

Evaluation of BBSRC Agri-Food Committee Responsive Mode Portfolio

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This document represents the conclusions of a Review Panel of experts in agricultural, and food sciences. The views expressed are entirely those of the members of the Panel.

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SUMMARY AND KEY CONCLUSIONS

This document sets out the views of a specialist Review Panel convened to provide an independent evaluation of the research supported in responsive mode through the BBSRC Agri-Food Committee since 1996. The objectives of the evaluation were to assess the quality of the research supported; to identify major outcomes arising from the research; to consider whether the Agri-Food Committee is currently funding the most appropriate areas of UK bioscience; and to identify ways to build on successes and to address identified gaps and issues.

The Panel's analysis was based on the results of questionnaire surveys of a sample of 156 current and previous grantholders, 11 past and present Agri-Food Committee members, and five other UK funding organisations; and on the final reports that had been submitted for 146 sample completed grants.

The panel was informed of proposed changes to the funding mechanism for agricultural, and food sciences within BBSRC following the decision by BBSRC Council to reduce the number of its responsive-mode research committees from seven to six in 2008. This will be done by reassigning those areas of science currently considered by the Agri-Food Committee into the remits of the other committees. BBSRC will continue to support all of the areas that are currently identified for funding under the four themes presently defined within the Agri-Food Committee portfolio.

In light of the BBSRC Committee restructuring the Panel would like to stress the importance of the science funded within the Agri-Food Committee remit. The Agri-Food Committee is the sole source of funding for many areas in this remit. Accordingly the Agri-Food Committee has provided good support for basic science and has produced mainly good outputs. The Panel would like to recommend caution, and extensive consultation with the community when reallocating the remit. In particular, it is not evident how the interests of the four themes in the Agri-Food remit can be effectively represented within the other committees, *unless the composition and remit of those committees are open to substantive change*. The review Panel considered that the Agri-Food Committee should be retained.

Key conclusions of the evaluation

Research outputs and achievements

- a. The overall quality of the research funded by the Agri-Food Committee is generally good with some excellent examples. However, inferior quality work which resulted in weak publications, or in some cases no publications, was identified in some areas. BBSRC must continue to support the strategically important agricultural, and food sciences; and to encourage scientifically-sound, high-risk work. More rigorous scrutiny of some applications and final reports would be beneficial.
- b. Staff recruitment and retention difficulties, and skills shortages have had detrimental impacts on the quality of research produced. Computing, mathematical and physiological skills are particularly scarce, as are staff trained to work with all types of weeds and crop pests (arthropods, nematodes and pathogens). BBSRC should take action to reverse these shortages and work with other funders and HEIs to address long term career issues faced by research assistants, support staff and post doctoral students.

Balance and coverage of the portfolio

- c. BBSRC should reconsider its decision to discontinue the Agri-Food Committee. Although in some areas of the remit demand for funding from the Agri-Food Committee over the period of this evaluation has fallen, the Panel felt that proceeding with the proposed committee restructuring will have detrimental effects on many

areas of the Agri-Food remit. While some aspects of Agri-Food research can be relatively easily accommodated within the remit of other committees, many cannot. These include: human studies in relation to diet; food quality; economic, social, and environmental aspects of sustainability of agricultural systems; the safety of food materials through the food chain; agricultural livestock; environmental protection and change; soil science; and interdisciplinary research.

- d. Should BBSRC decide to continue with the proposed committee restructuring it must ensure that all areas of the Agri-Food remit are found appropriate homes and/or alternative mechanisms of funding in the revised committee structure. In addition, each committee would need to draw on a specialist pool of expertise from the Agri-Food community to supplement the core expertise of the committee.
- e. It was felt that the Diet and Health, and Food Quality areas have been appropriately supported by the Agri-Food Committee, but that some areas of agriculture have been inadequately addressed. BBSRC needs to take account of the lack of support felt by members of the agricultural, and food science communities, and take steps to reverse this trend. To this end BBSRC should consult with the community in the restructuring process and use incentives to encourage applications in these areas.
- f. Given the end-user orientation of much of the Agri-Food research, the panel felt that there is considerable scope for a more joined up strategy with other funders (e.g. FSA, MRC and Defra) than there is at present. This would facilitate interdisciplinary research and better end-user outcomes.

Interaction with industry

- g. Overall the Panel was pleased with the level of interaction between Agri-Food-supported research and industry. However, it felt that there was potential for more involvement in the future. To achieve this BBSRC may wish to publicise the research it supports more widely, for example in user-focused media, and seek feedback from current collaborators about the benefits of working with BBSRC-funded researchers and how to encourage further interactions.

Public Engagement

- h. The science covered by the Agri-Food Committee remit is of high public interest and much of it is comparatively accessible to the lay person. However, the time and financial costs associated with public engagement activities often conflict with the research priorities of the PI. For this reason BBSRC should investigate institutionally-led and/or cross-funding body organisational support for these activities, and the possibility of declaring costs and allocating this money, from the outset as part of FEC calculations.

Generic

- i. BBSRC should develop an annual return procedure for research outputs, including publications, where PIs are required to document outputs arising from grants for three years after completion. This ought to be a condition of further BBSRC funding and be incorporated into the current review of final reporting procedures.
- j. BBSRC needs to address the issues of research career structure and stability. This might be helped by encouraging PIs to apply specifically for the length and size of grant the work requires, by allowing research assistants to be named as co-investigators, and by attaching doctoral studentships to 5 year grants.

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GLOSSARY

ASC	Animal Sciences Committee
BCB	Biochemistry and Cell Biology Committee
CASE	Cooperative Awards in Science and Engineering (studentships)
Defra	Department for Environment, Food and Rural Affairs
DIUS	Department for Innovation, Universities and Skills
FEC	Full Economic Cost
FSA	Food Standards Agency
GDB	Genes and Developmental Biology Committee
HGCA	Home-Grown Cereals Authority
LINK	Research grant/programme, funded jointly with industry
PI	Principal Investigator
PMS	Plant and Microbial Sciences Committee
RA	Research Assistant
SEERAD	Scottish Executive Environment and Rural Affairs Department

1. BACKGROUND

Introduction

1. The Biotechnology and Biological Sciences Research Council is one of seven Research Councils sponsored through the Department for Innovation, Universities and Skills (DIUS) of the UK government. Its principal aim is to foster a world-class biological science community in the UK. The mission of the BBSRC is to fund internationally competitive research, to provide training in the biosciences, to encourage opportunities for knowledge transfer and economic impact, and to engage the public and other stakeholders in dialogue on issues of scientific interest.
2. BBSRC supports research in a number of ways, including research grants, studentships, fellowships, and core strategic grants to BBSRC-sponsored research institutes. In financial year 2005/06, 38% of BBSRC research funding was spent via the 'responsive mode' scheme of the organisation, whereby research grants are awarded to unsolicited high quality research proposals from eligible applicants in any area relevant to the mission of the Council.
3. For organisational purposes, the BBSRC research remit is currently divided into seven key areas each covered by a Research Committee: Agri-Food; Animal Sciences; Biochemistry and Cell Biology; Biomolecular Sciences; Engineering and Biological Systems; Genes and Developmental Biology; and Plant and Microbial Sciences.

Evaluation context

4. Evaluation is of growing importance to BBSRC and, with its emphasis on evidence-based decision making, to the UK government. Evaluation plays a central role in:
 - justifying BBSRC funding allocation and contributing to the evidence that all Councils are required to submit to DIUS
 - informing internal funding decisions, providing evidence of progress and achievement, and facilitating the development of a strategic overview for future funding decisions
 - enabling BBSRC to account to government, the general public, the scientific community and other stakeholders for the funds it allocates
 - helping BBSRC to improve its policy and practice, through informing policy decisions and the design of new schemes, programmes and processes; and through identifying good practice, lessons learned, and ways to improve processes.
5. Formal evaluation of research is currently conducted at a number of levels in BBSRC:

Grant	<ul style="list-style-type: none">• Evaluation of final reports from individual grants
Scheme	<ul style="list-style-type: none">• Evaluation of the responsive mode scheme, evaluating the portfolio of each Research Committee in turn• Evaluation of research initiatives (time-limited research funding in strategically significant areas), 2-3 years after the grants have ended
Institution	<ul style="list-style-type: none">• Institute Assessment Exercise, conducted every four to five years at BBSRC-sponsored Research Institutes

6. BBSRC's Evaluation Strategy¹ outlines the Council's approach to evaluation and methodology used. The BBSRC responsive mode portfolio is evaluated by Research Committee area on a rolling basis whereby two Committee portfolios are evaluated every year. Agri-Food is the fourth Committee to be evaluated, succeeding

¹ Available at: www.bbsrc.ac.uk/organisation/policies/reviews/funded_science/bbsrc_evaluation_strategy.pdf

evaluations of the Animal Sciences, Biochemistry and Cell Biology, and Genes and Developmental Biology Committees responsive mode portfolios in 2005 and 2006.

7. This evaluation covers research grants supported in responsive mode through the Agri-Food Committee which have been given a final report grade since 1996. The objectives of the evaluation were to:
 - assess the quality and international standing of research funded through Agri-Food Committee
 - identify the major outputs and, where possible, outcomes of Agri-Food Committee responsive portfolio over the past 10 years
 - identify strengths, weaknesses and gaps in the Agri-Food Committee remit and the way it is structured
 - consult with the research community and other relevant funding bodies (government and non-government) to assess whether the Agri-Food Committee is currently funding the most appropriate areas of UK bioscience
 - identify ways to build on successes, and ways to address identified gaps and issues.

8. BBSRC evaluations are evidence-based, and conducted by an independent Review Panel comprising scientists not closely involved with BBSRC, but who between them have expertise across the Agri-Food Committee remit (see Appendix 1 for Panel membership), who were asked to provide an independent scientific evaluation of the evidence presented. This was:
 - **146** sample final reports (representing **53%** of all Agri-Food Committee responsive mode grants that had been completed and graded at the time of sampling). See Appendix 2 for list of sample grants.
 - Questionnaires returned by **90** PIs of completed grants (representing **33%** of all completed and graded Agri-Food Committee responsive mode grants) and **66** current PIs (**52%** of all current Agri-Food Committee responsive mode that had been underway for more than a year). For questionnaires see Appendix 3.
 - Questionnaires returned by **11** current and former Agri-Food Committee members
 - Questionnaires returned by **five** other government and non-government funding bodies relevant to the Agri-Food Committee remit
 - Additional information about the titles and themes of grants funded through Agri-Food Committee responsive mode drawn from BBSRC databases.

The sample final reports and PIs were chosen randomly from the point of view of the science, but in a structured way to be representatives of the years and, where applicable, the final report grades achieved.

9. Further information on responsive mode funding in BBSRC, the evaluation objectives and methodology, and on the Agri-Food Committee is at Appendix 4. Survey results are at Appendix 5.

2. RESEARCH OUTPUTS AND ACHIEVEMENTS

Research quality

10. From an international perspective the research supported by the Agri-Food Committee over the past ten years has been mainly good with some notably high quality examples, but also some that were weak. Examples of the most striking research outputs are set out as highlights below.
11. The Panel noted that 79% of the final reports of Agri-Food responsive mode grants over the past 10 years had been graded A or B by Committee members at the time (final reports are submitted three months after the end of the grant, and peer reviewed and graded on a scale of A to D² by Committee members). Moreover, in their questionnaire responses 90% of the sample PIs felt that their grant had been, or was likely to be, successful. Whilst most Panel members found much to commend within the final reports they reviewed, the quality of science reported in some fell short of the standards to be expected.

Highlights

12. 29 (19%) of the grants for which final reports were available for Panel scrutiny were identified by the Panel as having produced very good research outputs. These are shown below categorised by theme. The grants selected as highlights represent 12% of sampled Diet and Health grants, 19% of sampled Sustainable Agricultural Systems grants, 12% of sampled Food Quality grants, and 16% of sampled Control of Food Pathogens grants. The Panel also identified a number of additional notable grants described at Appendix 6.

Diet and Health

Serotonin receptor subtypes and ingestive behaviour

This project demonstrated that the behavioural expression of satiety following consumption of a palatable meal is enhanced by activation of two serotonin receptors, 5HT_{1B} and 5HT_{2C}, and also identified complex interactions between these two receptor subtypes. The data have important implications for our understanding of the pathophysiology of eating disorders and obesity. The work involved collaboration with industry and contributed significant background scientific information for the FDA on a 5HT_{2C} receptor agonist on clinical trial for the treatment of obesity. The group also used work from this project when addressing a Select Committee in the House of Lords on animal experimentation.

Co-operative activity of H⁺/solute symport and Na⁺/H⁺ exchange at the intestinal epithelial brush-border membrane

Using a validated *in vitro* cell model system, this research demonstrated how transepithelial dipeptide transport is functionally independent upon the activity of apical Na⁺/H⁺ exchange (NHE3). This work may have implications for human health, since the activity of NHE3 expressed in the apical membranes of the human intestine can be influenced by a variety of physiological (hormones and nutrients, pathophysiological bacterial toxins) as well as pharmacological (drugs) factors. As a consequence such effects may potentially influence optimal nutrient absorption. The outcome of this research has been widely disseminated through a series of strong publications in well respected journals, as well as through conference presentations in the UK, the USA, and Europe. The work is also notable for the academic and industrial interactions and collaborations that have been developed.

²A is defined as 'very high class work that has produced results of considerable scientific importance in a cost effective way, and met all of the agreed or related key objectives.' D is defined as 'work that has not added significantly to knowledge in the field and/or has failed to address the agreed or related objectives'.

Molecular insights into the role of dietary fibre and maintenance of colonic health

This research showed that butyrate, a significant product of bacterial metabolism in the gut, positively regulates the expression of its transporter, MCT2, through transcriptional control involving a defined promoter region within 70 bp upstream of the transcriptional start site. mRNA stability was also shown to be an important factor. This regulation is of potential functional significance to human health, since relative to normal human colon, a decline in MCT1 expression in pre-cancerous and cancerous tissue was observed. The work has been recorded through publications of the studies in appropriate and well-recognised journals, as well as through a number of presentations by the PI and her team at national and international meetings. In addition, they have been proactive in promoting their work to the public through lectures and demonstrations.

Integration and metabolism of xyloglucan in plant cell walls in vivo

This research has investigated the relative role of transglycosylation versus hydrogen bonding in plant cell wall assembly. As a result of this work it is now possible to determine *in vivo*, for the first time and in an accurate and reproducible manner, the effects of altered XTH enzyme gene expression. The results from this work will have important application in determining and improving the role of these isoenzymes in plant growth and fruit ripening, hence with long-term benefit in agricultural and food science.

Investigating synergy between genotype and behavioural phenotype in maintenance of energy balance

This research addresses key concepts of childhood obesity. The group has demonstrated the importance of a person's genetic makeup when studying obesity. In the first place the study confirmed the prevalence of obesity in children and extended the work to show the importance of gene-environment interaction in providing some protection against obesity and enhanced short term energy compensation. The work has been extensively publicised in the scientific media as well as bringing the results to the public through seminars, school presentations and science festivals.

Endocannabinoid involvement in the regulation of appetite

This project provided a comprehensive analysis of the roles and interactions of the endocannabinoid and opioid systems in the regulation of appetite. The data have important implications for the development of novel treatments for obesity. The work led to a patent, and collaborations with industry and a number of academic centres. The group worked hard to communicate their findings to the public, both through the media and through open days in their institution.

The effects of dietary Gal-GalNAc-binding lectins on intestinal epithelial proliferation

This very successful project showed that peanut lectin can cause intestinal proliferation and pancreatic hyperplasia while mushroom lectin was shown for the first time to be anti-proliferative. The main cell-surface receptor for peanut lectin has been found to be a high molecular weight variant of the adhesion molecule, CD44. A further study has been funded to explore the sites of glycosylation on CD44. Five excellent publications have resulted from the 36-month work, a patent has been taken, and future developments are really promising.

Gut-brain signalling: roles of lipid, cholecystokinin and the vagus nerve in man

This project was very successful. It has been shown that the vagal nerve cells that express receptors for cholecystokinin (CCK) also produce receptors for two other signalling molecules i.e. leptin and orexin receptors involved in control of food intake. For the first time it was demonstrated that vagal nerve cells in humans are different to those in the rat, a widely used model. The role of CCK release in nausea development was not substantiated. A new method has been developed to record impulses in the human nerve with expected important use in further research projects. Four very good publications resulted from the work.

Interaction between the influence of genomic variability and n-3 fatty acids intake on TNF-alpha production

In this study of 250 young men it was found that intake of n-3 fatty acids for 12 weeks resulted in a decreased TNF- α production in those subjects with intrinsically high TNF- α production only, and that an inverse effect can be observed in low producers.

Responsiveness to the anti-inflammatory effects of fish oil depends on a combination of genetic characteristics especially those of IL-6 and TNF- β . This work is of particular importance with the national trend of n-3 PUFA intake awareness. A patent application has been made and 3 very good publications have resulted from this work of key relevance for human nutrition and public health.

Food Quality

The elucidation of the biochemical pathway leading to the synthesis of (-)-epicatechins in plants

This food quality project aimed at defining the biochemical pathway involved in epicatechin synthesis in plants and the enzymes involved. The project made significant advances in our understanding of the enzymology of two key elements involved in flavonoid biosynthesis. An important highlight was the production of a crystal structure of one of the enzymes, anthocyanidin synthase, and this provides a template for future studies in plant biochemistry. It should be acknowledged that this project was successful despite huge difficulties through the PI leaving John Innes Centre (JIC), and later the death of the post-doc involved in the grant. It is a credit to the team at JIC and their collaborators at University of Oxford that the project delivered at all. Moreover, it produced four good papers in specialised journals, which have all been well cited and one particularly so.

Creation and dynamic evolution of rheologically complex cereal-based foams

This joint project, based at two institutions, has for the first time characterised, unambiguously, the turnover rate of gas during mixing of bread dough which has been shown to be surprisingly slow with average residence times of the order of half the total mixing time. It has shown that rheological tests under large scale, as opposed to conventional small scale deformation, closer resemble the processes occurring during baking and discriminate differences in wheat flour variety and baking performance. A polymer model has further been developed to relate polymer molecular architecture to rheology and bubble stability. The work has led to a number of international collaborations, industry dissemination, engaged public and private sector stakeholders, and been widely publicised in peer-reviewed journals, national and international conferences, and in an industry trade journal. The researchers have engaged with lay audiences.

Molecular mechanisms of wheat protein elasticity in relation to food processing and biomaterials

This work has shown that, although experimentally very demanding, it is possible to couple infrared spectroscopic measurements with rheological measurements in gluten systems and thus simultaneously obtain information about molecular structures and mechanical state. It has also been shown unequivocally for the first time that mechanical changes in gluten are related to conformational changes in the proteins as predicated by the Loop and Train Model. The outcome of the work is a more detailed understanding of the role of particular amino acid sequences in the behaviour of the above systems and forms the basis for the rational design of molecular structure for required functionality. The work has been widely disseminated by peer-reviewed papers and at international conferences.

Phenolics of the plant cell wall: improving raw material quality through their modification and cross-linkings

This project has developed new transgenic lines of tomato with modified levels of the antioxidant chlorogenic acid (CGA) and a patent application has been filed on plant-derived transferase genes. The work demonstrated strategies for improved levels of hydroxycinnamic acid intermediates and associated improved textural properties and disease resistance in

tomatoes. Extensive publication of the work has been inhibited by the wait for the patent application to be progressed. However, the researchers have now begun to publish peer-reviewed papers and during the course of the work demonstrated clear public engagement with lay audiences on the general topic of genetic modification of plants.

Manipulating the phenolic acid content and digestibility of forage grass cell-walls by targeted expression of a ferulic acid esterase gene

This research and related work has provided new insights into mechanisms controlling phenolic deposition in the cell wall, and the chemical determinants of cell wall digestion. It has generated new experimental material which is being used to investigate the nutritional consequences of modifying the cell wall phenolic composition of grasses. Progress has led to a full US patent application and to continued industrial funding on the expression of other fungal cell wall degrading enzymes.

3D quantification of temperature for enhanced food quality by microwave and convective heating

This work has enabled on-line measurements during the course of heating by hot air and water. In addition, protocols are available for measurement of moisture and structural changes in potato and chicken meat during cooking on-line and off-line after microwave heating. The work is of great interest to the food industry. It has been widely publicised in peer-reviewed journals and at international conferences. The work has attracted follow-on funding from the UK and US Governments as well as donation of the unique Trivection™ combination oven. The follow-on funding also enabled public awareness projects and the creation of two websites: 'seeing the invisible' and 'the kitchen as a laboratory'.

Reduction in meat toughness: regulation of calpastatin by the calcineurin pathway

The research makes a significant contribution to understanding how calpastatin, a calpain proteinase inhibitor, affects post-mortem proteolysis and tenderisation in meat. The work indicates that the level of a particular isoform of calpastatin, at slaughter, controls tenderisation and identifies factors controlling its production. This is fundamental work for identifying the genetic basis of calpastatin gene expression necessary for selective breeding programmes. Output from the project (papers, data, etc) is excellent as has been interaction and communication with international groups.

Control of Food Pathogens

Diarrhoeal mechanisms in *Campylobacter jejuni*

This project investigated a virulence mechanism in *C. jejuni*, largely using immortalised human gut epithelial cell lines, but with some work using primary human tissue. The project was scientifically very successful and was the first to identify a mechanism for diarrhoeal disease in *C. jejuni*, which provides a platform for further research. The project also developed a good *in vitro* model system, which is now widely used by scientists with an interest in campylobacter pathogenesis. There were a range of secondary but very important outputs, which deserve further investigation.

The role of secreted protein (Sips) and their interactions with host cells in virulence of *Salmonella*

This was an important and successful project. It identified important virulence mechanisms in *Salmonella* Dublin and met all of its objectives. The project also generated useful research tools in the form of anti-Sip antibodies. Six high quality publications were produced and the PI was successful in obtaining substantial follow-up funding from BBSRC. In addition to the above, EMBL/GenBank database submissions were made, and a patent has been granted to protect an attenuated salmonella generated as part of this work. International collaborations have been enhanced: the PI was involved in the India/UK TOMBIT project whilst working on this grant as this project aimed to transfer knowledge and technology to Indian scientists. The PI gave two public lectures in India, and strains and antibodies produced during the BBSRC-funded study were used in practical classes during this visit.

Molecular analyses of luminal and mucosal microbial biofilm communities in the human large intestine

This project aimed to explore a novel area at the time: the identities and metabolic activities of bacteria growing on epithelial surfaces and digestive residues in the gut lumen, an area now recognised to be of increasing importance. The work had a range of original objectives but not all of these could be explored because of funding constraints. The project used classical and molecular microbiology approaches and obtained data of real value. In particular, it showed that bacterial communities attached to epithelia were quite distinct from those in the intestinal lumen. In addition, the two communities had separate metabolic profiles. *In vitro* studies were also really informative and generated data of importance. The project produced three good peer-reviewed publications and three other significant papers; a number of collaborations; contributions to lay audiences; a gut modelling system; and has led to further research funding.

Sustainable Agricultural Systems

Bioethical analysis in technology assessment: application to use of bovine somatotrophin and automated milking systems

By determining the public position on the ethics of the use of two important novel technologies in dairying (somatotrophin and robotic milking), the project tests the ability of an 'ethical methodology' to provide an evidence base for rational decision making. The methodology was able to elicit divergent views (from a now adequately informed societal group) on the ethics of the two technologies. Points of disagreement and difficulty were elucidated. Clarification of the issues in this way will help decision-making with regard to how (or whether) new technologies might be best taken forward with a wider public support (thus avoiding contentions). Such issues and their rational resolution are important to the Agri-Food sector. This project had a high profile with the public sector.

Metabolic and pathogenic mechanisms of loss in supportive capacity of bovine hooves at calving leading to lameness

and

Cattle lameness at calving: a hypothesis involving metabolism of the collagenous tissues supporting the hoof

Lameness in dairy cattle is a serious affliction with negative impact upon cow welfare, productivity and efficiency. The first study set up the proposition that lameness at calving found in dairy herds was in substantive part due to metabolic/biochemical changes altering, and weakening, hoof structure. The later study followed on to confirm that the most frequent type of claw horn disruption was indeed associated with biochemical changes in the hoof occurring around the time of calving. Housing type influenced the degree of severity. These findings were appropriate for taking forward to the Agri-Food sector for development into improved husbandry procedures to reduce the risk and severity of claw horn disruption in dairy herds.

Functional genomics of wheat endosperm development: a high throughput *in situ* approach to gene discovery

This project has established an automated procedure for determining the spatial and temporal pattern of gene expression during wheat seed development, using RNA probes, automated tissue preparation, slide preparation and microscopy. Expression patterns of over 1000 genes in developing wheat endosperms were characterised. Many of these are tissue-specific, e.g. only expressed in the central starchy endosperm or in the modified aleurone. A large proportion of these genes are known to be involved in protein or carbohydrate storage. Expression patterns have been used in identifying gene promoters. The project also found the transcripts of some genes, mainly transcription factors, accumulated in the nucleus, suggesting an additional level of post-transcriptional regulation. During the project there was close collaboration with Syngenta, and numerous additional collaborations including Leeds University, Royal Holloway and the Scottish Crop Research Institute. Five peer reviewed publications resulted, including one in *Nature*.

An integrative study of S cycling and C, N and S interactions in agricultural ecosystems

This project compared S cycling in a range of soils, as mediated by inorganic fertilisers or crop residues, identified key soil factors that influence the processes of S immobilisation and mineralisation, and extended the Roth-C carbon cycling model to include soil S dynamics. A significant number of publications in specialist journals were produced, a substantial effort to engage stakeholders was made through the publication of over 20 popular articles in the agricultural press, and the work was brought to the public through lectures, media presentations and the Royal Show.

Molecular architecture and structural properties of plant cell walls

This large, coordinated research project involved 3 separate laboratories studying the mechanical properties of plant cell walls in relation to plant growth. The project identified that the cellulose and pectin networks have different and separate roles in determining cell wall properties and also highlighted the significance of a group of cell wall proteins. A very large number of publications were written for specialist journals (15) and the work was made accessible to the public through a well organised outreach programme targeting schools.

Testing the trans-situationality of bird-habitat models in agricultural landscapes

This project aimed to develop multivariate methods for predicting bird abundance as a function of farmland and other habitats. Despite disruption during the Foot and Mouth epidemic the research showed that rather than food abundance per se, it was food availability as a function of habitat characteristics that may affect bird distribution. This finding, although only preliminary, has major implications for agri-environment schemes aimed in part at reversing the declining trend in some farmland bird species. The SAFFIE project funded under Defra Sustainable Arable LINK programme substantially built on this research. The BBSRC-supported staff benefited A-level teachers and students, engaged with University students in Nigeria and contributed to media debates – all on farmland bird conservation issues related to this topic.

Spatial modelling of *Bombus terrestris* and *Bombus pascuorum* populations in agricultural landscapes

This project aimed to use spatial modelling approaches to determine the viability of bumblebee species in intensively farmed landscapes, supported by field and laboratory experiments and using microsatellite markers both for typing bumblebees and space utilisation. The research was collaborative, novel, and for the first time gave quantitative estimates of the foraging range of bumblebees. These findings have important implications for both bumblebee conservation and for efficient pollination of crops such as field beans and oilseed rape. Although there is little scope for direct commercial exploitation, this research provides simple and useful information for farmers on field margins management. The public engagement in the project was exemplary, involving landowners in the survey area, more than 700 volunteers took part in the survey work, media presentations and a BBSRC/NERC grant for Public Engagement in Science Week.

Control of somatic cell differentiation and oocyte development during early folliculogenesis: a new hypothesis

This study examines follicle growth and cell differentiation with an eye to increasing the availability of oocytes for IVF and embryo transfer (ET) by better understanding the influence of various hormonal and other factors. It pushes forward reproduction technologies that have application in both animal breeding (IVF & ET) and human clinical treatment of infertility (and associated stem cell and cloning work).

The evolution of resistance to Bt toxins: testing ecological and evolutionary hypotheses in environmental microcosms

This project reports important evidence on the extent of field evolved resistance to *Bt* toxins sprayed on field crops. Investigations with field-derived populations of the diamondback moth into variation in the costs of possessing a resistance gene to a *Bt* toxin showed that costs can vary markedly within and between populations. Larval competition and host quality

both affected the costs of resistance. The evolution of resistance to *Bt* toxins did not, however, produce a correlated response in resistance to nucleopolyhedroviruses, indicating that viruses are compatible with *Bt* resistance management strategies. Modelling demonstrated that for the virus to be effective at managing the evolution of resistance to *Bt* it is only necessary that the relative fitness of *Bt* resistant insects is reduced while being exposed to both virus and *Bt*. Five peer-reviewed papers in high quality journals have been produced from the work.

Ecological and behavioural side-effects affecting the evolution of insecticide resistance in the aphid *Myzus persicae*

Genes conferring insecticide resistance in aphids are shown to have negative side effects on aphid behaviour, which may impose an evolutionary trade-off. In particular it is shown that insecticide resistance in aphids confers a lower propensity to respond to the aphid alarm pheromone making them more vulnerable to attack by parasitoids and predators. The data thus provide strong evidence that a behavioural side-effect associated with insecticide resistance genes significantly increases aphid vulnerability to parasitoid attack. Parasitoids may therefore play an important role in moderating the establishment and spread of resistance genes in aphid populations. The work is of potential practical significance and two papers have been published.

13. The Panel recognised that the nature of scientific investigation inherently results in some failure and that it is important that funding for scientifically sound, high-risk applications is maintained. However, a few grants were identified where the objectives were flawed at the outset and the Panel was concerned that these may have been funded as a result of difficulties covering all areas of the broad remit with a limited number of Committee members. The balance and coverage of the portfolio is discussed further in Chapter 3.
14. The level of intellectual challenge of the research in the sampled grants was also variable. The Panel felt that this was generally appropriate in some circumstances and reflects the wide range of research supported by this committee from basic underpinning research to applied.
15. The analysis of the research quality and outputs was limited by the information provided in the final reports, which was of variable quality in terms of how well they had been written, and the detail provided. In some instances the grant objectives were not clearly set resulting in difficulty when attempting to measure the achievement of the grant against its objectives. This issue should be addressed at the point of application by the Committee and/or the referees (see paragraphs 71-72 for further discussion of final reports).

Research outputs

16. The Panel considered a range of short- to medium-term research outputs:
 - Publications
 - Trained people, new skills
 - New collaborations, further funding
 - New products, processes, tools and technologies
 - Intellectual property, spin-out companies
 - Contribution to the reduction, refinement and replacement of animals in research

Longer-term outcomes arising from the research supported through the Agri-Food Committee are discussed in Chapter 6.

17. The Panel commented that due to the time scale required for development of tangible outputs and deliverables it can be difficult to capture the origin of these, even within the scope of a 10 year evaluation. Furthermore, a specific and significant development or outcome may be the result of many inputs arising from different sources. This increases the difficulty of assigning an output to one grant or indeed one funder. For these reasons, invariably it is not possible to identify outputs resulting from specific grants.

Publications

18. Overall the Panel felt that the number of publications produced from the grants was acceptable. For the completed sample grants the median number of publications was three and this was the benchmark set by the Panel for a good grant. It was agreed that the quality of the paper and the publishing journal was also important when judging outputs. The Panel noted that comparing journals over a 10 year period may not be ideal as, for example, a journal preferentially chosen in 1996 may no longer be considered as the journal of first choice in 2005. As with all such analyses, the Panel felt that data on impact factors should be treated with caution, particularly as the impact factors cited were calculated in 2003. It was apparent that there was a degree of over-reporting of publications, with some PIs clearly listing publications resulting from other grants.
19. It was disappointing that a significant number of grants had failed to publish any results. This may be an effect of staff retention issues where a research assistant moves to another position and is unable to contribute to publications resulting from their previous work. The Panel was also concerned that in a few instances, where the quality of the research achieved seemed high, PIs had chosen to publish their work in comparatively low impact journals.
20. The Panel recognised that agricultural, and food sciences journals generally have relatively low impact factors. Therefore the large number of publications in journals with a low impact factor is a feature of agricultural, and food sciences rather than a reflection of the absolute quality of Agri-Food Committee-supported research. This was also recognised in the Animals Sciences Committee responsive mode portfolio evaluation.
21. The Panel felt that it is important to note the contradiction, particularly in the Agri-Food area, between encouraging interaction with industry, and the pressure to publish work in academic journals. Interactions with industry may mean that publication is not a priority and in some cases might be delayed or prevented. In addition, journals with high industrial appeal often have lower impact factors than journals targeted at an academic audience.

New collaborations, further funding

22. The number of new or improved academic contacts and collaborations reported was high. However, as further details on the nature of these contacts and collaborations were not always provided it is difficult to establish their significance or robustness.
23. The number of PIs securing further funding from the Agri-Food Committee was low (20% compared with 30% for ASC and BCB, but 18% for GDB) and may indicate the underpinning nature of the research funded: that PIs subsequently approached funding bodies with a more user-focused nature. This is supported by the fact that 29% of PIs sampled secured funding from 26 other funding bodies.

Trained people, new skills

24. The Panel felt strongly that maintaining staff and skills capacity is an important role for BBSRC should it wish to promote the international standing of agricultural, and

food sciences research in the UK. Accordingly, the Panel was encouraged that the majority of PIs (69%) reported that the Agri-Food grant had supported their wider research aims by strengthening the skills base of their group.

25. The high proportion (33%) of PIs experiencing long term recruitment and retention issues, which undoubtedly affects the quality of the research produced and the likelihood of achieving original objectives, was of concern.
26. It was clear to the Panel that the agricultural research community perceives a reduction in the level of support and importance given to their area by universities and BBSRC. The Panel was therefore concerned that this would become further entrenched as a result of the proposed BBSRC Committee restructuring (see paragraphs 34 and 35 for further discussion).
27. Crop pests (arthropods, nematodes and pathogens) and weeds were identified as areas of specific concern in relation to skills shortages. The majority of staff are trained as a result of NERC funding, even though this area is within the Agri-Food Committee remit. The Panel was also concerned about skills shortages in mathematical and computer sciences, where qualified staff can be attracted to better paid jobs in other sectors, and in physiology. The generic issues of career stability and skills shortages are discussed further in Chapter 7 (paragraph 67).
28. The Panel was surprised that only 10% of research assistants (RAs) had taken up positions in industry at the end of their work on the grant and felt that this may be something BBSRC could investigate in the future. This figure is the same as that reported for GDB and ASC evaluations, but lower than that for the BCB evaluation (16%).

New products, processes, tools and technologies

29. A proportion of PIs reported new products, processes, tools or technologies resulting from the research supported by their Agri-Food grant. These outputs were wide ranging including: new experimental techniques and equipment; modelling systems and statistical methods; novel reagents (including antibodies and primers); and transgenic or mutated organisms.
30. Some examples of particularly significant new products, processes, tools and technologies were identified:
 - Pre-harvest sprouting of wheat: this has practical implications for bread making, led to a LINK programme with wheat breeders, and a patent has been filed (see paragraph 31 for details of commercialisation).
 - Lameness in cattle: the biochemical basis of lameness was identified. This understanding will be used to reduce lameness and increase productivity. The outputs from this grant include software, a new methodology, and a training package.
 - Methodology for looking at ethical issues: this methodology has been widely used across the EU by regulatory bodies, industry, NGOs, advisory groups and other researchers. It has been helpful in solving difficult problems in communication with the public, and is freely available on the internet.
 - Three-dimensional imaging system: this has both agricultural and clinical uses. Measurement of the size and shape of livestock and meat carcasses has importance in relation to the sustainability of home-produced livestock and to food eating quality. Using a three dimensional imaging system these measurements can be taken with increased accuracy and utility. Clinically, this imaging system is now in use for facial cleft repair and breast reconstruction (see paragraph 31 for details of commercialisation).
 - Pore-Cor Modelling System: data have been used to develop simulations of nutrient leaching in highly structured porous media. These simulations are run

via the Pore-Cor™ Modelling system which has been marketed via Pore-Cor™ (see paragraph 31 for details of commercialisation).

- Infrared spectroscopic apparatus: this was developed to couple infrared spectroscopic measurements with rheological measurements so as to simultaneously obtain information about molecular structure and mechanical state of food.
- Air bubble apparatus: this apparatus was produced to quantify behaviours of air bubbles undergoing fast expansion or compression, and to study coalescence kinetics of bubbles. Bubble formation and structure is fundamental in the stability of aerated food protein systems such as ice-cream.
- Application of Magnetic Resonance Imaging methodology: this was used to determine structural changes and combined heat and mass transfer in food.
- Transgenic tomatoes: this work produced tomatoes with high antioxidant levels which have increased texture and resistance to disease.
- Cell walls: developed new insights into controlling phenolic deposition in cell walls and chemical determinants of cell wall digestion. This has led to an investigation into the nutritional consequences of modifying cell wall phenolic composition in grasses (important for animal feed), and into studies to increase the efficiency and decrease the cost of bioethanol production from maize.
- Metabolic fingerprinting of the transgenic lines: this has revealed far greater diversity than had previously been realised and opens new awareness for the exploitation of introgressed lines in plant breeding.
- Model cell culture system: this is based on normal urothelial cells and analyses PPAR γ activity. The elegant system offers a complementary and alternative approach to using animals for testing.

Intellectual property, spin out companies

31. 8% of the sample PIs reported having secured intellectual property (mostly in the form of patents) as a result of the work supported by the grant. A further 6% reported that they were likely to apply in the near future. This level of secured intellectual property is higher than that reported in the GDB and ASC evaluations. Of the grants identified as producing significant products, processes, tools or technologies (paragraph 30) two have become commercially available via spin-out companies: the three dimensional imaging system is available via Dimensional Imaging Limited; and Plant Biosciences Limited distributes the transgenic wheat plants that have regulated pre-harvest sprouting. One product (data on nutrient leaching) has been used in simulations to extend an already marketed modelling system (Pore-Cor™), and another (identification of a plant derived transferase gene) has licensed findings to a Canadian company. Industrial interactions will be discussed further in Chapter 4.

Contribution to reduction, refinement and replacement of the use of animals in experimentation

32. A small number of PIs (5%) reported that their research contributed to the reduction, refinement, and replacement of animals used in invasive experiments (the 3Rs), such as the urothelial cell culture system which will enable some important questions to be addressed without using animal models. 18% of Committee members felt that the research supported by the Agri-Food Committee had contributed to the 3Rs.

Key Conclusions

- a The overall quality of the research funded by the Agri-Food Committee is generally good with some excellent examples. However, inferior quality work which resulted in weak publications, or in some cases no publications, was identified in some areas. BBSRC must continue to support the strategically important agricultural, and food sciences; and to encourage scientifically-sound, high-risk work. More rigorous scrutiny of some applications and final reports would be beneficial.**

b Staff recruitment and retention difficulties, and skills shortages have had detrimental impacts on the quality of research produced. Computing, mathematical and physiological skills are particularly scarce, as are staff trained to work with all types of weeds and crop pests (arthropods, nematodes and pathogens). BBSRC should take action to reverse these shortages and work with other funders and HEIs to address long term career issues faced by research assistants, support staff and post doctoral students.

3. BALANCE AND COVERAGE OF THE PORTFOLIO

Overview

33. The Panel agreed that the remit of the Agri-Food Committee is very broad and although this has been generally beneficial, there have been some difficulties making sure the portfolio covers its entirety. The Panel felt there was evidence that some areas of the Agri-Food remit had been inadequately addressed over the last 10 years (see paragraph 36).
34. The Panel was concerned that the remit encompasses some areas that would not fit easily within the current remits of other BBSRC Committees and wished to flag them, particularly for forthcoming discussions of committee restructuring. These areas are: human studies in relation to diet; food quality; livestock; and soil science. The Panel was also concerned that dividing the remit would inevitably result in the inability to consider all disciplines within the agricultural and food sciences as a whole when developing and applying strategies. This would be a significant disadvantage and decrease the impact of the resulting science.

Coverage of the Portfolio

35. The Panel believed that certain members of the agricultural, and food sciences communities lacked support in their specific area/s. This may reflect BBSRC policy, in addition to difficulties of maintaining Committee membership across all areas of the remit (see also Chapter 2, paragraph 13). This has discouraged PIs from applying to BBSRC; it is important that BBSRC addresses the observed drop in applications from the agricultural, and food sciences communities, and the Panel suggests that restructuring the Committees may not be the appropriate action. The Panel felt that the inevitable increase in the remits of each of the remaining Committees as a result of the committee restructuring may exacerbate this issue. Altering the Committee structure to a core of members and a pool from which to select the required expertise, dependent on the applications, could address the problem of the large remit. However, it would be important that the names and areas of expertise of all members of the core and pool were made available to the community to increase confidence in the ability of the Committee to assess applications across the entire remit.
36. The Panel thought that the coverage provided for the diet and health area was appropriate and therefore suggestions by Defra, HGCA and SEERAD that there was too much emphasis on this area were questioned by some members. The Panel's view was supported by those PIs who identified their area of expertise: the areas falling under the diet and health theme showed no significant over-representation in comparison with other areas. However, the Panel echoed the sentiment of the comments by Defra, HGCA and SEERAD that the Committee has not addressed the balance of the entire portfolio.
37. Specific areas within the remit that appeared not to have been covered adequately over the period of this evaluation were: the economic and social aspects of sustainability of agricultural systems; agricultural livestock, and safety of food materials through the food chain. Since the inception of the Agri-Food Committee the importance of environmental protection and climate change has increased; the funding provided by the Agri-Food Committee does not reflect this. The RELU programme³ was welcomed, but much of the remit overlaps that of the Agri-Food Committee; therefore BBSRC should investigate why PIs are not directing such applications to the Agri-Food Committee. The Panel felt that the agricultural sciences, especially agricultural-environmental science, have suffered from the effect

³ Rural Economy and Land Use Programme: a joint interdisciplinary research programme funded by BBSRC, ESRC, NERC, SEERAD and Defra (www.relu.ac.uk)

of a reductionist approach by BBSRC. This may be an explanation for the fall in numbers of applications in this area and possibly reflects a lack of communication between the Committee and the agricultural science community.

Interdisciplinary research

38. Interdisciplinary work has huge potential to address many of the big questions currently posed in the biosciences. In an analysis of all BBSRC Committees the Agri-Food Committee was shown to fund 8% of all current BBSRC interdisciplinary grants, fourth when ranked against other committees. This analysis was based on joint awards where co-PIs were based in different departments, and hence is an under-representation of the true figure. The Panel felt that this level of interdisciplinary work is lower than should be expected; however, they also felt the criteria used to derive this value were limited and suggested further investigations would be necessary before drawing conclusions.

Overlap with other funders

39. The Panel did not identify any significant areas of inappropriate overlap between BBSRC and other funders, and instead felt that the work supported by the Agri-Food Committee often underpins research supported by other funding bodies. BBSRC has a fundamental role, particularly in providing training, and is very distinct from other funders.
40. The Panel was concerned that in the process of restructuring the Committees some strong links between the Agri-Food Committee and other funders may be lost. BBSRC must make every effort to ensure that these contacts are maintained and that BBSRC fulfils its role in facilitating a smooth flow of research from basic science to final delivery. In particular the Panel queried the likelihood of achieving all the objectives of the BBSRC Food Research Strategy⁴ if links with FSA were lost or weakened.
41. Despite some strong links between BBSRC and other funders, generally the Panel felt there was a lack of joined up thinking in relation to BBSRC's interactions with other funders, and suggested that current strategies for this need improvement.
42. The suggestion from Defra, HGCA and SEERAD that there may be inappropriate overlap between the work funded in the diet and health theme and the MRC was questioned by the Panel. Many of the areas of the Agri-Food diet and health theme do not fall within the MRC remit.
43. In the area of sustainable agricultural systems, the Panel felt that improved integration across disciplines is needed, specifically to incorporate socio-economic factors. This may be an issue for RCUK as well as BBSRC. The Panel could not see how placing this area of the remit within another Committee would help. In fact the Panel felt that, due to the importance of sustainable agricultural systems, BBSRC may wish to investigate establishing a Committee specifically for this area, incorporating areas from other Committee remits such as PMS and AS.
44. The Panel would caution against cross-Council schemes that require applications to pass through more than one processing system, because PIs may think the application process too cumbersome and that they have a reduced chance of funding. By contrast the LINK scheme was cited as an example of a well organised scheme. Areas where BBSRC may want to consider further cross-council

⁴ This Strategy is available on the BBSRC website:
http://www.bbsrc.ac.uk/about/pub/reports/07_feb_foodresearchstrategy.pdf

development are agricultural-environmental science (with NERC), diet (with MRC), and food (with EPSRC and Defra).

45. In general the Panel thought that BBSRC should liaise further with other funding bodies to ensure that important user needs are met and that cohesion between funding bodies is maximised. BBSRC Committees have the benefit of being more flexible than other funding bodies and would benefit from making further use of this facility. The Panel felt that creating activities between BBSRC and other funding bodies to link fundamental and end-user work would be very valuable and suggests that BBSRC considers a strategy to address this.

International comparison

46. Given the scope of this evaluation, it was not feasible to generate specific internationally comparable data for agricultural and food sciences. However, in relation to the biosciences as a whole, the UK ranks very highly internationally for impact as measured in terms of citations. The UK ranked second (after the USA) for its share of citations in the biosciences for 2001-2005; and has the highest citation impact (ratio of citations to publications) in the world. The UK also had the lowest proportion of uncited papers for biosciences for 2000-2005 amongst the G8 countries.
47. Both international Panel members felt that the overall quality of science was good or very good. The member from France was struck by the diversity of topics within the remit and felt that this could be beneficial in certain circumstances but noted that collaborative projects, EU funded projects, and industrial interactions are more common in France than in the current sample. The member from the Netherlands had the impression that obtaining BBSRC funding could be difficult, but once an application is approved the funding provided fits well within the research environment.

Key Conclusions

- c BBSRC should reconsider its decision to discontinue the Agri-Food Committee. Although in some areas of the remit demand for funding from the Agri-Food Committee over the period of this evaluation has fallen, the Panel felt that proceeding with the proposed Committee restructuring will have detrimental effects on many areas of the Agri-Food remit. While some aspects of Agri-Food research can be relatively easily accommodated within the remit of other committees, many cannot. These include: human studies in relation to diet; food quality; economic, social, and environmental aspects of sustainability of agricultural systems; the safety of food materials through the food chain; agricultural livestock; environmental protection and change; soil science; and interdisciplinary research.**
- d Should BBSRC decide to continue with the proposed Committee restructuring it must ensure that all areas of the Agri-Food remit are found appropriate homes and/or alternative mechanisms of funding in the revised committee structure. In addition, each committee would need to draw on a specialist pool of expertise from the Agri-Food community to supplement the core expertise of the committee.**
- e It was felt that the Diet and Health, and Food Quality areas have been appropriately supported by the Agri-Food Committee, but that some areas of agriculture have been inadequately addressed. BBSRC needs to take account of the lack of support felt by members of the agricultural, and food science communities, and take steps to reverse this trend. To this end BBSRC should consult with the community in the restructuring process and use incentives to encourage applications in these areas.**

f Given the end-user orientation of much of the Agri-Food research, the panel felt that there is considerable scope for a more joined up strategy with other funders (e.g. FSA, MRC and Defra) than there is at present. This would facilitate interdisciplinary research and better end-user outcomes.

4. INTERACTION WITH INDUSTRY

48. The industrial Panel members felt that the level of interaction between Agri-Food Committee-supported PIs and industry is very good and that this is a reflection of the quality and availability of the schemes provided by BBSRC. BBSRC must ensure that it maintains industrial representation on its Panels and Committees. The LINK scheme, Industrial Interchange programme, and Industrial CASE awards were particularly commended. The Panel was concerned over possible disruptions to the very successful LINK scheme as a result of Committee restructuring.
49. It should be noted that it is increasingly difficult to promote academic interactions within the food and agricultural industries because of the shrinking UK food and agricultural sectors, and the increased cost of academic research resulting from the introduction of FEC. In particular IPAs are not particularly cost effective for industry, whereas fundamental studies to support basic technologies are important. As industry and academia often have very different timelines and strategies, BBSRC should continue to take care to ensure that industrial interaction schemes and programmes have the flexibility to meet these timelines and strategies.
50. BBSRC has a significant role to play in the training of scientific staff to supply research and non-research positions within industry, and as staff are often recruited as a result of student placements associated with Industrial CASE studentships, these should be continued and, where possible, extended.
51. Although there were a large number of industrial interactions reported by PIs these were often with a restricted number of companies. To reach a broader range of companies BBSRC should be more proactive in publicising its research, for example in short articles in user-focused journals/magazines. BBSRC may find it beneficial to seek feedback from industrial partners involved in existing schemes on how to encourage further interactions and to visit companies to promote the current schemes.

Key conclusion

- g Overall the Panel was pleased with the level of interaction between Agri-Food-supported research and industry. However, it felt that there was potential for more involvement in the future. To achieve this BBSRC may wish to publicise the research it supports more widely, for example in user-focused media, and seek feedback from current collaborators about the benefits of working with BBSRC-funded researchers and how to encourage further interactions.**

5. PUBLIC ENGAGEMENT

52. It is a condition of BBSRC funding that PIs (or a member of their group) spend one to two days per year on public engagement activities, and they are expected to give details of these activities in their final report. There was some evidence of very successful activities:
- one PI became a member of the Teacher-Scientist Network which involves scientists taking part in school science classes
 - field work led to contact with many farmers, several of whom have taken considerable interest in the work, and have become more aware of BBSRC-funded work pertinent to agriculture and the environment. A website is being developed to encourage these links. Farmers will also be provided with relevant data on their soils on request
 - presentation on 'Bubbles in Food' at Café Scientifique, Manchester Museum
 - results from one project have been used in presentations to farmers and the general public, including an Open Weekend at Rothamsted Research in September 2006 which was attended by approximately 10,000 people, including around 800 school children
 - advertised and ran The National Bumblebee Survey (2004), in conjunction with the Royal Entomological Society and BBC Wildlife magazine, in which over 700 volunteers participated
 - presentation about the role of carbohydrates on behaviour at a conference entitled 'Food on the Brain' organised by Barnardos, Scotland, in October 2006.
53. Despite some successes, the Panel noted that public engagement activities were not universally undertaken. As the Agri-Food remit covers areas where public interest is known to be high, in areas such as genetic modification, BSE, and Foot and Mouth Disease, it was disappointing that this intrinsic interest had been poorly exploited.
54. Public engagement activities can be expensive and time consuming and the Panel felt that it may be beneficial for applicants to set out and cost these activities at the application stage. Moreover, host institutions, rather than individual PIs, are better placed to organise such events, and BBSRC might consider working further with leading biosciences departments or parent institutions to develop public engagement activities.
55. The nature of scientific discoveries means that there is often more than one funder contributing to a specific breakthrough. For this reason it might be worthwhile for BBSRC to collaborate with other funders in public engagement activities. The Panel felt that RELU have made good progress with Public Engagement activities.

Key Conclusion

- h The science covered by the Agri-Food Committee remit is of high public interest and much of it is comparatively accessible to the lay person. However, the time and financial costs associated with public engagement activities often conflict with the research priorities of the PI. For this reason BBSRC should investigate institutionally-led and/or cross-funding body organisational support for these activities, and the possibility of declaring costs and allocating this money, from the outset as part of FEC calculations.**

6. ULTIMATE IMPACTS

Introduction

56. Ultimate impacts are those that relate to the overall objectives of BBSRC as an organisation, and would generally be expected to arise in the longer-term. The following 'ultimate' impacts (relating to the objectives expressed in BBSRC 10-year vision) that should arise from BBSRC support for agricultural, and food sciences research through responsive mode funding have been identified:
- research findings are used for the 'public good', e.g. diet and health research, food safety, government policy
 - income to the research community and to 'UK plc', e.g. from new technologies, intellectual property
 - the UK maintaining and, in some areas, restoring its international standing in agricultural, and food sciences research
 - BBSRC maintaining its role as a key funder of agricultural, and food sciences research in the UK
 - public confidence in UK agricultural, and food sciences research is maintained.
57. The Panel recognised that these impacts are clearly difficult to measure, and even more difficult to attribute. However, it is particularly important that they are evaluated because they relate to the overall objectives of the organisation; they help to answer the question: 'how effectively is BBSRC doing its job?' The Panel identified some potential impacts and felt that identification of impacts will be easier in the future should BBSRC take action on Key Conclusion i (page 27) as, without detailed information, BBSRC was likely to underestimate its impacts.
58. Income to the research community and UK plc, and the international standing of the UK in agricultural and food sciences research (as measured by the quality of UK research in this area) are discussed in Chapters 4 and 2, respectively.

Research findings used for the public good

59. A number of the sample PIs with completed grants identified direct contributions to the public good that the research supported by the grant had made (or could potentially make). Examples are shown below:
- a bioethical analysis tool was used to assess the opinions of stakeholders on bovine somatotrophin injections and automated milking systems. It also provided further evidence of the validity of the methodology (the Ethical Matrix) to clarify issues surrounding biotechnologies and encourage constructive dialogue.
 - advances in the understanding of bovine lameness to facilitate animal welfare and increase productivity
 - with subsequent funding of related research, work on plant derived lectins has resulted in a potential new treatment for inflammatory bowel disease
 - improved use of nitrogen fertilisers applied by farmers, coupled with decreased leaching of nitrate resulting in greater crop yields and quality of food
 - established the level of atmospheric pollutants which compromise the welfare of poultry
 - provided a fuller understanding of the factors affecting welfare of fowl housed in extensive systems
 - improvement in understanding the thrifty genotype and potential causes of obesity in children
 - improved understanding of neurochemical controls of appetite, supporting new pharmaceutical approaches to appetite/body weight disorders
 - identification of a plant derived transferase gene could lead to enhanced food texture and nutrition

- new insights into controlling phenolic deposition in cell walls and chemical determinants of cell wall digestion in animal feed, and potential for use in bioethanol production
- new understanding of which dietary lipids may be associated with arthritis
- work on the role of serotonin receptors on appetite and satiety was used to address a Select Committee of the House of Lords on Animal Experimentation
- contributions to policy on farming methods best suited to reducing the impact of UK agriculture on the environment, particularly with respect to greenhouse gas emission.

60. The contributions to the 3Rs, discussed in Chapter 2 (paragraph 32), are also relevant here, helping the UK research community to move towards using fewer animals in invasive research, in line with government policy.

The role of BBSRC as a key funder of agricultural, and food sciences research

61. BBSRC is a key funder of agricultural, and food sciences research in the UK and, in some areas, it is the sole source of funding. The work completed as a result of BBSRC funding often underpins the more applied research commissioned by other funding bodies such as Defra, FSA and SEERAD. However, over the past five years, the number of applications to the Agri-Food Committee has remained reasonably constant, whilst the number of applications to BBSRC overall has increased. While acknowledging the good support for research in diet and health, the Panel questioned whether BBSRC was providing sufficient support for agricultural research, particularly in relation to livestock. This might reflect a lack of communication between BBSRC and the community with respect to the funding available and should be addressed during the committee restructuring.

Public confidence in UK agricultural, and food sciences research

62. The public can draw confidence from the fact that Agri-Food Committee-supported research is peer reviewed and funded only when judged to be of sufficiently high quality although, as discussed in Chapter 2, the Panel had some concerns that a few weak applications were funded.
63. Public engagement can increase public confidence in agricultural, and food sciences research and, as discussed in Chapter 5, almost half of PIs reported completing this type of activity. BBSRC and research institutions should continue to encourage public engagement and take a greater role in its facilitation.

7. GENERIC ISSUES

64. A number of points relating to BBSRC administration and grants processing were raised by the Panel, and in questionnaire responses. These will be considered internally with information provided from other Committee portfolio evaluations. The main points are summarised here.
65. The Agri-Food Committee members considered the quality of referees' comments to be generally high. However, both the Committee members and PIs stated that variations from this high standard occur. The Panel felt BBSRC should be more robust about the quality and quantity of referees' comments that are included in the funding decision.
66. To increase the number, and maintain the quality of referees' comments PIs suggested a reward system, or making refereeing a condition of current funding. PIs who had been referees felt that although peer reviewing was an important process, the low success rate of applications (25%) meant they spent a lot of time providing comments to applications which were not funded. The Panel felt that referees should be provided with information about the outcome of the application including the score given by the Committee and its ranking in comparison to all applications assessed by that Committee in that round.
67. As discussed in Chapter 2, the Panel felt strongly that career instability, and the resulting staffing difficulties, is having a detrimental and concerning effect on the quality of science produced from Agri-Food Committee responsive mode grants. The Panel agreed that the standard three year, one RA grant may not always be appropriate, especially in cases of seasonal work, and that long term support for technical staff is also an issue.
68. Skills shortages could be a reflection of the lack of career structure and stability within the academic community. Increasing the length of responsive mode grants from three years would increase stability, decrease the number of applications, and decrease the administrative workload for PIs and BBSRC executive. However, it is important to emphasise that all grants should be fit for purpose and therefore flexibility to apply for the length and size of grant required to complete the work should be encouraged.
69. Linking doctoral studentships to longer grants would enable these students to complete some RA work to supplement their stipend. In addition, students would have increased expertise and experience, and be better suited to take up postdoctoral positions.
70. A significant increase in the length and/or size of grants is likely to result in fewer being funded and hence potential difficulties for young researchers to secure a grant. Accordingly, the Panel felt that it is important that BBSRC continues to support its New Investigator scheme⁵ and allow these PIs to apply for shorter and/or smaller grants if necessary. Allowing RAs to be named as a Co-Investigator (Co-I) would provide them with greater incentive and ownership of a grant. It would also provide a valuable educational experience and a stepping stone between RA and PI. In addition, it may assist with career progression when cited on a C.V. Although the 'named researcher' option does address this to some extent, this status falls short of 'ownership' and may not reflect the individual's contribution to the work or provide an adequate incentive to see a project to completion. Further incentives are also necessary to retain talented, young RAs, for example increasing the number of fellowships available.
71. The Panel identified a large variation in the quality of final reports and this should be addressed by BBSRC in order to ensure fairness during evaluation of grants.

⁵ For further information on this scheme see: http://www.bbsrc.ac.uk/funding/research/grants_booklet.pdf

Collecting output data three months after the grant finished is not sufficient, and in questionnaire responses, over-reporting of publications occurred resulting in difficulty identifying outputs from each grant. An annual return procedure for PIs to report all outputs, including publications, to BBSRC for three years after completion of the grant, could alleviate this problem. In addition, the Panel suggested that reporting outputs from previous BBSRC awards should be mandatory for future applications.

72. The Committee should have the authority to return final reports that have not been completed to a sufficient standard, and mechanisms should be put in place to ensure the quality of final reports, such as withholding a proportion of the grant or attributing a proportion of the final report grade to the quality of the final report. Revising the final report template to ask specifically for the information required would be beneficial. The Panel agreed that combining these changes will reinforce to PIs the importance of the final report in the evaluation of BBSRC spending.

Key Conclusions

- i. BBSRC should develop an annual return procedure for research outputs, including publications, where PIs are required to document outputs arising from grants for three years after completion. This ought to be a condition of further BBSRC funding and be incorporated into the current review of final reporting procedures.**
- j. BBSRC needs to address the issues of research career structure and stability. This might be helped by encouraging PIs to apply specifically for the length and size of grant the work requires, by allowing research assistants to be named as co-investigators, and by attaching doctoral studentships to 5 year grants.**

8. CONCLUSIONS

73. Over the past ten years the Agri-Food Committee has supported good quality, basic, underpinning research which has the potential to be applicable to end users. This is a strength of the current structure and is the basis for interaction with other funders.
74. The Panel felt that where there were areas of weakness in the portfolio these arose because BBSRC had failed to exploit its position fully. For example, although the Agri-Food Committee had some communication with other funders, much greater value could be produced from further interactions such as in strategic planning. In the same way BBSRC should endeavour to exploit contacts with end users and to encourage greater public engagement.
75. The level of interaction between industry and Agri-Food-supported researchers is very high. BBSRC may wish to build on this by promoting its schemes and programmes to a wider range of companies in the future.
76. The number of interdisciplinary and multidisciplinary studies was limited in the sample examined in this evaluation. The Panel felt that BBSRC should continue to promote these and suggested that BBSRC not only focuses on science areas (biology, chemistry, physics and mathematics), but also includes economics, social sciences and psychology. It would also be very beneficial for BBSRC to promote projects linking all disciplines of biology from the molecular level to the field. The remit covered by the Agri-Food Committee is ideally situated to multi- and inter- disciplinary studies and BBSRC must continue to facilitate this type of work.
77. The Panel felt strongly that it would be more beneficial to the science within this remit for the Committee to be maintained. It is important that the strengths of the Agri-Food Committee are supported and that the weaknesses are addressed. The Panel felt that by discontinuing the Committee there is a danger that the strengths may be lost, and that negative perceptions of BBSRC support for these areas may be re-enforced.