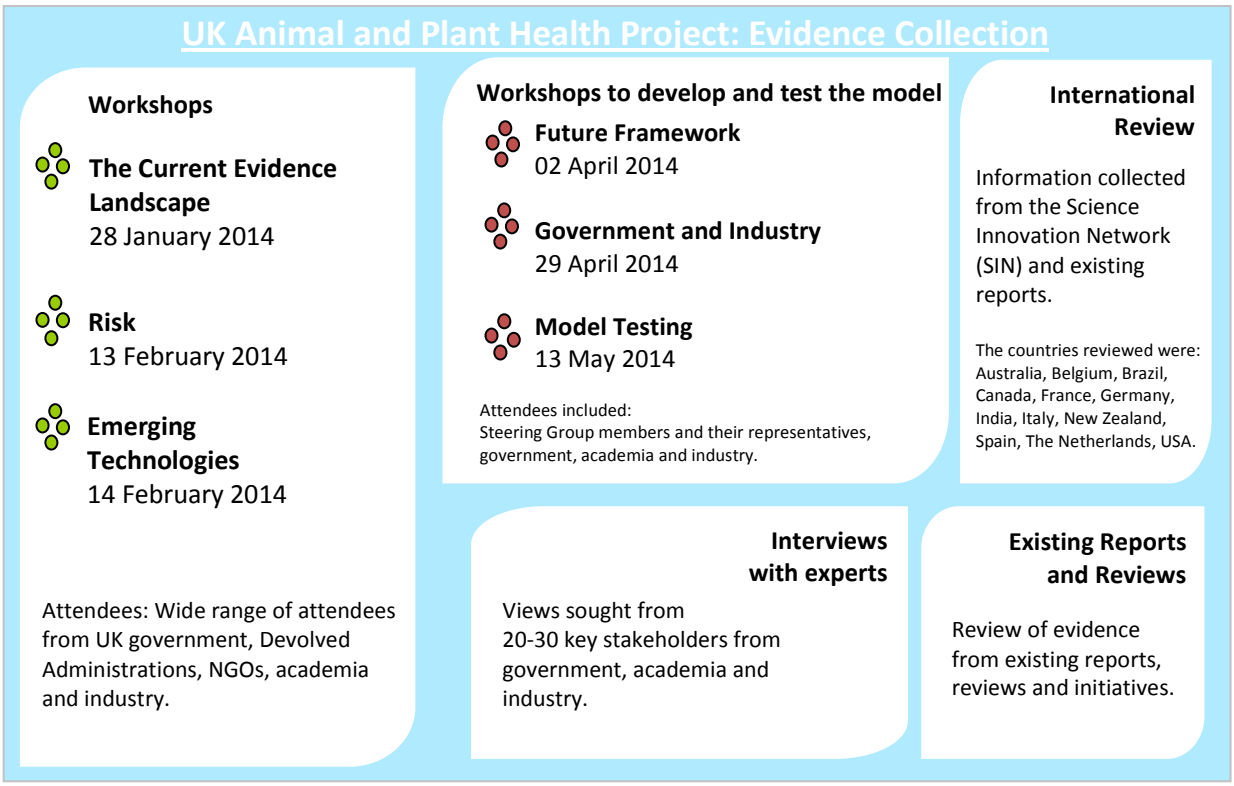


Annex 2: Methods

A Steering Group of experts from the UK government, the Devolved Administrations, the Research Councils, industry and academia guided this project. This group structured its work around two phases of activity: evidence collection; and the assessment and diagnosis of the problems of delivering effective national science capability to respond to animal and plant disease.

Evidence collection phase

The evidence collection phase of this project consisted of a programme of workshops and face-to-face interviews with the Steering Group and a wide range of experts from across the animal and plant health science landscape. The project team also reviewed existing reports and initiatives and drew upon international evidence. The chart below provides a high level summary of the evidence collection phase.



Interviews with experts

Qualitative, in-depth interviews were carried out with a range of experts from government, academia and industry (20 -30 people) using a topic guide based on the themes and issues set out in Annex 1. Interviewees included senior officials from the UK government and Devolved Administrations, Chief Executives of Research Councils, Research Institutes and government agencies and laboratories, as well as academics involved in animal and plant health research. These interviews, which lasted 1-2 hours, explored views on current animal and plant health science capability including evidence gaps, overlaps and potential for efficiency gains, as well as what capabilities, including leadership and delivery structures, are needed for the future. The information collected in these interviews was analysed and key themes extracted. This evidence has informed this study and the project recommendations.

Workshops

A key part of the evidence collection stage of this project was a programme of workshops to obtain input, views and advice from subject matter experts from government, academia and industry. In total about 150 people attended these workshops.

The first phase of workshops brought together experts to explore the Current Evidence Landscape, Risk and Emerging Technologies. The second phase of workshops focussed on developing proposals for improvements.

Phase 1:

- **The Current Evidence Landscape**: Discussions at this workshop focused on the current animal and plant health evidence landscape including where evidence and advice currently comes from, and current enablers and disablers. This workshop also explored the potential for efficiency gains and identified evidence gaps. Evidence collected at this workshop informed the animal and plant health science institutional map (Annex 5).
- **Risk**: Participants at the risk workshop discussed views on Defra's current risk assessment processes, on the current top risks to animal and plant health, explored strategic risks, and raised a number of important issues including the need to take account of wider risks relating to the interplay between pathogens, hosts and the environment.
- **Emerging Technologies**: This workshop was designed to identify the emerging technologies that participants considered would be most likely to make a difference to capacity to manage animal and plant disease during the next 10-15 years. Participants were prompted to explore:
    - emerging technologies and applications from other sectors that are facing similar problems and that could be tapped into;
    - technologies that are closer to maturity for example genomic approaches, and those that are more speculative, for example, novel materials, which could be realised within 10-15 years; and
    - whether there are emerging technologies in animal health that could be tapped into for plant health and *vice versa*?

Phase 2:

- **Future Framework**: A workshop of Steering Group members (and their representatives) was held to help: shape a proposed 'vision' for animal and plant health science, identify a set of desired outcomes, and discuss ideas for a future model for national science capability in animal and plant health.
- **Government and Industry**: This workshop brought together key stakeholders to explore the relationship between government and industry in the development of animal and plant health evidence.
- **Model Testing**: This workshop further investigated key features of potential new models for animal and plant health science capability. The workshop used viable systems modelling, a conceptual tool for understanding organisations, redesigning them and supporting the management of change.

International evidence

The project looked at the animal and plant health science arrangements in 12 countries (Australia, Belgium, Brazil, Canada, France, Germany, India, Italy, New Zealand, Spain, The Netherlands and USA). It collected data in two main ways: through desk research and questionnaires sent via the BIS Science Innovation Network (SIN).

Annex 3: Steering Group

The Steering Group included the following members:

Sir Mark Walport (Chair)
Government Chief Scientific Adviser

Professor Ian Boyd
Chief Scientific Adviser, Defra

Professor Paul Boyle
Chief Executive, ESRC

Dr. Mike Bushell
Principal Scientific Adviser, Syngenta

Dr. Alistair Carson
Departmental Scientific Adviser, Department for Agriculture and Rural Development, Northern Ireland Executive

Jeremy Clayton *(until September 2014)*
Director, Research Base (BIS)

Jenny Dibden & Rebecca Endean *(from September 2014)*
Directors, Research Base (BIS)

Professor Rob Fraser
Professor of Agricultural Economics, University of Kent

Nigel Gibbens
Chief Veterinary Officer, Defra

Professor Louise Heathwaite
Chief Scientific Adviser, Rural Affairs and Environment, Scottish Government

Professor Jackie Hunter
Chief Executive, BBSRC

Chris Lea
Deputy Director, Land, Nature and Forestry Division, Welsh Government

Professor Quintin McKellar
Vice Chancellor and Chief Executive, University of Hertfordshire

Professor Dilys Morgan
Head of the Department of Gastrointestinal, Emerging and Zoonotic Infections, Public Health England

Professor Nicola Spence
Chief Plant Health Officer, Defra

The Steering Group was supported by a project team of officials from the Government Office for Science, Defra, Defence Science & Technology Laboratory (DSTL) and BBSRC.

Annex 4: Government investment in animal and plant health science

Government Investment in Animal and Plant Health Science
Defra Defra evidence spend across animal and plant health was £57m (approximately) in 2014-15. This includes: £52m on research and surveillance for animal and plant health; £1.7m research on Integrated Pest and Disease management as part of overall Crop Management, research on Crop Genetic Improvement; £1.9m research on pesticides related to crop health and £0.9m research spend on Innovate UK led Sustainable Agriculture and Food Innovation Platform projects related to Crop Health.
BBSRC BBSRC spend per annum on animal and plant health is about £57m. (This spend is in the context of a wider body of animal, plant and microbial research of relevance to agriculture and food security). In addition to research spend, BBSRC has significant capital investment in its sponsored institutes, much of which underpins plant and animal health research capability.
Other Research Councils ESRC and NERC spent about £15m in 2012-13 on research on crop and livestock diseases, pests, weeds and parasites, including of edible fungi. This does not include post farm-gate research and may exclude other research relevant to animal and plant health in non-domesticated species and the wider environment.
Forestry Commission The Forestry Commission spend about £2.5m per annum on tree health research and associated knowledge exchange with additional resources allocated to tree health statutory work, surveys and control of outbreaks as necessary.
Innovate UK In early 2014, Innovate UK together with Defra, BBSRC and the Scottish Government invested up to £16.5m in a thematic call for animal and crop disease solutions under Innovate UK's sustainable agriculture innovation platform.
BIS BIS, in partnership with DFID and BBSRC have committed to spend £70m on an Agri-tech catalyst and £90m for Centres of Agricultural Innovation over the five years following the launch of the strategy (Summer 2013). Some, but not all of this funding will contribute toward animal and plant health science.

Government Investment in Animal and Plant Health Science (continued)
DFID DFID's spend in 2014-15 which can be directly attributed to animal and plant health research is approximately £16m. This includes a £6m contribution to plant and animal health projects co-funded with the Bill and Melinda Gates Foundation, £5m to CABI, an international not-for-profit organisation which helps address issues of global concern such as improving global food security and safeguarding the environment, and £3.2m to the International Centre of Insect Physiology and Ecology (ICIPE). Funding to the CGAIR consortium (a global agricultural research partnership), some of which will contribute to animal and plant health research, is not included here.
Scottish Government Indicative annual spend of £2.86m on plant health science and £10.4m on research related to animal health and welfare. In addition the Scottish Government operates an annual animal health surveillance and advisory budget of approximately £5.2m and SASA allocates £1.2m annually on activities associated with non-indigenous and indigenous (certification) pests and pathogens.
Welsh Government The current plant health evidence budget and animal health research budget are covered in the 'Defra' figure which includes Wales. An additional sum (£1.2m) is devolved to cover animal health surveillance activities.
Department of Agriculture and Rural Development Northern Ireland (DARD NI) DARD NI R&D spend is approximately £2m; surveillance, monitoring and statutory testing is approximately £21m; and postgraduate studentships relating to animal and plant health is £0.375m.

Annex 5: Animal and Plant Health Science institutional map

This annex is attached separately.

Annex 6: Animal and Plant Health Science governance and leadership

This annex is attached separately.

Annex 7: Technologies identified by workshop participants as most likely to make an important difference during the next 10-15 years

Within 5 years

Underpinning knowledge

1. 'Next-Generation' genome sequencing of every sample to understand disease epidemiology.

    - Further developing 'next-generation' sequencing methods which can identify and record DNA information much faster than current methods.

Improving plant and animal resistance and tolerance

2. Genomics for resistance and tolerance breeding.

    - Using the full genome data to accelerate identification of novel traits and breeding for disease resistance.

3. Endophyte engineering for disease resistance.

    - Using endophytes (organisms which live symbiotically within another organism for part of their life cycle) to better protect the species they inhabit.

4. Phenotyping for trait assessment and selection.

    - Using phenotype data (physical traits of a plant or animal dictated by their genes) to better identify useful genetic traits which could be engineered into future animal and plant species to improve their health.

Detection and diagnostics

5. Global surveillance networks for detection and tracking of trans-boundary diseases.

    - A global, decentralised network dedicated to detecting and tracking the spread of pathogens which pose a threat to animal and plant health, with data constantly fed in and updated by all nations.

6. Rapid real-time detection and diagnosis of plant and animal disease.

    - Sensor technology to aid with physically identifying and diagnosing animal and plant disease, including tailored, specific on-site diagnostics for each infection on a case-by-case basis rather than the current system of identification using generic symptoms.

7. Disease biobanks containing samples, in different formats, e.g. DNA, sequence data blood, with associated metadata (where and when a sample was collected etc.) to act as a "library" of diseases to assist diagnosis.

    - Creating a series of physical repositories where samples can be stored for future reference alongside metadata such as where and when each sample was collected.

8. Using an integrated diagnostic capability with supporting infrastructure and informatics.

    - An example of a service available from the private sector is the Illumina Genome Network which can provide whole-genome sequencing of biological samples.

9. Miniaturisation of mass spectrometry for biomarker identification in the field.

    - Developing mass spectrometry machines which can measure the elemental make up of samples without requiring their preparation, so that they can be used for identification of small molecule biomarkers in the field.

10. Non-invasive tests for plant and animal disease, such as acoustics, volatiles, imaging.

    - Using new methods for identifying diseases was highlighted by participants as of particular benefit for diagnosing tree disease as they avoid the need to remove samples from the tree which would risk further harm. Non-invasive testing would also be beneficial for animals.

Control

11. Sterilisation and release strategies for plant pest control (insects).

    - Causing infertility in insects to prevent them propagating and spreading disease in an environment.

12. New vaccine development, quickened by research into biosynthetics.

    - Using advances in biosynthetics (inserting man-made components into biological organisms) to help develop better vaccines.

Within 10 years

Underpinning knowledge

13. Improved modelling and mathematics primarily for use in epidemiology.

    - Using computer modelling to predict the spread of an individual disease, including new diseases.

14. Genomic analysis of complex mixtures in soil and water samples (metagenomics) to profile the microbial biodiversity of an environment.

    - Using genomic analysis to completely identify all the different organisms inhabiting the soil and water of a particular area.

Detection

15. Remote sensing to monitor immune defence responses in sentinel plants and animals.

    - Using sensor networks/remote imaging techniques to monitor immune system defence responses (symptoms of illness) in 'sentinel' plants and animals to identify the spread of infections in an area. A successful case study of this approach is the monitoring of Soybean rust on soya using sentinel plants.

Control

16. Tailored biological control agents.

    - Engineering an organism, such as an insect or plant disease, for use in managing the spread of a pest species.

Within 15 years

Control

17. Delivery systems for RNA interference treatments for disease.

    - A method for genetically modifying plants and animals using RNA interference treatments to give better protection against disease.

Annex 8: Examples of existing science capability coordination mechanisms

Details of existing coordination mechanisms in the areas of health research and marine science are provided below. In establishing the new UK Science Partnership for Animal and Plant Health, the Implementation Group will investigate further how these and existing coordination mechanisms across the animal and plant health landscape work.

Office for Strategic Coordination of Health Research (OSCHR)

OSCHR was established in January 2007 following the 'Cooksey' Review of UK Health Research Funding[50] in order to develop a more coherent strategic approach to health research in England. OSCHR is headed by a non-executive, independent Chair, Professor Sir John Bell, Regius Professor of Medicine at Oxford University and President of the Academy of Medical Sciences. The Chair is appointed by, and reports directly to, the Secretary of State for Business, Innovation and Skills and the Secretary of State for Health.

OSCHR was setup to:

- ensure a more strategically coherent approach to publicly-funded health research;
- create a step-change improvement in the translation of basic research into health and economic benefits; and
- encourage a stronger partnership with the health industries and charities.

The work of OSCHR is overseen by the OSCHR board which has representation from BIS, DH England, the Medical Research Council (MRC), the National Institute of Health Research (NIHR), the Scottish Government, the Welsh Government and the Northern Ireland Executive as well as three non-executive members. Research funders, (referred to as 'The OSCHR Partners') retain their own budgets, but, under the oversight of the OSCHR board, coordinate their strategies to deliver the shared Vision for UK health research.

The Office is supported by BIS, DH and the Devolved Administrations and has four members of staff.

Marine Science Co-ordination Committee (MSCC)

The Marine Science Co-ordination Committee (MSCC) was founded in 2008 to provide a high level decision-making body on marine science to meet priority policy needs and help deliver the UK's vision of 'clean, healthy, safe, productive and biologically diverse oceans and seas'. It is a partnership of Government Departments, the Devolved Administrations of Scotland, Northern Ireland and Wales, the Environment Agencies and research bodies involved in funding and carrying out marine science in the UK.

[50] A Review of UK health research funding, Sir David Cooksey, 2006.

The Committee, which meets twice a year, is co-chaired by Marine Scotland and Defra. The MSCC has two main responsibilities:

- to deliver the UK Marine Science Strategy; and
- to improve UK marine science co-ordination.

The Secretariat is jointly located at Defra (London) and the National Oceanography Centre (Southampton) and is funded by MSCC members.

Annex 9: List of acronyms

ADAS	ADAS Ltd- formerly the Agricultural Development Advisory Service
AFBI	Agri-Food and Biosciences Institute
AHVLA	Animal Health and Veterinary Medicines Laboratories Agency
ANIHWA	Animal Health and Welfare ERA-NET
APHA	Animal and Plant Health Agency
BBSRC	Biotechnology and Biological Sciences Research Council
BIS	Department for Business, Innovation and Skills
BSPP	British Society for Plant Pathology
CAMERAS	Coordinated Agenda for Marine, Environment and Rural Affairs Science
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CEH	Centre for Ecology and Hydrology
CSA	Chief Scientific Adviser
DARD NI	Department of Agriculture and Rural Development Northern Ireland
Defra	Department for Environment, Food and Rural Affairs
DAFM	Department of Agriculture, Food and the Marine
DFID	Department for International Development
DH	Department of Health
EPIC	Epidemiology, Population health and Infectious disease Control
EPPO	European and Mediterranean Plant Protection Organization
ERA-NETS	European Research Area Networks
ESRC	Economic and Social Research Council
EURL	European Union Reference Laboratory
EUPHRESCO	European Phytosanitary Research Coordination
FAO	United Nation's Food and Agriculture Organisation
FERA	Food and Environment Research Agency
FRP	Food Research Partnership
FSA	Food Standards Agency
GCSA	Government Chief Scientific Adviser
GDP	Gross Domestic Product
GVA	Gross Value Added
HEI	Higher education institutions
IPI	Insect Pollinators Initiative
LWEC	Living with Environmental Change Partnership
MSCC	Marine Science Coordination Committee
MRC	Medical Research Council

MSS	Marine Scotland Science
NERC	Natural Environment Research Council
NGO	Non-governmental organisation
OIE	The World Organisation for Animal Health
OSCHR	Office for Strategic Coordination of Health Research
R&D	Research and Development
SASA	Science and Advice for Scottish Agriculture
SRUC	Scotland's Rural College
STAR-IDAZ	Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses
STEPS	Social, Technological and Environmental Pathways to Sustainability Centre
THAPBI	The Tree Health and Plant Biosecurity Initiative
TSE	Transmissible spongiform encephalopathy
VMD	Veterinary Medicines Directorate
WHO	World Health Organisation
ZELS	Zoonoses in Emerging Livestock Systems

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