

**HOUSE OF LORDS SCIENCE AND TECHNOLOGY SELECT COMMITTEE
INQUIRY**

Nanotechnologies and Food

SUBMISSION FROM RESEARCH COUNCILS UK

SUMMARY

Nanotechnologies offer a broad range of potential applications in the food sector. For example:

- Food production and agricultural processes may be improved through the use of nanotechnologies in the applications of pesticides, or in crop monitoring.
- Use of nanotechnologies in both packaging and edible film coatings for food products may help to extend product shelf life by reducing exposure to moisture or gases.
- Nanoencapsulation technologies for improved delivery of food functional ingredients and manipulation of dietary nanoparticles to optimise absorption of nutrients offer benefits to human health.

The Research Councils fund relatively little research relating directly to the applications of nanotechnologies in the food sector, but support a much wider portfolio of nanotechnology research which underpins a variety of potential application areas, including applications relating to food, in areas such as nanotoxicology, nanometrology, characterisation and detection, nanotechnology-based sensor devices, food manufacturing and processing, and food structure.

While the use of nanotechnologies and nanomaterials in the food sector offers the prospect of significant benefits, there are uncertainties about the potential risks of nanoparticles to human health (as well as potential environmental impacts, though these are outside the scope of this inquiry). More evidence is required to inform policy and regulation.

Regulatory considerations, economic viability and consumer acceptance will ultimately dictate the success of nanoproducts and nanotechnologies in the food sector. It is therefore important that clear regulatory and risk assessment frameworks are established as soon as possible, and that public engagement activities are initiated at an early stage and are continued as the technologies and applications develop.

INTRODUCTION

1. Research Councils UK¹ (RCUK) is a strategic partnership set up to enable the seven UK Research Councils to work together more effectively and enhance the overall impact and effectiveness of their research, training, innovation and public engagement activities.
2. The Research Councils welcome the opportunity to respond to this Inquiry. This evidence is submitted by RCUK on behalf of the following Councils:
 - Arts and Humanities Research Council (AHRC)
 - Biotechnology and Biological Sciences Research Council (BBSRC)

¹ Further details are available at www.rcuk.ac.uk

Economic and Social Research Council (ESRC)
 Engineering and Physical Sciences Research Council (EPSRC)
 Medical Research Council (MRC)

3. It represents their independent views, and does not include or necessarily reflect the views of the Department for Innovation, Universities and Skills (the sponsoring Government department for the Research Councils).
4. This response focuses mainly on research, training and public engagement, in keeping with the Research Councils' missions and roles. [Annex 1](#) provides summary information about relevant cross-Council research programmes, and [Annex 2](#) sets out some definitions.
5. The field of nanotechnology is one in which the UK has considerable investment and an increasing potential for exploitation in industrial applications to the benefit of the UK economy and society. All Research Councils have activities associated with this broad area of research. Examples of Research Council activities are highlighted throughout this response.
6. All of the Research Councils, with the exception of AHRC, are members of the cross-agency Nanotechnology Research Co-ordination Group (NRCG) and the Nanotechnology Issues Dialogue Group (NIDG). The RCUK Nanotechnology Group, which has representatives from all Councils and the Technology Strategy Board, co-ordinates Research Council activities in the area of nanotechnology, including Research Council inputs to NRCG and NIDG. All of the Research Councils and the Technology Strategy Board are partners in the EPSRC-led programme *Nanoscience through Engineering to Application*².

STATE OF THE SCIENCE AND ITS CURRENT USE IN THE FOOD SECTOR

What are the main potential applications and benefits of nanotechnologies and nanomaterials in the food sector, either in products or in the food production process?

7. An overview of potential applications of nanotechnology in agriculture and food is available on the Nanowerk internet portal at:
<http://www.nanowerk.com/spotlight/spotid=1846.php>

Food production and agriculture

8. Nanotechnologies will play an important role in the food supply chain from 'farm to fork', where improvements in food quality, efficiency of processing and supply, and reduced losses of food bring major benefits, including in terms of increased choice, higher quality and lower costs for consumers. Nanotechnology promises new products and approaches to assist crop protection. For example, smart sensors and delivery systems may help combat viruses and other crop pathogens through early detection of disease, and monitoring of soil conditions to improve application of water, fertilisers and pesticides. In addition, new products may help plants' ability to absorb nutrients.

² <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Nano/Intro.htm>

Food safety and quality

9. The application of nanotechnologies and nanomaterials in food packaging may contribute to increased food safety, e.g. nanoprinting for product authentication and identification, or nanoscale *in situ* sensors for food quality monitoring.
10. Nanotechnologies used in both packaging and edible film coatings for food products may help to extend product shelf life by reducing exposure to moisture or gases. For example, the MRC funds work into the development of nanoparticulate surfaces that inhibit bacterial biofilm formation, with potential applications to food storage. Increased shelf life for foods subject to rapid spoilage such as fruit and vegetables not only impacts on food quality, but could also contribute to reducing household waste, and so food demand. In the UK, roughly a third of the food bought by consumers is thrown away.³
11. Nanotechnologies may also be used to improve the textural properties of food, or to enhance flavours.

Health

12. Food based nanotechnologies have the potential to improve health. The range of potential benefits is large, and likely to be underestimated.
13. Absorption of nutrients may be optimised by manipulating the properties of nanoparticles in the diet. For example, current fortification and supplemental forms of iron are poorly absorbed and potentially toxic in the circulation and/or gastrointestinal tract. Scientists at MRC Human Nutrition Research (HNR), Cambridge, are exploiting nanoparticle technology to synthesise novel ferric iron structures that mimic natural food iron, allowing optimal bioavailability. These are currently being tested in human volunteers, and may lead to better treatment of iron-deficiency anaemia. This nanotechnology is also being used to control levels of other key molecules, including through sequestration to reduce harmful accumulation in disease. Further evidence on this work will be given orally to the Select Committee by MRC scientists, although further written details can be provided on request.
14. Improved delivery of food functional ingredients (e.g. vitamins, antimicrobials, flavourings, colourings, preservatives) through use of nanoscale carriers is another potential application. Nanoscale delivery systems for micronutrients (essential for human growth and development e.g. vitamins and minerals), and nutraceuticals (non essential but confer health benefits and contribute to prevention of some diseases) are intended to maximise delivery to, and release at, the desired site of action. Nanoencapsulation of functional ingredients such as preservatives and flavourings may improve functionality whilst minimising concentration by protecting against degradation and allowing controlled release.
15. Nanoparticles may be used to protect people with food allergies by blocking the surface structures which trigger the response.
16. Nanotechnologies and nanomaterials may be used to make food healthier (e.g. by increasing the nutrient content, inclusion of antioxidants) without adversely affecting the taste.

³ WRAP, The food we waste, http://www.wrap.org.uk/retail/food_waste/research/the_food_we_waste.html

17. Nanotechnology also has the potential to improve food processes that use enzymes to confer nutrition and health benefits. For example, enzymes are often added to food to hydrolyze anti-nutritive components and hence increase the bio-availability of essential nutrients such as minerals and vitamins. To make these enzymes highly active, longlived and cost-effective, nanomaterials can be used to provide superior enzyme-support systems due to their large surface-to-volume ratios compared to traditional macroscale support materials⁴.
18. The MRC funds a range of nanotechnology-based projects with therapeutic potential, although these are mainly outside the scope of the present inquiry.

What is the current state of the market for, and the use of, food products and food production processes involving nanotechnologies or nanomaterials, either abroad or in the UK?

Food products

19. Publically available information on the use of nanomaterials in food products is limited. The Woodrow Wilson International Centre for Scholars (The Wilson Centre) has established an online inventory of consumer products using nanotechnology⁵, identified by the manufacturers. As of August 2008, this inventory indicated that of 803 products or product lines using nanotechnologies, 80 products were in the food and beverage category, none of which were produced by UK based companies. Of these 80 products, just three involved use of nanoscale materials as ingredients in food products. However, this inventory relies on information provided by companies about the scientific characterisation of their materials, and is therefore unlikely to present an accurate reflection of the current state of the market.

Food production processes including packaging

20. As part of the food supply chain, nanotechnology has already delivered improvements to pesticide delivery through encapsulation and controlled release methods. Capsules can be inert until contact with leaves or insect digestive tracts, at which point they release the pesticide.⁶ In combination with the use of nanoemulsions (suspension of nanoparticles), pesticides can be applied more easily and safely.
21. Nanotechnology is used in packaging to improve the shelf life of foods, for example by the inclusion of silicate nanoparticles that prevent oxidation and spoilage.

⁴ <http://www.nanowerk.com/spotlight/spotid=1846.php>

⁵ <http://www.nanotechproject.org/inventories/consumer/>

⁶ <http://www.syngentaprofessionalproducts.com/to/prod/primof/>

What might the ‘next-generation’ of nanotechnologies and nanomaterials look like? How might they be applied in the food sector, and when might they enter the market?

22. Nanotechnologies and nanomaterials which will have particular relevance in the food sector⁷ include:
- a) Nanoscale encapsulation technologies, such as nanoemulsions (suspensions of nanoparticles) and biopolymeric nanoparticles (nanometer sized particles derived from food grade biopolymers such as proteins or polysaccharides), which can be used to encapsulate, deliver and release food functional ingredients. These nanomaterials offer better release efficiency, improved protection from degradation, and controlled delivery systems for functional ingredients, compared with traditional encapsulation technologies. The use of nanomaterials in food to sequester, and then enable the excretion of, unwanted materials from the body is also being explored by MRC scientists.
 - b) Food-grade nanoscale coatings (comprising two or more layers of material with nanometer dimensions) which can be used in the production of edible films for foods such as fruits, vegetables, meats and chocolate. These edible films protect foods from (spoilage caused by) exposure to moisture, lipids and gases, and can also be used to improve the textural properties of food, or serve as carriers of colourings, flavourings, antioxidants, nutrients and antimicrobials. Nanoparticulate surfaces may also be used directly to inhibit bacterial growth.
 - c) Nanofibres and nanotubes derived from food biopolymers may have applications in the food industry as elements of environmental friendly food packaging, as scaffolding for bacterial cultures or to provide support systems for enzymes
 - d) Sensor devices which use nanotechnology (e.g. lab-on-a-chip, cantilever devices) might be used to monitor foods either for impurities/contaminants or for spoilage.

What is the current state of research and development in the UK regarding nanotechnologies and nanomaterials which have or may have an application within the food sector? How does it compare to research and development in other countries?

23. The Research Councils support a broad range of activities relating to nanotechnology, which includes support for research which has or may have applications in the food sector. Some indicative figures on recent Research Council investment in the area are provided in paragraphs 24–35 below.
24. The MRC spent £3.8M on research into nanotechnology (including nanotoxicology) in 2007/08. The MRC has a current commitment of £900k for two grants which have/may have an application within the food sector. The MRC is also supporting a programme in one of its units with relevance to the area, with a spend of £840k in 2007/08.
25. The MRC’s mission is to improve human health through world-class medical research. Within this remit, research into both the health benefits and potential

⁷ <http://members.ift.org/NR/rdonlyres/FA9DE19E-1AFF-4B94-9012-CDAC3C45B0FF/0/Nanotech.pdf>

health risks of nanotechnology is supported. Research in this area is funded in responsive-mode and as part of the MRC's intramural programme. As the potential therapeutic uses of nanotechnology in food begin to be realised, the MRC expects to receive increasing applications from the scientific community in this area. In particular, nanotoxicology has been identified as a topic for one of 5 MRC "highlight notices", encouraging applications in nanotoxicology relevant to human health. The highlight notice has recently been refined, particularly to promote applications involving an *in vivo* component. The aim of this highlight notice is to help inform policy development in this important area.

26. EPSRC leads the cross-Research Council Programme on '*Nanoscience through Engineering to Application*⁸', which supports investigator-led research and training as well as infrastructure/equipment to ensure the best use of resources. The programme has also identified a series of 'grand challenges' in nanoscience and nanoengineering, focused on the areas of energy, healthcare and the environment, spanning basic research through to application. All of the Research Councils and the Technology Strategy Board are involved in the programme.
27. In total EPSRC has committed over £220M to nanotechnology research in the last five years. None of this is directly related to food research although a significant amount supports underpinning research in areas such as nanometrology, characterisation and detection that might lead to new measurement or processing techniques that would be of relevance to the sector.
28. BBSRC has an extensive portfolio of food research (covering the entire food supply chain, from agricultural processes to dietary impacts), with an estimated spend of £185M in 2007/08. BBSRC also has an active nanotechnology portfolio (based on a specific definition of nanotechnology, set out at [Annex 2](#)), with an estimated spend of £6.1M in 2007/08. The total BBSRC spending in 2007/08 on research relating to nanotechnology (as defined above) and food was £0.7M. Other grants in the BBSRC nanotechnology portfolio might also have downstream applicability to the food sector.
29. Some of the underpinning technologies developed in areas related to nanotechnology, such as drug delivery, materials and sensors, could also potentially be applied to the food sector. Using a broader definition of nanotechnology (encompassing related areas of drug delivery, materials, sensors, tissue engineering and tools), the total BBSRC estimated spend in 2007/08 on research relating to nanotechnology and food was £4.5M.
30. Many conventional food materials contain structures at the nanoscale. BBSRC supports research on food structure and processing within a broad category of 'food manufacturing'. BBSRC's estimated 2007/08 spend on food manufacturing research (a subset of the food research portfolio) was £5.3M, a significant proportion of which was awarded as Core Strategic Grant funding to the Institute of Food Research. The Institute of Food Research will be providing independent evidence to this inquiry.
31. ESRC has funded research on more cross-cutting issues which relate to food. Research questions include: what are the key drivers of public and scientist perceptions of risks and opportunities of nanotechnologies in this application?;

⁸ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Nano/default.htm>

what is the likely impact on industry and economies, including from the convergence of nano with other technologies?; how will the global development of science and innovation and their multi level regulation-affect these technologies?; how, when and why will public engagement and social influences affect development of these technologies?

32. The ESRC has also carried out an authoritative review of the social, ethical and economic aspects of development of nanosciences and nanotechnologies. The reports, published in 2003⁹ and a follow-up in 2007¹⁰, explain what nanotechnology is as well as its existing and potential consequences, and identify important issues for research and society.
33. In January 2009 a workshop on 'Nano: Regulation and Innovation: The role of the Social Sciences and Humanities', facilitated by a UK academic and supported by the Research Councils was held at the RCUK Beijing Office. The workshop, jointly presented by both UK and Chinese academics, covered aspects of ethical challenges, and governance and regulation.
34. Cross-Research Councils programme and activities relating to nanotechnology are outlined at [Annex 1](#).
35. Details of Research Council Units, Centres and sponsored Institutes that conduct research relevant to this inquiry are at [Annex 3](#).

What are the barriers to the development of new nano-products or processes in the food sector?

36. Regulatory considerations, economic viability and consumer acceptance will ultimately dictate the success of nanoproducts and nanotechnologies in the food sector.
37. Continued uncertainty over EU/UK regulations for the use of nanotechnologies and nanomaterials in the food sector may stifle research and development in the area. A clear regulatory and risk assessment framework would serve to increase (public) confidence in technologies, and stimulate investment in food-related nanotechnology research.
38. Development of new nanoproducts or processes must be coupled to appropriate research into, and risk assessments of, the potential effects of those technologies. Adequate funding for research into the environmental and health and safety implications of nanotechnologies will be essential to their application and acceptance in the food sector.
39. Further underpinning research to develop understanding in areas such as molecular self-assembly, surface engineering and techniques such as electrospinning, will be vital for reliable production of nanoscale structures. Further research is also needed on measurement and characterisations systems so that they can be deployed on a widespread basis.
40. There are limited funding opportunities targeted directly at nanotechnology applications in the food sector, compared with competing application areas

⁹ http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/Images/Nanotechnology_tcm6-5506.pdf

¹⁰ http://www.esrcsocietytoday.ac.uk/ESRCInfoCentre/Images/ESRC_Nano07_tcm6-18918.pdf

(e.g. healthcare, energy). In the current economic climate, where industrial/commercial sector funding for research may also be limited, there is a risk that the development of new nanoproducts or nanoproducts related to food will be restricted.

HEALTH AND SAFETY

What is the current state of scientific knowledge about the risks posed to consumers by the use of nanotechnologies and nanomaterials in the food sector? In which areas does our understanding need to be developed?

41. Nanotechnologies have the potential to cause harm as well as benefit, but their toxicology and toxicokinetic properties are not well understood. The same unique properties that confer many of their benefits may also cause damage to the body in unexpected ways. The MRC has made awards at a total level of £3M for research projects in the area of nanotoxicology. This research aims to better understand the uptake of nanoparticles into cells and the functional consequences including oxidative stress, inflammatory response, cell death and genotoxicity. By linking this information to the physical and chemical characteristics of nanoparticles, predictive models for nanoparticle toxicity can be developed that will help risk assessment. A lot of this work is currently focused on the lung and, although some of the principles may be transferable to other organ systems, more evidence is needed to inform policy and regulation.
42. The MRC has a current commitment of £900k (see para 26 above) for two grants relevant to the health and safety implications of the use of nanotechnologies in relation to food.
43. ESRC's remit covers research into the health and safety implications of nanotechnologies and nanomaterials in the food sector, however currently there are no projects being funded directly related to this area.
44. EPSRC funds potentially relevant research in the area of developing new methods of measurement and characterisation.
45. The Research Councils also support research into the environmental impacts of nanomaterials and the potential effects of environmental exposure on human health, for example through the Environmental Nanoscience initiative and the Environment and Human Health initiative, both led by the Natural Environment Research Council (NERC). However, this is largely outside the scope of the present inquiry.

Is research funding into the health and safety implications of nanotechnologies and nanomaterials in the food sector sufficient? Are current funding mechanisms fit for purpose?

46. The Research Councils have a variety of funding mechanisms through which research into the health and safety implications of nanotechnologies and nanomaterials can be supported:
 - Responsive mode – applications are accepted at any time and in any research areas which fall within the Council's remit. Highlight notices,

signposting or identification of priority areas may be used to encourage submission of applications in particular areas.

- Research programmes at Research Council Units, Centres and sponsored Institutes (see [Annex 3](#))
- Nanotechnology grand challenges¹¹ - the primary delivery mechanism for the cross-Council programme *'Nanoscience through Engineering to Application'*, each Grand Challenge works through a stage gate process, starting with the basic science but looking to the issues of scale up, including reliability, reproducibility and safety considerations. The two Nanotechnology Grand Challenges established so far do not relate directly to food sector applications, though safety issues identified in other application areas (e.g. healthcare/nanomedicines) may be of relevance.

47. The current Research Council funding portfolio for research relating to the health and safety implications of nanotechnologies and nanomaterials in the food sector is relatively small (see paragraphs 41 - 45 above). It is likely that further research will be needed to inform policy and regulation, and the Research Councils will continue to welcome applications for research in this area through the mechanisms described in paragraph 46 above.

Can current risk assessment frameworks within the food sector adequately assess the risks of exposure to nanotechnologies and nanomaterials for consumers? If not, what amendments are necessary?

48. The draft scientific opinion published by the European Food Safety Authority¹², highlights current uncertainties for risk assessment of nanotechnologies (specifically engineered nanoparticles - ENMs) and their possible applications in the food sector. The reports states that: *"Current toxicity testing approaches used for conventional materials are a suitable starting point for case-by-case risk assessment of ENMs. However, the adequacy of currently existing toxicological tests to detect all aspects of potential toxicity of ENM has yet to be established"*, and recommends that *"risk assessment of ENM in the food and feed area should consider the specific properties of ENM in addition to those common to the equivalent non-nano form"*. The report recognises that formulation at the nanoscale changes the physico-chemical characteristics of materials as compared to the dissolved and macroscale forms of the same substance, and that properties such as particle size, surface-to-mass ratio and surface reactivity will be important for new applications, and in establishing the associated potential health and environmental risks.

Are the risks associated with the presence of naturally occurring nanomaterials in food products any different to those relating to manufactured nanomaterials? Should both types of nanomaterials be treated the same for regulatory purposes?

49. Many foods naturally contain nanoscale materials; these are not considered to require additional regulation. For manufactured nanomaterials, even when

¹¹ <http://www.epsrc.ac.uk/ResearchFunding/Programmes/Nano/RC/grandchallengesnanotech.htm>

¹² European Food Safety Agency, *Draft opinion of the Scientific Committees on the Potential Risks Arising from Nanoscience and Nanotechnologies on Food and Feed Safety*, (October 2008) http://www.efsa.europa.eu/cs/BlobServer/DocumentSet/sc_opinion_nano_public_consultation.pdf?ssbin_ary=true

derived from naturally-occurring nanomaterials, appropriate assessments of risk and safety should be made. In many cases, there is no prior reason to expect that manufactured nanoparticles would be any more hazardous than naturally-occurring ones. Regulations should then be risk-based and proportionate.

REGULATORY FRAMEWORK

Is the regulatory framework for nanotechnologies and nanomaterials fit for purpose? How well are imported food products containing nanotechnologies and nanomaterials regulated?

50. There are currently no internationally accepted definitions of 'nanotechnologies' or 'nanomaterials', leading to problems both for industry and regulatory bodies in terms of labelling protocols, risk management strategies and methods for regulatory data capture.
51. Regulations should ideally cover the entirety of the process – from basic idea to product development and commercialisation – in a consistent manner. International mutual recognition of standards should be a parallel consideration.

How effective is voluntary self-regulation either in the UK or EU or at an international level? What is the take up by companies working in the food sector?

52. The UK Voluntary Reporting Scheme for engineered nanoscale materials, co-ordinated by Defra, was set up for industry and research organisations to provide Government with information relevant to understanding the potential risks posed by free engineered nanoscale materials, though this was not specific to the food sector.
53. It may be beneficial to compare the UK's experience of voluntary reporting with the impacts of new regulations elsewhere in the world, e.g. Canada's proposed mandatory reporting requirement for nanoscale materials.
54. Use of voluntary regulatory codes in other areas has often been directed more at public relations than at standard setting. As such voluntary codes cannot be considered as adequate replacements for effective regulation.

Will current regulations be able adequately to control the next generation of nanotechnologies and nanomaterials?

55. Regulatory and risk assessment frameworks should be informed by research into the environmental and health and safety impacts of nanotechnologies and nanomaterials in the food sector. Regulations should be reviewed regularly to ensure they remain fit-for-purpose as new technologies and materials are developed.

**Is there any inter-governmental co-operation on regulations and standards?
What lessons can be learned from regulatory systems in other countries?**

56. Intergovernmental co-operation should address the responsibility in research, and the need to share knowledge of potential or emerging hazards between stakeholders in a reasonably open way.
57. Depending on the definition of 'standards', ISO (International Standards Organisation) TC229 (Technical Committee) is defining basic standards such as 'nanotechnology'; the UK is well connected with this and chairs the Committee (Defra leads in this activity) There is also a significant OECD activity in this area, where the UK is playing a significant role (Defra leads in his activity), though this may be outside the scope of 'food'.

PUBLIC ENGAGEMENT AND CONSUMER INFORMATION

What is the current level of public awareness of nanotechnologies, and the issues surrounding the use of nanotechnologies and nanomaterials in the food sector? What is the public perception of the use of such technologies and materials?

58. An initial point to note with reference to public awareness of nanotechnologies is that although terms such as nanomaterial or nanotechnology have specific meanings to scientists, their definitions are blurred in popular language. This is indicative of the limits of the information available with which to engage the public. There is little information about how commercial and public developers intend to use nanotechnology, few if any commercially available products and no specific formal risk assessment and regulatory processes are in place.
59. Further, it should be noted that the debate around nanotechnology and food is likely to be a 'lightning rod' for a range of other issues which will require careful handling, for example corporate control, use of patents, relationship between government regulatory procedures and industry, and in particular the precautionary principle and the safety of nanoparticles. This poses a risk that any possible issues specific to nanotechnology and food become lost in wider debate. Framing of the engagement to avoid or minimise this is therefore required, though it is also important to maintain an awareness of public engagement activities undertaken in related areas (e.g. nanomedicines), where comparable issues may be raised.
60. The industrial, scientific and regulatory community should not take public acceptance for granted, especially whilst potential safety risks are being openly acknowledged. Despite a deficit of 'hard facts', the public could and should be involved, even at an early stage, in identifying key concerns and laying down benchmarks so that systems are in place to deal with issues as they arise when more evidence emerges. The Research Councils have been involved in several public engagement activities (see paragraph 63 below).
61. In depth focus groups (conducted for the ESRC SCARR network by Cardiff University School of Journalism, Media and Cultural studies) found the following:
 - few people who participated in the research knew anything at all about nanotechnology.

- if people 'know' anything about nanotechnology they tend to associate it with medical treatments (e.g. mini robots healing sick people) or minaturisation serving consumer convenience (e.g. 'Ipod Nano' brand)
- the current association of nanotechnolgy with medical science or consumer-sensive business gives it a different - more positive - profile than GM crops (GM was most associated with food and industry-out-for-profit).

How effective have the Government, industry and other stakeholders been in engaging and informing the public on these issues? How can the public best be engaged in future?

62. All of the Research Councils are committed to public dialogue and engagement around the research they fund, and recognise the need to be as open and transparent as possible about the publically-funded research they support. Details of funded research grants, including any industrial or other commercial co-funding, are published on the relevant Research Council website.
63. The Research Councils have been involved in several public engagement activities used to examine public perceptions of nanotechnology (see [Annex 4](#)), though these have not related specifically to the use of nanotechnologies in the food sector, where public acceptance will be critical.
64. Initially, small scale deliberative dialogues may be an appropriate way to engage the public about nanotech applications in the food sector. This would help to scope a wider public engagement, and could follow a format similar to, and build on, those that have already taken place around other aspects of nanotechnology. This would enable an understanding of likely public attitudes including nanotechnologies specifically associated with foods, and reactions to some specific actual or possible applications. This will inform as to how the technology and its potential might be discussed most constructively both to raise public awareness and engender public participation in shaping research and policy development, and regulation (including labelling).
65. Public engagement should be independently co-ordinated (e.g. not by Government or industry) and overseen by a panel representing a wide range of stakeholder opinion.
66. It is important to ensure that industry are involved in public dialogue surrounding new technologies from an early stage, to build trust between public authorities, industry and NGOs.

What lessons can be learned from public engagement activities that have taken place during the development of other new technologies?

67. The timing of public engagement is important. In the past, engagement activities have been most successful (e.g. stem cells) where they have been pre-emptive of significant breakthroughs in the development of new technologies, but where the underlying principles are widely available and disseminated. This has allowed the public to help influence the direction that the technology takes and to ensure that it is regulated to a level that they feel comfortable with. The Royal Society/Royal Academy of Engineering report

*'Nanoscience and Nanotechnologies: Opportunities and Uncertainties'*¹³ (2004) strongly recommended 'upstream' public engagement.

68. Limited current awareness of nanotechnology and its breadth as a subject and range of potential applications in food, will be challenges in public dialogue. Whilst the public will have many, probing questions which they will rightly expect answers to, the information may simply not be available to answer those questions. Engagement activities should handle this uncertainty openly and positively, so that it does not trigger negative attitudes towards nanotechnology even before the benefits of the technology are apparent.
69. Applications in food, as opposed say to medical uses, are likely to raise concerns about ownership, consumer choice, and adulteration of natural processes, as seen in the GM debate.
70. Organisations such as AHRC/SCRIPT and Innogen have long-standing experience in related fields (e.g. biotechnology, GM food etc) on which it would be prudent to draw.

Should consumers be provided with information on the use of nanotechnologies and nanomaterials in food products?

71. Previous experience with GM food has shown that the public values transparency and choice. This suggests that it would be advisable to provide information or even labelling, about products that contain nanotechnologies or nanomaterials. However, this might inadvertently imply hazards, or be completely meaningless or confusing to consumers. Any information that is provided should be accurate, impartial and balanced, and clearly distinguished from any advertising.
72. Public engagement should involve asking people what information they want. Information about why products are made in a particular way and what the benefits are is likely to be of more interest than technical information.

RCUK, March 2009

¹³ <http://www.nanotec.org.uk/finalReport.htm>

Cross-Research Council programmes and partnerships related to nanotechnology

RCUK Nanotechnology Group

A cross-council group which co-ordinates Research Council activities in the area of nanotechnology, including Research Councils' inputs into the NRCG/NIDG. This group also includes representation from the Technology Strategy Board.

Nanoscience through Engineering to Application

<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Nano/Intro.htm>

A cross-Council programme which operates primarily through a series of Grand Challenges aimed at enabling nanotechnology to make a unique contribution to areas of societal importance such as energy, healthcare or the environment. Each Grand Challenge works through a stage gate process, starting with the basic science but looking to the issues of scale up (reliability, reproducibility, safety etc). The programme has also supported, through EPSRC, three centres for doctoral training and an equipment sharing scheme. The Programme is managed by the RCUK Nanotechnology Group.

Definitions

RCUK has adopted the following definitions, provided by the Royal Society/Royal Academy of Engineering report '*Nanoscience and Nanotechnologies: Opportunities and Uncertainties*'¹⁴ (2004):

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

Nanotechnologies are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometer scale.

In conducting portfolio analyses, BBSRC used the following definitions:

Nanotechnology is the field of science focused on the design, synthesis, characterisation and application of materials and devices at the nanoscale. This involves the control and characterisation of properties at a molecular level, rather than inferring (hence controlling) properties from macro-scale performance. More broadly, nanotechnology includes the many techniques used to create or manipulate structures at a size scale below 100 nm.

Includes:

- fabrication of DNA nanowires, DNA tweezers or DNA based nano structures and machines;
- lithography techniques;
- molecular self-assembly techniques;
- molecular motors;
- molecular machines;
- studies involving scanning probe microscopy and arrays / microarrays;
- MEMS (microelectromechanical systems);
- miniaturisation and single molecule studies.

Excludes:

- Research included in the broader definition of bionanotechnology, i.e. drug delivery, biomaterials, sensors, tissue engineering, tools – unless included according to the definition above.

¹⁴ <http://www.nanotec.org.uk/finalReport.htm>

Research Council Units, Centres and Institutes relevant to nanotechnology and food

BBSRC institutes

www.bbsrc.ac.uk/organisation/institutes/sponsored_institutes.html

The BBSRC institutes conduct long-term, mission-oriented research using specialist facilities, some of which are unique in the UK or internationally (such as animal disease containment facilities, long-term field experiments). They maintain strong interactions with industry, government departments and other end-users of their research to provide advice and promote knowledge transfer, and are leading partners in numerous overseas collaborations. BBSRC institute that conduct research of particular relevance to this inquiry are:

- Institute of Food Research (Norwich) – food structure, quality and safety, diet & health. The Institute of Food Research will be providing independent evidence to this inquiry.
- John Innes Centre (Norwich) – plant and microbial science underpinning crop production.
- Rothamsted Research (Harpenden) and North Wyke Research (Devon) – arable and grassland agricultural systems, including long-term field experiments (some continuous since 1843).

ESRC Centres

CARR, the ESRC-funded *Centre for Analysis for Risk and Regulation*¹⁵ is an interdisciplinary research Centre which focuses on the organisational and institutional settings for risk management and regulatory practices. CARR has identified that there is a great deal of regulation and governance research which is at the core of CARR's work; for example: learning from the attempts to regulate previous novel materials; issues around the framing, enforcement and impact of regulation; examination of how risk and uncertainty are handled in regulation and governance situations. Another aspect of CARR's remit is analysing how different groups work together and regulate i.e. state regulators and regulators who are situated beyond the state e.g. Professional groups (e.g. scientists), industry groups and other forms of self-regulation. Also relevant of course is the potential for public engagement.

Cesagen (the ESRC *Centre for Economic and Social Aspects of Genomics*¹⁶), a collaboration between the Universities of Cardiff and Lancaster, focuses on the social, policy, economic, ethical and legal aspects of 'genomics' and associated developments. This is focused primarily upon genomics-related sciences, and such molecular-scale sciences and interventions encompass nano research and innovation. Issues such as whether the development of nanotechnology requires the development of new ethical and/or regulatory approaches or principles are being researched.

Innogen (ESRC *Centre for Social and Economic Research on Innovation in Genomics*¹⁷) is a collaboration between the University of Edinburgh and the Open University. Research includes work on strategies to facilitate interdisciplinary science

¹⁵ <http://www.lse.ac.uk/collections/CARR/>

¹⁶ <http://www.genomicsnetwork.ac.uk/cesagen/>

¹⁷ <http://www.genomicsnetwork.ac.uk/innogen/>

(as in nanotechnology), company strategies for the development of socially beneficial innovations, and the effective governance of life sciences; and key researchers are involved in the development of a new approach to risk governance of nanotechnology, particularly to bring in more effective public engagement and a more sensitive approach by companies to public concerns.

SCARR (*Social Contexts and Responses to Risk*) is a recently completed research network which looked at risk in everyday life and how the actual risk, or those risks identified as high priority by organisations such as government or business, may differ from people's perceptions.¹⁸ This included work in the field of nanotechnology.

STEPS (Centre for Social, Technological and Environmental Pathways to Sustainability at the University of Sussex) has investigated nanotechnology as one example of the effects of new technologies on people and the environment, in the context of developing countries.

BRASS (Centre for Business Relationships, Accountability, Sustainability and Society at the University of Cardiff), produced a policy briefing entitled 'Nanotechnologies: Gaps in the Regulatory Framework'¹⁹. The current regulatory framework was designed to regulate traditional technologies. The policy brief considers a report produced by BRASS and asks whether the current regulatory framework is sufficient to regulate free engineered nanoparticles (development, manufacture, supply, use and end of life).

MRC Units and Centres

<http://www.mrc.ac.uk/Ourresearch/Unitscentresinstitutes/index.htm>

The MRC funds a range of directly-supported units, several of which conduct work relevant to nanotechnology and food:

- MRC Human Nutrition Research (Cambridge) - this "collaborative centre" exists to develop the evidence underpinning public health nutrition strategies. It provides a national centre of excellence for the measurement and interpretation of biochemical, functional and dietary indicators of nutritional status and health. Work currently conducted in this Unit includes the use of nanotechnology to regulate mineral uptake from foods, and the associated health (and safety) implications of this technology.
- MRC Toxicology Unit (Leicester) - this Unit aims to study and understand the fundamental mechanisms of toxicity, particularly mechanisms of cellular and tissue response to injury caused by drugs, chemicals and endogenous molecules. The study of nanotoxicology comes within this remit. The MRC Toxicology Unit also manages the Integrative Toxicology Training Partnership (ITTP). ITTP aims to build capacity in toxicology and related disciplines that is required to ensure the safe and effective development of drugs, chemicals and consumer products through partnerships between academia, industry and government. The initiative has a budget of ~£3.5m and so far 20 studentships and one career development fellowship have been awarded to UK Universities, including projects to investigate the toxicity in nanoparticles.

¹⁸ <http://www.kent.ac.uk/scarr/scarrprojects/scarrprojects.htm#media>

¹⁹ <http://www.brass.cf.ac.uk/uploads/NanotechPBD.pdf>

RCUK involvement in public engagement activities related to nanotechnology

EPSRC Consultation on Nanotechnology for Healthcare

As part of the nano Grand Challenge in Healthcare, developed through the cross-council theme *Nanoscience through Engineering to Application*, EPSRC conducted a public dialogue exercise. Information on this activity is available at:

<http://www.epsrc.ac.uk/ResearchFunding/Programmes/Nano/RC/ConsultNanoHealthcare.htm>

NanoJury UK

BBSRC provided financial support to NanoJury UK, which took place in summer 2005.

This 'citizen's jury' brought together twenty people, chosen to represent a broad cross section of society but also inclusive of a number of ethnicities and religions, to discuss issues surrounding nanotechnology.

The report summary is available on the BBSRC website at:

<http://www.bbsrc.ac.uk/society/dialogue/activities/nanotechnology.html>

NanoJury UK was sponsored by Greenpeace UK, The Guardian, The IRC in Nanotechnology at the University of Cambridge, and the Policy, Ethics and Life Sciences Research Centre at Newcastle University

Nanodialogues

The Nanodialogues project, led by Demos, was a series of four public engagement experiments about nanotechnology, which ran from 2005-2007.

BBSRC and EPSRC were involved in the second of the four experiments, which set out to answer two questions:

- What are the sorts of questions that are likely to determine future public response to nanoscience and nanotechnologies?
- What should public engagement with early technologies look like and how can Research Councils build public value into their work?

The project report and evaluation are available at:

<http://www.bbsrc.ac.uk/society/dialogue/activities/nanotechnology.html>

BBSRC 'What is nano?' exhibition and 'Nanotechnology and You' meeting

The Government's 10 Year Investment Framework for Science and Innovation, and the think-tank Demos in their leaflet 'See-through Science', called for public engagement early on in the development of technologies, such as nanotechnology.

BBSRC's first 'Nanotechnology and You' discussion meeting took place at Edinburgh International Science Festival in April 2006, supported by BBSRC's *What is nano?* Exhibition. A summary of the discussion meeting is at:

http://www.bbsrc.ac.uk/society/meetings/archive/meeting_nanotech.html

BBSRC's 'What is Nano?' exhibition is available to view at:

http://www.bbsrc.ac.uk/society/meetings/archive/exhibition_nano/exhibition_nano.pdf

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