Farm Animal Genomics Review Report: July 2005

Executive Summary

- 1. For the purposes of this review we use the term Farm Animal Genomics to encompass a range of genomics and genetics approaches. It is defined as: *Science that promotes the understanding of genetics and gene function in livestock animals and the application of this knowledge to life sciences in general, in particular to farm animal health and welfare, product quality and efficiency, and human health'.*
- 2. Genetics and genomics provide powerful approaches to address questions in basic animal biology and for strategic research to inform policy development (including public goods), sustainable land use applications, the animal breeding and animal health industries and ultimately the food industry.
- 3. The UK has research strengths in quantitative and molecular animal genetics and is wellplaced to exploit this knowledge base as it is home to some of the world's leading animal breeding companies. Whilst most farm animal genomics research is set in an agricultural context, farm animal species are also important model animals. The chicken, in particular, is widely used to study early vertebrate development and has made important contributions to our understanding of immunological mechanisms.
- 4. The selective breeding of farm animals has been based, for the past 50-100 years, on the discipline of quantitative genetics, but the genomics era has now changed the manner and the context in which biological research is conducted. There are now unprecedented opportunities to expand our basic knowledge of the genetic control of traits, including difficult to measure traits such as quality of produce or disease resistance, and to develop breeding strategies that encompass molecular and quantitative approaches to a wider range of breeding goals.

Recommendation 1. BBSRC should attach a very high priority to current and future research in farm animal genomics. It has great potential to generate basic knowledge and is of enormous strategic importance.

Current BBSRC research relevant to farm animal genomics and genetics

- 5. BBSRC currently invests ~£16 million pa in farm-animal related research. Of this, approximately £5.5M relates to research with a genetics component, and a further £5.3M relates to research with a genomics component (2003/2004 snapshot). This makes BBSRC the UK's largest funder of basic research in this area. However, BBSRC's overall investment in this area has been static in the period 2001-2004, decreasing in real terms and as a proportion of BBSRC's research budget.
- 6. Defra and SEERAD have significant strategic investments of £6.1M and £4.8M pa in livestock genetics programmes, respectively, which are heavily reliant upon the basic science portfolio of BBSRC. In addition, the Wellcome Trust has investments in the complementary area of farm animal health, including a new £25M initiative in farm animal health in the developing world. BBSRC therefore has a particularly important role in funding the basic science that underpins both its own strategic research and that of other major funders.

Future priorities for research

- 7. The most important areas for future research fall under four broad headings. These are the areas where we see significant scientific opportunity and which received a high level of support both from industrial and non-industrial respondents to our consultation:
- **animal health:** understanding the susceptibility to endemic and exotic diseases and selection of genetic traits to improve resistance to disease and pests, and development of therapeutic agents, vaccines and diagnostic tools. From this and other consultation exercises, **animal health** emerged clearly as the top research priority. More broadly, the influence of genetic variation on morphological, behavioural and other factors influencing animal welfare was also viewed as an important research area.
- **animal production:** identification and selection of genetic traits to improve the quality and efficiency of animal products. A high priority is identification of traits that support the economic and environmental **sustainability of livestock agriculture**. Research to improve farm **animal welfare** in the context of production systems was also a high priority.
- **animal biology:** exploiting the opportunities created by the availability of genomics tools and information for the use of farm animal species, especially chickens, as experimental animal models; comparative genomics and genetic biodiversity management and conservation. The highest priority here is research to **benefit human health** through reduction of zoonoses, improved nutritional quality of animal produce, and a better understanding of human biology from translational research.
- **enabling tools and resources:** essential to realisation of the priorities above, and including generic molecular and numerical tools and skills, including genomics technologies, GM technologies, bioinformatics and quantitative genetics.

Recommendation 2: Within farm animal genomics, animal health should be the leading priority. This will require a fully integrated 'systems' approach including pathogen and pest research. Farm animal sustainability, welfare and human health also form important priorities. BBSRC should engage with other funders to co-ordinate coverage of priority areas, and should particularly seek to develop both the environmental genomics interface with NERC and the human biology interface with MRC.

Prioritisation of research by farm animal species

8. Having identified the leading priority areas for future research, there is also merit in further prioritisation on the basis of farm animal species.

Recommendation 3. BBSRC should continue to focus support on genomic/genetic research in the species in which it has significant prior investment (chicken, cow and pig), whilst ensuring the flexibility to invest in other species as important opportunities emerge. In particular, thus there is a strong strategic case for supporting the upcoming genome sequencing project for the pig, and the UK has an opportunity to take a lead in genomics and genetics research for economically important fish species.

Delivery mechanisms

9. We make a number of recommendations that will improve the delivery of farm animal genomics research in the UK.

Improving coordination and communication between the main funders

10. The UK lacks a coherent national strategy for farm animal genomics research, and all of the main funders (principally BBSRC, Defra, SEERAD, Wellcome and industry) would benefit from more coordination of their activities, particularly in developing opportunities for joined-up strategies, joint funding and effective international engagement

Recommendation 4: BBSRC - as a major player in this area – should take the lead in seeking to bring together the other funders, including industry, in an appropriate way – for example a funders forum. Early aims should be to map how current strategies join up, seek opportunities for joint funding and effective international engagement and explore how SR2006 monies might be jointly leveraged for this area of research.

11. BBSRC has two main institutes that conduct research of relevance to farm animal genomics - Roslin Institute and the Institute for Animal Health, which together receive ~60% of BBSRC's funding in this area. RI and IAH provide a critical mass of complementary expertise and resources and as such have a major strategic role to play in delivering the research priorities. It is clear to us that these institutes should be working together more effectively than at present; particularly given that animal disease is the highest priority for future research.

Recommendation 5: In the light of the 2005 IAE and the new Institute Science Strategy, Council should work with the Institute Directors to ensure that CSG is deployed appropriately for collaborative research and to consider the need for a new crossinstitute programme (CIP) focussed on genetics/genomics of animal disease and resistance.

12. We are also aware of the potential developments in the Edinburgh area, following the Sibbett report in 2004, involving the proposed creation of a new centre for animal bioscience. We consider that embedding farm animal genomics and genetics research at RI within such a larger structure is highly likely to bring significant benefits: We strongly encourage BBSRC to support timely implementation of this initiative.

Management of resources

13. Farm animal genomics is resource intensive e.g. requiring access to research farms, herds, challenge facilities, large-scale data handling capability and bioinformatics resources. With a few exceptions (see section 8) the UK is generally well-equipped, but further gains could be made by improved coordination and utilisation of existing resources. BBSRC should also ensure that grants in this area do not encourage unnecessary duplication of existing resources.

Recommendation 6: Council should invite the other main funders (as part of recommendation 4) to discuss how better coordination of collective resources can be achieved. The parties should consider the scope for consolidation of expensive research tools and resources, how best to secure their long-term viability and minimise duplication.

14. We propose that use of experimental herds should be complemented by more extensive use of normal commercial farm herds to test hypotheses built using experimental animal populations. This could potentially be achieved by drawing and building upon the networking experience of veterinary and industrial associations in this area. Commercial populations provide large numbers that are essential for fine-scale genetic mapping, and whilst logistically ambitious, such measures will contribute greatly towards meeting the challenges of our recommended priority areas, especially farm animal health.

Recommendation 7: BBSRC should seek ways to promote greater utilisation of commercial farm animal resources in academic farm animal genomics research. We encourage BBSRC to take an ambitious stance in this matter; to take the initiative and use financial leverage to work with other stakeholders (Defra, SEERAD, industry) towards the formation of a national network of commercial farms collaborating with academic researchers.

Communication between research communities

15. There is great potential for the outputs of farm animal genomics to inform the understanding of human systems and vice versa. Whilst there is evidence of joint activities there is scope to stimulate more interest in the value of farm animal genomics research for informing human systems, particularly in comparison to accepted experimental model species (e.g. mouse).

Recommendation 8: BBSRC should promote more interaction between the animal and human bioscience research communities. Options include joint workshops or networking activities, studentships and fellowships. We are of the opinion that a targeted initiative specifically aimed at translational studies would be a positive move by the Council to establish collaborative research.

Communication between public and private sector research

- 16. The UK has a strong animal breeding industry of global importance. However there is little concerted investment in research because, with a few notable exceptions, the sector is composed largely of SMEs operating on tight margins. Poor communication and flow of people between the public sector and industry is another issue of concern in farm animal genomics. The general situation is being improved by the Genesis Faraday Partnership (established in 2003, core funded by the Scottish Executive and Defra and supported in part by BBSRC), which received much praise in the consultation.
- 17. The consultation also highlighted a concern of the end-user community that there often remains a clear gap between research that falls under BBSRC's remit and the necessary level of development of a technology before it can be taken forward by industry and other funders.

Recommendation 9: The Bioscience for Industry Strategy Panel should be invited to review BBSRC's current KT/innovation activities in this sector and advise how best to engage and leverage more joint funding in the future. We further recommend:

- continuing support for the activities of Genesis-Faraday, or an organisation fulfilling its role, over the medium term period and beyond, subject to review;
- funding mechanisms need to take better account of strategic relevance
- the funding available through the follow-on-fund should be increased, or expedite the current application process.

Improving funding mechanisms

- 18. Basic and strategic research in farm animal genomics often involves commitment over a number of years, and therefore tends not to lend itself well to the 3-year quanta of funding prevalent in BBSRC project grants. There is a significant advantage of the CSG-funding work in institutes, where there is a level of continuity of longer-term strategic research. Whilst longer-term research proposals are not excluded from the responsive mode, there is a perception in the community that such applications are disadvantaged compared to shorter, less expensive project proposals. We are aware that the Tools and Resources Strategy Panel recognise the difficulties in funding tools and resources and will be reporting to Strategy Board on how to overcome them. We welcome and fully endorse this move.
- 19. BBSRC's Strategic Plan emphasises the importance of tools, resources and technologies in advancing bioscience and this is particularly true for the resource-intensive field of farm animal genomics. However, tools and resources are often not considered to be 'hypothesis driven' and consequently do not fare well in the responsive mode. Further, the longer-term funding commitment required for upkeep and development e.g. of databases or biological resources and access to high throughput technologies, is not best delivered via 3-year project grants.

Recommendation 10: We are aware that the Tools and Resources Strategy Panel will be reporting to Strategy Board on how to best fund and maintain tools and resources. The Panel should consider how best to support long-term resources on a more stable basis – such as decoupling funding from the model of 3-year responsive mode awards.

20. Some aspects of farm animal genomics and genetics research are best delivered through large national or international consortia, e.g. genome sequencing or annotation. Opportunities for the involvement of UK research teams can arise relatively quickly, and must be seized where the scientific and strategic case is strong. The involvement of UK researchers in international efforts brings many 'unquantifiable' benefits from having a seat at the table. A highly relevant example of an emerging opportunity is that of the international effort to sequence the pig genome, in which we urge BBSRC's participation.

Recommendation 11: BBSRC's funding mechanisms need to be sufficiently agile to allow involvement in national and international consortia at relatively short notice. We suggest that this could be achieved by utilising a small 'e-panel' of experts to peer review and support or reject a proposal to participate in a new initiative. Taking a proposal for such involvement through the normal peer review process at the next available grant round may miss the window of opportunity. The move to four grant rounds per year will increase the frequency of application points but will not reduce the time to reach a funding decision post closing date.

21. It is important that a proportion of BBSRC responsive mode research is aligned to the needs of its users, in this case a diverse farm animal industry and Defra as the principal policy department. BBSRC should ensure that its Technology Strategy takes due account of the underpinning needs of this sector.

Recommendation 12: BBSRC's Technology Strategy should take full account of the needs of the farm animal genomics sector. In the first instance we would recommend that enabling technology priorities include the development of informatics platforms, real-time diagnostics, SNP-typing at 0.1 cents per genotype, creation of embryonic stem cell lines and development of cryopreservation capabilities for farm animal germ lines.

Training

- 22. From the consultation exercise, academia and industry report shortages of researchers with skills in mathematical genetics, bioinformatics, biochemistry and whole animal pharmacology/physiology. Some of these skills shortages are impacting elsewhere in BBSRC's remit, and unless addressed will have consequences for the overall delivery of BBSRC's Vision and Strategic Plan.
- 23. There is an opportunity for the farm animal genetics industry to contribute to the funding of studentships in shortage areas to make them more attractive, following a similar scheme recently initiated to increase the level at which *in vivo* pharmacology and physiology studentships are funded. In addition, short-term visiting fellowships, industrial fellowships, more joint university/institute studentships which involve periods of research at both institutions and increased flexibility of student funding are all mechanisms by which training shortages could be met.

Recommendation 13: BBSRC should use the full spectrum of activities under studentships and fellowships, including bespoke fellowship calls and targeted incentives where necessary, to address:

- skills shortages in the farm animal genomics area, in particular informatics and quantitative aspects;
- improve the flow and communication between industry and academia (see recommendation 9);
- improve the flow and communication between this area and research on human systems (see recommendation 8).

BBSRC should also invite industry to jointly fund in key shortage areas using a similar model to that employed for integrative mammalian physiology and robustly support Genesis-Faraday CASE awards.

Ethics and public dialogue

24. Societal and ethical concerns related to farm animal genetics and genomics include concerns about the integrity, health and welfare of new genotypes, and the production of animals able to survive in poor and inappropriate environments. All BBSRC sponsored research in the area of farm animal genomics and genetics should be firmly embedded in a context of ethical awareness and public dialogue, and funders, institutions and researchers in the field share this burden of responsibility. However, it is our opinion that in most cases it is considerably more effective for individual PIs to contribute to established communication networks and programmes than to create their own.

Recommendation 14: All BBSRC research in this area should be embedded in a context of ethical awareness and public dialogue. Concerns about the health and welfare of animals used in and produced by farm animal genomic technologies can partly be addressed by the development of new welfare screening methods.

Future Funding

25. BBSRC is already the largest funder of basic research on farm animal genetic/genomics in the UK but its real-terms and proportional investment in this area has been steadily decreasing since 2001. Council may wish to consider in the light of this report whether the current level of investment is sufficient going forward? We are aware the BBSRC has earmarked £6M over the SR2004 period for research into animal heath and welfare to seize opportunities presented by advances in genomics. This is to be welcomed but is not sufficient if the UK is really to capitalise on existing expertise, become a leading Nation - scientifically- in this field and retain its current strong economic position in animal breeding and animal health.

Recommendation 15: BBSRC's SR2004 investment should be seen as the vanguard for increased investment in farm animal genomics through into SR2006 and beyond. BBSRC should seek to ensure that the total new investment in this area is in the order of $\pounds 25M$ over the next 5 years. Earlier in this report we propose several priorities for such funding and mechanisms to improve its deployment.