TUESDAY 21 APRIL 2009

Present

Crickhowell, L.
Cunningham of Felling, L.
Haskel, L.
Krebs, L. (Chairman)
May of Oxford, L.
Methuen, L.
Neuberger, B.
O'Neill of Bengarve, B.
O'Neill of Clackmannan, L.
Selborne, E.

Memoranda submitted by Leatherhead Food International and Institute of Food Research

Examination of Witnesses

Witnesses: **Ms Kathy Groves**, Leatherhead Food International, **Dr Vic Morris**, Institute of Food Research, **Dr Paul Butler**, Packaging Materials and Technologies Limited, and **Dr Frans Kampers**, Wageningen, BioNT, examined.

Q86 Chairman: I would like to welcome our four witnesses. Thank you very much for coming to join us for this second public hearing in our inquiry into nanotechnologies and food. We are very grateful to you for sparing the time to come and answer some questions and hopefully enlighten us on this important and interesting topic. I should inform you that proceedings of this hearing are webcast, so are available to the public. I should also draw attention to the information note which is available to those members of the public who are here in the audience and that note sets out the declared interests of members of this Select Committee so we do not need to repeat those during the questioning. When we start in just a second I would like to invite the four witnesses to introduce themselves for the record, but also if you wish to make any form of opening statement describing your views about the

issues then you are very welcome to do so, otherwise we will move straight on to the questions. Perhaps I could ask Kathy Groves to kick off and introduce herself and then move along the row.

Ms Groves: Good morning. I am Kathy Groves. I am the principal microscopist at Leatherhead Food International.

Professor Morris: I am Vic Morris. I work at the Institute of Food Research in Norwich, which is a BBSRC institute, and I am interested in nanoscience techniques to look at food structure.

Dr Butler: I am Paul Butler. I run a consultancy company advising packaging converters and retailers on the latest advances in packaging materials and technologies, including nanotechnology.

Dr Kampers: My name is Frans Kampers. First of all I would like to thank you for inviting me to this prestigious committee. I am from the Netherlands, from Wageningen UR. One half is the university and the other half is a contract research organisation. I co-ordinate the bionanotechnology research at Wageningen, so I head a virtual institute called BioNT within Wageningen UR, and our main focus is on the applications of nanotechnology in food. Various groups within Wageningen UR work on food, applications in food, sensors, processing improvement and things like that. That is my interest in this.

Q87 Chairman: Thank you very much. Would any of you like to make any further statement before we start? Let us move straight on to the questioning. I would like to kick off with a very general question to all of you. We are obviously interested both in the potential of nanotechnology in the food industry in the future and also on the regulatory side of that whether there is any need for additional regulations and what the uncertainties are in risk assessment. I wonder if we could start off by seeking your views on what you think the

potential benefits of nanotechnologies and nanomaterials are to the food industry and, of course, to consumers of food?

Professor Morris: There are four areas I would think of. One is the reduction of waste in the food chain; safer foods, particularly anti-microbial effects; healthier foods, you can design food structures to try and prevent and slow the progression of diseases and you can also design foods to combat things like obesity and build effects into foods that would control hormonal responses that control the amount people eat; and there are new commercial opportunities, particularly with small firms, in the nano area.

Ms Groves: That sums up a lot of them. An added one is the advantages of nanomaterials in the food processing and manufacturing side, either anti-microbial surfaces or anti-stick surfaces that would stop machinery clogging up and reduce the downtime for cleaning.

Dr Butler: My background is packaging so I will just address the food packaging side of things. In food packaging, one of the major problems we have in all the developing countries is food waste. This is consumer food waste from the home. I think nanotechnology could help in terms of producing packaging that is more communicative and informative to the consumer. For example, a consumer would have a much better idea of whether the food was safe to eat or had to be discarded. At the moment we have some very ineffectual date coding systems on food and a lot of food is thrown away that is perfectly healthy and still suitable to eat. Nanotechnology as an enabling technology could help with what is known as smarter packaging or intelligent packaging.

Dr Kampers: I would like to place the question into the larger perspective of challenges for mankind basically. We have a growing world population and increasingly people want to have more protein in their diet but we know at the moment that is impossible to produce in the way that we produce it now. Since meat is a nanostructured material that has a structural hierarchy from the nano level up, you can understand that if you want to have replacements

for meat in a more sustainable production way then we will need to look at how we recreate the structural hierarchy from the nano level up, so you start with nanotechnology in these areas. Another big challenge for mankind is keeping the health system economically viable. The curative healthcare system that we have nowadays will not be sustainable in the long run because it is too costly. We believe that with a paradigm shift towards preventive healthcare we can both help individuals remain healthy and also keep the system within economic boundaries. Food is a very important component of that preventive healthcare system paradigm. We believe that nanotechnology can add to that system. Mind you, if everybody ate 200 grams of vegetables a day and two pieces of fruit a day in a varied diet nobody would need any technology to stay healthy. We very rarely do that, so the food industry is looking at technologies to help individuals get the nutrients that they need to stay healthy and in that way we hope to reduce some of the costs of the healthcare system. These are basically large challenges to mankind in which we believe nanotechnology can play a role as an enabling technology.

Q88 Chairman: Thank you for those helpful responses. In the work we have done so far and the literature we have read we understand that nanotechnology may mean different things to different people, so we deliberately entitled our inquiry "nanotechnologies" rather than "nanotechnology". I wonder whether any of you would like to comment on distinctions that you might see amongst different nanotechnologies that could be usefully drawn in terms of the food sector and what the functional indications of those differences might be.

Professor Morris: I think an area where there is a big difference is in talking about nanotechnology we are talking about natural structures and materials which are manufactured which are not broken down in the body and that is an area where possibly the risk benefit analysis is harder to assess because of a lack of knowledge in those areas.

Q89 Chairman: So natural versus persistence?

Professor Morris: Particularly in manufactured materials that are not broken down in the body and so are likely to persist in the body and we do not know the consequences of that. I think that is an area that attracts too much public concern, particularly because there seems to be a reluctance to label materials or you have labelling over the Internet which is not regulated and there seems to be a reluctance in the UK to want to label packaging or these non-metabolisable materials put into food and people might feel, therefore, they have not got a choice in assessing the risks themselves either in what they buy on the Internet or what they might buy in the UK.

Dr Butler: My own view on nanotechnology is that obviously it is everyone's favourite prefix - we have got the Nano iPod and everything like that - so it has become a bit of marketing hype. My own view is that nanotechnology only gets really interesting - and I know you do not want to get sucked into what size is nanotechnology and what size is not – when you have property changes which you do not normally have. I grew up with my Periodic Table of 92 elements and I was quite happy with all their physical properties. Nanotechnology gets very interesting when you get down to the 20-50 nanometre size and all kinds of unusual properties are now generated by these so-called bulk materials. It is like a material scientist who is given a whole new palette of materials, strange elements with unusual properties. I did metallurgy at university and with something like silver, silver melts at 960°C and it does until it gets tiny, tiny, tiny and then you can melt it with a hairdryer. These are dramatic changes in properties that could have huge effects in terms of aerospace and medicine. Packaging and agri-food just happens to be one of the many applications of nanotechnology, but to me true nano is when the quantum effects kick in and you get these dramatic changes and the material just does not behave like it ought to behave and then you can do some really, really interesting things with it.

Dr Kampers: It is really from what perspective you look at nanotechnology. If you look from the opportunities perspective then you look at the quantum effects that allow you to create new functionality that we have not been able to create before. The various applications in all sorts of application areas benefit from these new properties and arise from quantum mechanics basically and from the fact that you have a lot of surface versus volume ratio. If you look at it from the benefit side, we have all sorts of different applications for nanotechnology in food which ranges from sensors that have very little to do with the food itself and packaging materials that come into contact with food, but also applications that go into the food that are intended to be eaten. There are very many sorts of nanotechnology in the application area of food. If you look from the perspective of risk and risk assessment then you have to look at what classes of nanotechnology could pose risks and toxicologists agree that the persistent nanoparticles, especially those that are non-biologically degradable, in-organic, the inorganic metal oxides and metals, are the particles that pose most risk. There we start to look at what sorts of properties determine that risk and that is an area we know very little of yet, especially if you ingest the particles. This is an area that still needs to be assessed, but it is only a very, very small part of all the applications of nanotechnology in food. For me, it is a pity that everybody focuses on that specific area. I know risk is something that concerns us all but, on the other hand, the benefits may be tremendous and outweigh the risks to a very large extent.

Q90 Lord Cunningham of Felling: I just wondered whether very briefly each of you could say what you think the public reaction would be to manufactured nanoparticles in food, given that, for example, there is still something of a debate going on about putting fluoride ions in the drinking water even though the evidence in terms of dental health is pretty overwhelming. What do you think would be the prospect of persuading people that it is in all our interests to have nanoparticles in the food chain?

Dr Kampers: Are you referring to inorganic nanoparticles, the persistent nanoparticles?

Q91 Lord Cunningham of Felling: Any kind. I said manufactured nanoparticles.

Dr Kampers: The most important area of application in food probably is not nanoparticles but in delivery systems. These are larger systems so they usually are not seen as nanoparticles. They are nanotechnology because the nanotechnology is in the wall of the particle, but it is not a nanoparticle per se since it is much larger than 100 nanometres, although you would like to include that as well. I think you have to explain to the general public what the benefit for the individual consumer is, like there is a product that delivers oil to the small intestine and it makes sure that the oil does not come free in the stomach, in the mouth or anything, it is delivered to the small intestine, and the idea is it triggers the small intestine to give a signal to your brain that you are saturated basically and is a way of convincing your body that you have eaten enough. This is a product that when you use it is supposed to make sure that you stop eating sooner than you would have done if you had not had this product. Obviously the product falls apart in your gastrointestinal tract so there is nothing left of the nanotechnology except molecules, of course, but these are all harmless molecules, they are food grade molecules. If you have story like that ---

Q92 Lord Cunningham of Felling: Excuse me, I think fluoride ions are pretty harmless too myself but that has not persuaded the public to universally accept it. The question is not really about the efficacy or otherwise of the technology in scientific or nutritional terms, it is the public acceptance.

Ms Groves: Your answer would be in how you asked the question. It depends on how you ask the question. If you say, "How do you feel about the food industry putting nanoparticles in your food" then I think you would probably get a big response saying, "I'm not keen on that at all", but if you say, "The food industry are structuring food on a nano scale" then you

might get a different answer. If you put choice of benefit from healthier food against less healthier food then that would weight their response. The public do not really know how food is manufactured and then put on the shelves in the shops. There is a lack of information on actually how it is currently manufactured.

Q93 Lord Cunningham of Felling: I am struck by what you have just said on what was happening with the genetically modified tomato sauce, which was a best seller until people discovered that it was genetically modified and then they stopped buying it.

Professor Morris: I think the most important thing is people aim to exercise choice. We might think it is unreasonable they do not want to eat those sorts of foods but they ought to have the choice as to whether they do or not, and they ought to be able to access the benefits and risks in an understandable form so they can make their own assessment. I think if they have that choice, whether it means labelling or information in some way, their perception would be much better and they would not feel it is something that is being forced on to them.

Q94 Lord May of Oxford: If I understood your example right, and I may not have, it was an example where you put in something that is completely harmless and safe which, however, in effect modified behaviour in a way that was advantageous, and all I can say, like Lord Cunningham having had experience of the genetically modified fuss and so on, is just wait until Greenpeace hears that you are going to put nanoparticles in food that modify behaviour, there will be some term like "Frankenstein food" that comes with that.

Dr Kampers: It is inevitable that some of the NGOs will come on to this area. However, I believe that communication about the application, benefits and potential risks of these technologies is essential and it is also important, as my colleague said, that the consumer has the choice so they can choose whether or not they would like to have the benefits versus the risks or perceived risks of such a product. It is important not to do that in obscurity.

Chairman: I think the choice point has an echo in the response of the public to fluoride because although people object to fluoridation of water almost everybody buys toothpaste with fluoride.

Q95 Lord Haskel: I wonder if we could move on to another aspect, which is the politics of nanotechnology in food. You have told us about the way in which nanoparticles enhance food safety, reduce waste, is healthier and more sustainable. In view of the fact that there are so many benefits, are there any Government initiatives in place to encourage nanotechnology development that contributes to these objectives and towards achieving these objectives? Are governments doing anything to help you?

Professor Morris: Certainly the Research Councils are. There are research programmes on nanotechnology in most of the Research Councils and there are programmes on things like health into old age in the BBSRC which fits that agenda. Certainly in terms of basic research there are programmes available to fund that. I am not sure about the other Government agencies, such as the FSA or environmental agencies.

Q96 Lord Haskel: Is there any co-ordination between the Government and the industry? I notice that there is a technology transfer network.

Ms Groves: There is, and there are nanotechnology centres dotted about the country. There is one we have been working with that has been set up with Government funding through the Technology Strategy Board and the Knowledge Transfer Network for Nanotechnology is obviously set in place to enable technologies from difference research areas to be translated into food or other areas.

Q97 Lord Haskel: Obviously your company supports that. Do you find it effective? Does it work?

Ms Groves: It is very limited in resources, I would say. There are not enough resources for that sort of knowledge transfer.

Q98 Lord Haskel: Where do the resources come from?

Ms Groves: They come from the funding for research and development and that has short pockets.

Q99 Lord Haskel: It is not the commercial companies?

Ms Groves: The commercial companies will put money into research and they do collaborate together on pre-competitive research funding. In fact, they are doing that on a small scale.

Q100 Chairman: I wonder if Dr Kampers would like to add any comment about the situation in the Netherlands or other European countries.

Dr Kampers: Obviously I cannot say very much about the situation here in the UK, but in the Netherlands we have just completed a proposal for the next generation of nanotechnology programming, science programming and one of the ten themes that we have identified is food. The proposal is to spend about €40 million over five years on applications of nanotechnology in food in the Netherlands. In the Seventh Framework Programme, both in the nanotechnology theme and in the food theme, there are calls that address nanotechnology applications in food.

Dr Butler: The Institute for Nanotechnology in the UK is one of the partners for this European project which is funded for four years from April 2008. There are 16 partners from ten European countries. Part of that is to share information about health and safety, about regulatory aspects of nanotechnology. Again, they are looking at all the major sectors, which includes agri-food.

Dr Kampers: Can I add one point. You also asked about the involvement of the industry. In the proposal in the Netherlands, 50 per cent[1] of all the money comes from industry. It is aimed at collaboration between government institutes, science institutes and the industry.

Q101 Lord O'Neill of Clackmannan: On this point about funding, to what extent could you draw an analogy, say, with the biotech industries? Admittedly, there it is linked with pharmaceuticals and specific research programmes for the development of particular drugs, but that has been very successful in attracting venture capital and that kind of money. Would it be right to say that the state of nanotechnology at the moment is that it is insufficiently advanced to attract the attention of specific investors rather than people who have, as it were, food industry interests, the like of which you were alluding to both in your introduction and your example?

Dr Butler: It is quite early. Nanotechnology is such a broad platform that at this stage where you are discovering what it is and what it can do you are probably not going to get the VCs involved until you have got a specific application in a specific sector, and that is beginning to happen, but at the moment we are still exploring the many, many potential applications of nanotechnology. That would be my take on it.

Ms Groves: Yes, it is very broad and that complicates it to some extent. Also, it is at a very early stage in terms of the food industry and I think it is fair to say there is a nervousness in the food industry about how the consumer views what they are doing if they launch into nanotechnology, yet they want to see what is available and what could be beneficial so they are courting it.

Dr Kampers: In the Netherlands we see two ways in which the results of the research get to market. The first is existing companies adopting results from the research and putting them

[1] This figure is actually 25%. 50% of the total funding comes from the participants (including universities, industry and research institutes) and of this, half is contributed by industrial participants.

into products or processes and improving them. The second way, that is probably the most important and effective, is spin-outs, small companies, new companies, start-ups generated by the knowledge institutes and the knowledge infrastructure. So PhD students start up their own business, they attract a little venture capital but basically rely on funding from the market side. There is a little bit of venture capital involved there but most of the funding is through other funding programmes that are available and things like that, subsidies.

Q102 Lord May of Oxford: You have already given us some examples of potential applications of nanotechnologies and nanomaterials, but I wonder if you could say a bit more about the applications of these technologies that UK companies or, more generally, companies in other countries are currently working on and what applications we are likely to see on the market maybe next year, in five years or ten years?

Dr Kampers: You have got everything about sensing and diagnostics. These are low-hanging fruits, as we call them, where small companies are working to improve sensing devices, sensors basically that can detect volatiles or bacteria, fungi, things like that, to improve food quality. Another application area is improving processes like the emulsification processes, sieves and things like that, these kinds of areas. In the application area where you add technology, nanostructured materials to foods, nanoparticles, there are very few applications of persistent nanoparticles in food at the moment, but these delivery systems are something that attract a lot of attention and are not very far from the market as we speak. Then you have got packaging materials that improve the shelf life especially of fresh products but also inform the consumer about the quality of the food inside the package with sensors and also systems that change colour when the quality of the product deteriorates or the ripeness changes. These are applications that are already available in the US. There are systems that you can buy at the moment for these applications. They are fairly close to market.

Dr Butler: From a food packaging point of view, to give one specific application which will involve using nanotechnology to create a self-adjusting use-by date. We need to move away from date coding to more visual displays on a package to inform the consumer whether the food is still good enough to eat or not. That will involve a display, a printed battery, some very, very simple electronics which will be printed on flexible trace paper or plastic and the enabling technology to do that will be nanotechnology, for example inkjet printing using nanoparticles to lay down circuits on flexible films to then put on top of food packaging, but of course the nanoparticles that you inkjet print will be part of the manufacturing process and once they are consolidated and have been cured they will no longer be nanoparticles, they have done their job, they have created a structure so will present no problems at all to the consumer. I think it is important we understand that sometimes in nanotechnology you might start off in the manufacturing process with a nanoparticle with perhaps some concerns over its health and safety and what it might do, but at the end of the day you might produce a product where, yes, you would use nanotechnology but that product is now completely benign.

Professor Morris: There is another example of that. Frans mentioned the idea of marketing nano-encapsulating oils and delivering them further down the small intestine to generate a hormonal response. Using nanoscience you can actually look at how you design the structures in the emulsion and you can manipulate those structures to have the same effect so you can slow down the rate of hydrolysis of the fats so they are hydrolysed further down the small intestine and you can visualise how to do that and then you can use normal processing techniques to generate those structures by using nanoscience to understand how to use conventional processing to generate a new product that has got new properties. I think they are the sorts of products that could come on the market in perhaps five to ten years.

Q103 Lord May of Oxford: Let me put it another way. We had a study from something called Cientifica and it seems concordant with other studies. First of all it makes the

projection that by 2015 it is going to be a trillion dollar industry, and then it looks at 2007 and it says excluding semiconductor applications it is nearly all the applications in chemistry, less than one per cent in the food sector, and its projection for 2012 is that maybe the share of the food sector by 2012 of all nanotechnological research might be as much as two per cent. My question is what are the main drivers of R&D in the food sector? Are there research drivers that are driven by the food industry or does the food industry, insofar as it is a player, primarily rely on adopting and applying new technologies that have been developed in other sectors? I find it a little bit disconcerting to think that the main driver of applications for nanotechnology in food is going to be chemicals. I do realise food is chemistry but, again, it plays into the hands of the NGOs who are worried.

Ms Groves: Those are really probing questions and the others will have a view on them. There is no doubt that one of the main drivers, and there are drivers for the food industry and their R&D, is in healthier foods. Consumers are very keen, and I am keen to carry on eating fatty, nice tasting foods but I want to be healthy as well, so people do want that. Healthier foods is a big driver. Cleaner labels or removal of E numbers and trying to simplify manufactured products is a big driver. In order to do that you have to understand what those ingredients do and then you have to understand how maybe changing the process of the food will allow you to remove some of those ingredients by using nanostructures of those natural ingredients in food. Those are just two drivers but I am sure there are many others.

Dr Butler: No. I think there are many, many ways to skin a cat and there are many ways to get lighter packaging and more recyclable packaging. I think we have got the nanoclays, which have been floated as a way of getting better barrier properties on transferred plastics, which has been hyped up a little bit. I know of no commercial examples. They have certainly tried PT plastic beer bottles, for example

Q104 Lord May of Oxford: Are there any applications?

Dr Butler: I do not know of any at all, in packaging. I know lots of people working on it.

Dr Kampers: Apparently, in the US, you can buy beer in PT bottles, thanks to the nanoclay and nanocomposite applications. I know that one of the brewers in the Netherlands is looking at that application but it is not on the market. Can I also add one more application area or driver for the industry? The industry, also, apart from the health aspects of food, looks very much at the safety of foods. Food has never been as safe as it is now in industrialised countries and it is a tremendous effort for the food industry to enhance that even more, and that is why they are very anxious to look at all sorts of measuring devices, diagnostic devices, that can maintain that or improve even on that aspect, and they are looking for devices that can give them an answer quicker with less qualified personnel and closer to the production line. Basically, that is what they are looking for, also, in nanotechnology - if nanotechnology can deliver on devices like that.

Professor Morris: I think there is an example of sectoral use of nanotechnology, in terms of future chips, and so on, in GPS and radio frequency identification of food, and tracking them from source right through to the shop or the consumer, so you can actually check the conditions under which they are stored and transported, and you can check whether that route has been interrupted. So if the food was adulterated you could very quickly find out where it happened and track it down. So there is that aspect of nanotechnology which applies to the agri-food sector which is readily acceptable at the moment by the public.

Q105 Lord Crickhowell: The question I want to address is: what are the main challenges to the use of nanotechnologies and nanomaterials in the food sector? We have in front of us, as it happens today, a submission from the Leatherhead Food International & Nanotechnology Knowledge Transfer Network. Basically, what this submission says is that they see enormous potential and considerable scope for growth but that we know almost nothing about the whole subject. They say: “There is very little research and development in the UK regarding

nanotechnology within the food and drink industry … very little is known about what is out there, what is feasible, what is safe and how it might be applied", and they refer to the lack of research or the forthcoming research. We have heard in earlier evidence that we really do not know yet very much about the long-term effects on the gut of certain manufactured nanoproducts. So over the millennia, nature has been absorbing nanoparticles into the gut and modifying it but we do not know very much about it. So I suppose my question is: is the lack of knowledge and the lack of much research yet the biggest obstacle? What are the obstacles? What is the main challenge, if it is not that?

Ms Groves: In looking at that question that was sent to me, I put "scientific challenges". As a scientist that, perhaps, would be a natural answer for me to give. There are some huge scientific problems in both structuring at that nano-level in complex foods (and nearly all manufactured foods are pretty complex) but, also, measuring them. It is a challenge just to know where fat, sugar and protein are in a lot of foods, let alone what size and scale they are. Obviously, there are challenges in terms of consumer acceptance of the food industry manufacturing foods at a nano-scale with nanoparticles. I think it is important to, again, stress the distinction between nanoparticles which are not normally consumed in large quantities, like titanium dioxide or silica or silver or any of the metals, and the foods which are usually consumed – fats, proteins and carbohydrates. I think it is important to distinguish between those.

Q106 Lord Crickhowell: As I understood it, you referred, I think, to really changing the process of manufacturing but not really using nanoparticles in the gut, except you have learnt how to change the process. We did have a description, I think, at one of our seminars, of the way in which you might reduce the fat content in food by, basically, attaching the food from much smaller – I am not sure what the word is – segments, but it did seem to me that we are into an area of confusion, which I am not sure I understand, about what is a manufactured

nanoparticle and what is simply a change in the manufacturing process. Is this an area that we really know enough about and understand enough about?

Ms Groves: No. I think it is very difficult because early on, I think, one of the first questions was a distinction between manufactured and natural. Actually, a lot of manufactured particles are natural particles; they are natural foods which have been manufactured into structures within a food product. So, yes, there will be changes to food processing which may well need to involve nanotechnologies in order to change the structure of the ingredients in the food that we put in. That is one aspect of the nanotechnology of foods, and it is the distinction as to whether they are manufactured nanoparticles of water being boiled, which I think, in the seminar is one of the low-fat examples. So if you have water in oil and water, emulsion, in a salad dressing, are those water droplets manufactured nanoparticles or are they natural but they have been processed to be very small? That is going to be something that needs to be decided in order for legislation purposes and regulation.

Q107 Lord Crickhowell: If there is a need for more research, again we heard in evidence at our last session the difficulty about manufacturers' intellectual property rights; even if they are not worried so much about intellectual property rights they are, perhaps, reluctant to exchange too much information about technological developments which may have huge commercial advantages. Is that an obstacle that you see as a real one to real progress – the very natural lack of willingness to communicate too much between companies about their research programmes?

Professor Morris: I think it comes down to a matter of choice. If those products are introduced without any way that the consumer can tell that it involves nanotechnology, they might be concerned. I think then there could be a problem. However, if those were labelled in some way, so that people can choose whether they use them or not, I think it would not be so much of a problem.

Q108 Lord Crickhowell: You keep coming back to labelling as a solution.

Professor Morris: It is a possible solution.

Q109 Lord Crickhowell: One of the problems is that we have got far too much labelling, in many ways, and people now find almost all labelling confusing. Surely it is a step too soon to talk about labelling if we cannot actually know quite what the threats are, what is right and what is wrong and we have not got the basis of scientific research on which to label. Are you not jumping a bit far ahead?

Professor Morris: I am not saying labelling has to be the way to do it; I am saying that the consumer needs to have some choice as to whether they opt to buy a particular food or not, and they need some way of knowing whether the processing of that food is something that might concern them. We might think it is unreasonable they should be concerned, but they still feel they have a choice as to whether they buy it or not

Q110 Lord Crickhowell: My final question on research, if this is an obstacle, is that we found it rather difficult in our last session to get really reliable and complete information about the amount of government research and finance for the research in this field, and we hope we are going to get a rather more complete paper from the department concerned in the future. Would any of you like to comment on the adequacy of the government's research programmes in this field in this country, in Europe or elsewhere?

Dr Kampers: "In the field" – you mean ----?

Q111 Lord Crickhowell: If it is so important that we know more about the science of nanotechnology, if it is going to be possible to assess the safety of these products, ought there not be a more concerted scientific programme, and what are governments doing, or should governments be doing, to see that that happens?

Dr Kampers: In my personal view, building trust with the consumer is very basic; it is a pre-requisite for the acceptance of the technology. "Building trust" means that we understand the risks, so risk assessment is important. We know that the risk is predominantly located at the inorganic nanoparticles, but still we feel that we have to do more research into the risk assessment, both hazard assessment and the exposure assessment of nanoparticles. There it is tremendously complex because if we talk REACH, basically, that is governed by the chemistry; for bulk or small particles it is the same. Nanotechnology has added a whole new dimension to that problem because size matters now. There is another dimension that nanotechnology has added because we also can control the geometry of the particles, so we can make rod-like particles and we can link spherical particles. So there is another dimension added to the complexity. There are even other dimensions because we can functionalise particles so that they behave totally different from the particles that we started off with. So the complexity to look at these kinds of issues is tremendous, and we lack the data to get to a level where we have generic knowledge of where the risks really are in this multidimensional space. That is something that, in my view, needs to be addressed internationally; it is too complex for one country to do. We have to co-operate to find out where the hot spots are and where the relative safe zones are in this area, and that is something that we have not succeeded yet. But it predominantly focuses on nanoparticles. So the application of nanotechnology in sensors and surfaces is totally different; it is something that focuses on these particles.

Professor Morris: I think there is an emphasis on manufactured nanoparticles, and I think it really should be on materials that are not broken down in the body. I think that is the distinction that alters the risk involved in these technologies.

Q112 Lord Haskel: Of course, the research that you are speaking about is very, very important, but is there any research going on to look at what are the concerns of the public? What are the concerns of the consumer? Obviously, the two go together.

Dr Butler: Yes. If any of us buy a packet of crisps, or potato chips, inside is a metallised plastic film. That film is nanodimensional[2], but it is not declared anywhere on the label and it has been around for donkeys years. It depends how you define "nanotechnology" but actually if you wanted to define it that way, as aluminium metallised film, which is used extensively, people are totally relaxed about it, are they not?

Professor Morris: Certainly *Which?* have carried out workshops to look at public concern on nanotechnology, and the nanotechnology institutes, particularly Cambridge, have actually hired social scientists to try and answer public questions and have public forums where people can ask the sorts of questions they are concerned about and get scientific answers.

Q113 Lord Haskel: So you think the public will just be quite passive ----

Professor Morris: I do not expect them to be quite passive about it.

Dr Kampers: As a matter of fact, Wageningen UR is doing research on the mechanisms that govern the processes within groups in society to accept this kind of technology in food. So we are doing research to get some generic knowledge on how these processes are conducted and what influences these processes and how communications, for instance labelling, could help make society accept these kinds of new technologies in application areas of food. We are doing research ourselves in that area.

Professor Morris: The worst thing that can happen is that people are told: "This is a product that involved nanotechnology; it is perfectly safe, you should accept it", and not be allowed to assess the risk themselves. I think people feel that whatever the risk they may choose not to

[2] It is nanosized in one direction only, as are nanoclays.

accept it, even if it is a very, very small risk. They want that choice, and as long as they have that choice I think they are more likely to accept it.

Q114 Lord May of Oxford: At the risk of seeming unduly obsessed with risk and public attitude, I would remind you that, at least in the UK, when nanotechnology first appeared on the scene there was concern voiced in various quarters, not least by Prince Charles, and Michael Crichton's book, and I think we managed to handle that pretty well, by putting together a committee that consulted and met with many of the concerned people and sketched some of the credible worries, and so on, and possible regulatory things to do. So that we have not had any fuss about it because we have learnt, at least, some of the lessons of GM foods. However, I am not myself at all convinced that that will persist once you have the particularly sensitive issue of putting what some people would feel are worrying things into food. I am a little surprised that none of you share this worry.

Professor Morris: I think the worry is about what is available on the internet which is not regulated. One of the things that would be useful is if the first products that come from large, multinationals have really demonstrable good health benefits, or good benefits to people. With GM, the benefits did not seem to outweigh the risks that people were concerned about. At the moment, some of the products you can buy over the internet seem fairly trivial and the benefits in using those seem almost non-existent.

Q115 Lord May of Oxford: My own personal view is that the answer to this is to have products that people want to buy, so that they can see a benefit and they can weigh that against the risk. What happened with GM is that the first wave of products was not offering benefits of a manifest kind to the consumer. I would hope that in the food industry the first wave of products would be for things that offer clear benefits to the consumer rather than to

the food business. I wonder whether you share that. Do you have any thoughts about what to do about that?

Professor Morris: I agree with that. Certainly in terms of healthier foods and foods that provide protection, I think those are things that people can see a real benefit for. The trouble is that to do that science, it is not concerned about risk it is simply about doing the science to understand how to manipulate these things using conventional processes. I think that is just taking time and while that is happening lots of trivial products are appearing on the internet, and I think that is the problem.

Dr Kampers: One of the problems, as was addressed earlier, also, is that the industry is very, very reluctant to communicate that they are using nanotechnology in food. It is not that they are not willing to share the knowledge with their competitors; it is because they are very much afraid of the reaction of the consumer to the product.

Q116 Lord May of Oxford: That is surely a mistake?

Dr Kampers: Yes, sure, but I cannot help it. We try to communicate ----

Ms Groves: Who is going to put their head above the barrier first? Which company is going to risk going to the wall?

Dr Kampers: The effect is that nobody tells anybody that nanotechnology is used, so the benefits of the product are not associated with the nanotechnology used; the benefits are claimed to the product. So the wider public cannot distinguish between benefits that are generated by this new technology and will not learn to appreciate the technology in this way. So that is one of the reasons why labelling might have a beneficial effect on this.

Ms Groves: Coming back to your question on research funding, generally, in the years that I have been in science, research funding has gone from quite generous funding in the food industry to being very specific, and anything which was near-market or was in any way commercial would not be funded by government. Maybe there is now a point for discussion

where you could actually say there should be some government funding, linked with food industry funding, to make open research into the sorts of nanotechnologies in food product development.

Q117 Baroness O'Neill of Bengarve: Is there any research going on into this question of identifying those nanoparticles (inorganic nanoparticles, I understand) which might be the area of risk, and, also, conversely, identifying where the areas of relatively low-risk are? Is that research something that is being done behind closed doors and in a non-co-ordinated way?

Dr Kampers: There is a project by the OECD at the moment going on where they look at different kinds of nanoparticles, and this is the first initiative to co-ordinate this kind of research. What I am always saying is very many people, research institutes, are doing research on the toxicology of more sexy particles, like carbon nanotubes and things like that, and there are few people looking at the toxicity of particles that are less applicable or less sexy. There is really a need for more co-ordination in this area. There is research going on looking at what kind of properties will influence the risk of particles. For instance, I know of research in the US where they look at particles that are used in the bloodstream for medical purposes and where there are four parameters that are seen as crucial in determining whether the particle is in a hot zone or in a relatively safe zone. So there is research going on and we are making progress but, as I said, it is a very complicated issue and then there are many aspects to that. So we really need to do more in this area.

Q118 Earl of Selborne: I would like to follow up the line of thought that you have been developing as to what extent UK public funding of research in this area might contribute to this international need. I think Dr Kampers reminded us that this is too big for one country, that we lack data and that there is an urgent need to get this data on risk assessment and

hazard assessment, particularly to head off any public concern which may well be coming at us. First of all, my question is: are we pulling our weight already? Leatherhead say, in their evidence, that we are under-funded in this area, and we have heard from Holland that you have, in Holland, a €40 million programme with 50 per cent funded by ----

Dr Kampers: It is only the food part of the programme. There is also a risk theme, so there is also €20 million going into risk research.

Q119 Earl of Selborne: That is over and above the €40 million?

Dr Kampers: That is on top of that. Food is one of the 10 themes and risk is also one of the 10 themes in that programme.

Q120 Earl of Selborne: Perhaps I could ask our witnesses from the UK as to where we fit into the scheme of things at the European level. Are we able to pull our weight? Are we contributing to these, clearly, European level programmes that you have identified as needing to be undertaken?

Ms Groves: In terms of gut health, there is considerable funding. In terms of real products and foods there is very little.

Q121 Earl of Selborne: So are you making a plea that the government funding (research council funding in the main, we are talking about and departmental funding) should be directed to this area of hazard assessment, risk assessment and determination of what happens to these nanoproducts in the human body?

Ms Groves: I think you have to, again, make the distinction between persistent, non-digestible products, particles, and other normal foods – normal manufactured foods - which may well be enclosed or packaged or made with nanotechnologies, in terms of research into toxicity.

Professor Morris: I think the difficulty is that those particles are very unlikely to be added directly into food. So it is a big problem in understanding what would happen to those particles if they got into the body, particularly in the food matrix, and how they would interact with things like gut bacteria. There is a lot of information in the environmental field on how they affect bacteria, but when you are talking about aerobic and anaerobic conditions they are very different. You need a lot of understanding of the risk associated with those particles, and their applications in the food industry are going to be very small. They are very expensive and there is very little reason why you would want to introduce them.

Dr Butler: I think it is going to be in health and medicine that there is going to be a major application of nanoparticles, and that is, of course, going to bring this whole issue about interaction with the body into sharp focus. I agree with colleagues that the food side is going to be relatively small, and I still go back to what I originally said, that in many instances nanotechnology is an enabling technology, and nanoparticles are used to create something – to devise a system – and that something that you have created is totally benign because the properties of the nanoparticles are now no longer what they were at the beginning. That is what we do not really understand: when you have got this brand new functionality and brand new properties, what does it mean to various sectors? It is security, it is information technology, it is energy and it is construction, including food, but there are many, many sectors and application areas where using nanotechnology to make things is going to be terrifically important.

Q122 Earl of Selborne: Would you give your thoughts as to what role the United Kingdom's research communities should be playing in addressing these issues?

Dr Butler: I think printed electronics, to me, which underpins many of these industrial sectors, is terrifically important. In other words, the ability to print a two-dimensional,

flexible, electronic display, or battery-powered sensor, whatever it might be - it could be an e-book, or an e-newspaper that constantly updates, for example, when you are on the tube or it could be a smart package on a food – that uses nanotechnology as an enabling technology for printed electronic displays, sensors or batteries, all printed at high speed, roll-to-roll printing. That is an area that the UK is a little active in but, in my view, needs to be more active. So it is using nanotechnology but the result is printed electronics, and then the applications are in a number of fields, which include things like alternative energy, for example - solar. If you can print solar cells then you will get much more dramatic properties using nanoparticles. Having printed the solar cell it is now completely safe and benign.

Q123 Earl of Selborne: Where within the European Union would you expect the most progress in this area to be made?

Dr Kampers: May I comment on your first question first? Obviously, we made a different choice. We are doing research and we would like to know about the kinetics and the dynamics of nanoparticles in the gastrointestinal tract, because we see that worldwide there is very little attention to these persistent nanoparticles in the gastrointestinal tract and the oral route. There is a lot on inhalation toxicology, also the skin is researched for certain particles, but there is very little known about the oral route. We have decided, within the Netherlands, that since we are looking at applications of nanotechnologies in food it is also our obligation to know what might be the risks of these applications. Also, we do not want to wait until somebody, somewhere in the world, starts with an application of some kind of nanoparticles in a food product and it comes on somewhere in the market or it can be bought on the internet; we would like to know what kind of risks are associated with these kinds of applications of nanotechnology. Although, at the moment, there is very little of these applications known, there are very few persistent nanoparticles in food products at the moment. But we cannot rule out that there might be, in the future, somebody who wants to put

nanoparticles in food. In the Far East we already know that there are companies that, for instance, add nanoplatinum to food products because they think it is beneficial. As I said, in the Netherlands we would like to know what kind of risks are associated with these kinds of applications, from a generic point of view, so that we can distinguish between things that have low risk and things that have high risk, so that we can focus in the first instance on these high risk applications.

Q124 Chairman: Can I come back and seek a bit of clarification, because we have had two written submissions? On the one hand, the Institute of Food Research, from which Professor Morris hails says: "The UK has played a leading role world-wide in developing a nanoscience understanding of food structure and materials …", and the Leatherhead, from which Kathy Groves hails, says: "There is very little research and development within the UK regarding nanotechnology within the food and drink industry." Those two statements seem to me to be, at one level, almost contradictory. I wondered which one is correct, or are they different slants on the same position?

Professor Morris: I assume they are, possibly, different slants. When we are talking about what has been done in the UK we are talking about the understanding of actual food structure itself, the food matrix, its functionality and how to process it. We are one of the world leaders in that respect.

Q125 Chairman: Are you saying that, as so often happens in the UK, the basic research is being done but the translation of research into products and benefits is being done elsewhere?

Professor Morris: I think that probably needs qualifying. I think it is being done in major companies like ICI and Unilever, but they do not talk about it, at the moment. It is a fear of public perception of nanotechnology. Who is going to be the first person to bring these products on to the market?

Q126 Chairman: As Lord May has said, it does not make any sense to do it and keep it a secret because eventually you are going to have to divulge that it is going on.

Professor Morris: I think there is a real concern within companies that people find out they are using what somebody might call nanotechnology when, in fact, they are using nanoscience; they are trying to understand the foods and through that understanding they will produce products using conventional technologies, and then they can talk about those products and sell the benefits without the associated risk. They are not really nanoproducts; they are conventionally processed products but they are done in a rational way.

Q127 Lord Methuen: What mechanisms are in place for companies, academia and the Government to share information on new developments in this field? Is this limited by IPR considerations?

Ms Groves: Well, there is the NanoKTN centre set up by the Government and the Technology Strategy Board, and Leatherhead does play a role in linking universities to industry. I do not think there are many structures in place designed to do that.

Q128 Lord Methuen: How much involvement is there with academia?

Ms Groves: A limited amount, but only limited by the amount of time you have in your life and the number of resources or people that can liaise between industry and academia. Sometimes industry will go to universities directly, but there is a need, I think, for an interpreter between universities and industry, to be honest, because fundamental research on food is a long way off what will happen in the manufacturing process. So there are companies like Leatherhead which are good at being able to make that connection between the two.

Professor Morris: I think there is an effort to try and correlate all the safety data and the toxicity data; the FSA and the Central Science Laboratory are trying to build up databases, and that sort of information is freely available.

Q129 Lord Methuen: Would it be true to say that this is not a subject which tends to interest universities – it is not sexy enough?

Professor Morris: Which - the food or complexity?

Q130 Lord Methuen: This type of research into food. It seems to be more into industry rather than academia.

Dr Kampers: Not in the Netherlands.

Ms Groves: I think in the UK it is.

Professor Morris: There have been very good universities in the past - the University of Leeds, the University of Nottingham, and Unilever Research, Colworth where there was almost a university kind of atmosphere, which were doing very fundamental research and published it, on food structure and how to manipulate it, at that sort of scale. There has been academic research on manipulating the nanostructures in food, and it is published and is available.

Q131 Chairman: You talk about it in the past tense.

Professor Morris: It is still being done. I think, in the past, it was simply trying to understand the food structure in terms of understanding the functionality of foods – how you can make foods last longer or more attractive to eat. Now it is more about what happens to that food when you digest it, how it is broken down by the body and how you can manipulate those structures to control that breakdown. It comes back to this idea about controlling fat; if you can make a full-fat product but you can slow down the breakdown of the fat, then you can

actually make people think that they have eaten enough, so the next time they eat the food they will eat less of it. You can try in a rational way now, from past understanding, to try and do those sorts of processes. Certainly, in the lab, on an in-vitro scale it works. You can change food structure and control lipolysis and you can do it at a sufficient rate to actually expect to create hormonal change.

Q132 Chairman: Is any research done in-vivo or is it all in-vitro?

Professor Morris: It is starting to be done. We have contacts across Europe, particularly in countries like Finland, where we are starting to do human trials on those types of food. That work is starting to occur but it is quite difficult because translating the science on interfaces on to emulsions – what happens to emulsions when you process it on a large scale and then eat it - is quite difficult. That is why it takes a long time to translate it into practice.

Q133 Baroness O'Neill of Bengarve: You have spoken about the universities doing research that is published and open, and you have also spoken about the companies doing research that is, I take it, not published and not open. That is a pretty unstable situation, in some ways, if it is to end up as consumer products. What would you see as a useful thing that this Committee could recommend that would move things forward in terms of co-ordination? An alternative thought: if you were making a pitch to the Technology Strategy Board to put more resource into the development of research on the use of nanotechnologies in food, what would you say to them?

Ms Groves: I think there is a need for a pre-competitive area of research which is publicly funded with full, open information to the public that the industry are willing to participate in. It has got to be close enough to their drivers and to their products for them to realise the benefit and the need for doing it. Also, it has got to be far enough away, if you like, so they

can take their IP, their whole ownership of the final development. Ultimately, I am not sure if you are asking should we control the food industry far more in terms of what they produce.

Baroness O'Neill of Bengarve: I was thinking of empowering rather than controlling.

Lord O'Neill of Clackmannan: Commercial research is done not for philanthropic or blue skies reasons, it is done for profit, and it is trying to reconcile these two, what appear to be, conflicting objectives. If the Unilevers of this world can get an edge over their competitors they are not going to share it in the interests of humanity, in general, because they have shareholders who have a higher priority.

Q134 Baroness Neuberger: Are we not hearing, also, that there is a rather different attitude in Holland, from what we are seeing in the UK? Clearly, the companies keep their secrets, as it were, close to their chest, but there is a greater emphasis on doing more general research, if I understood you rightly, Dr Kampers.

Dr Kampers: Yes. Also, in the Netherlands, it is true that, for economic reasons, of course, you keep results confidential, at a certain point in time. It is a continuum from pre-competitive research towards application-driven research, and somewhere we meet each other and we are trying to find ways of exchanging the results in such a way that we are bridging the knowledge gap - which is not typical to the UK; it is there everywhere. So methods of bridging the knowledge gap are very important, so results are applied in the industry and the economics start to work and we start making money with these results. Because if we do not make money we do not earn the money to do the research for the next generation of applications, of course. We are looking at things like, as I explained, these other research initiatives in Holland where we participate with the industry to make sure that results in academia are used by the industry, because they also have invested in these research projects. Also, we look at things like setting up joint research centres where academia use the infrastructure but, also, industry can use the infrastructure, so that people meet up and start

discussing the possibilities of results while the research is being done. These are ways of trying to bridge this knowledge gap, but it is also there in the Netherlands, I have to admit.

Ms Groves: In the Netherlands, my feeling is, there is a better set up for linking universities to industry. Going back to your point, yes, the industry is there to make a profit but it is then part of the economy, so it is important that we have successful industries. The universities are there to conduct fundamental research but, also, to teach, and there is a need for industry to link up with the universities far more closely, but I do not think you can do that easily directly because they are operating to completely different goals and at completely different levels. Maybe one recommendation will be to have some sort of set-up where you have an intermediary which can understand how the industry works but, also, can understand the fundamental science that the universities produce, and merge the two together.

Q135 Lord Haskel: There is, of course, a third element to this, and that is the regulator.

Ms Groves: I thought you were going to say "the consumer" then.

Q136 Lord Haskel: Presumably, with so much uncertainty around, and you have been telling us about the uncertainty, what do you say to the regulator? How much information do you give to the regulator about the work that companies are doing?

Dr Kampers: As much as possible. I think the role of the regulator is very crucial in building trust with the consumer. Regulatory bodies represent an objective body to the consumer and they are generally regarded as looking after the interests of the consumer. Having regulation in place implies that somebody, objectively, has assessed the risks of such products, and that means that the consumer is more likely to trust the claims and, also, the low risk of such products. I would say having good regulation is crucial to the acceptance of these technologies in food, and therefore it is my vision that both academia and industry should

give as much information as possible to these regulatory bodies in order to have the right regulation in place at the right time.

Professor Morris: I think, also, when they are regulated it should not just be on the risks and: "Is this a safe product?" but what are the actual benefits of a product, what are the health claims and are they viable claims?

Q137 Chairman: One of the points we have heard in a previous session is the question of whether or not foods incorporating nanotechnologies would require regulation under the Novel Food regulations or whether they would pass into public consumption under more general, food safety regulations. I think that we were not quite clear about the situation with regard to different nanotechnologies. I do not know whether any of you have a view about that.

Ms Groves: I think part of the difficulty with regulation is that you get into semantic arguments about definitions rather than trying to look and see whether something is actually safe or how you might label it. So maybe there needs to be a change to the nature of regulation, certainly for something as complicated as nanotechnologies where you have to look at a far wider spectrum of technologies and applications.

Q138 Chairman: That is not the view of the regulators themselves; the Food Standards Agency told us that the current framework is adequate.

Ms Groves: I think it is adequate in terms of health and of safety, but if you want to move on to regulate nanotechnologies, it needs to be more than just definitions.

Professor Morris: I think it may also need to co-ordinate the different parts of the regulation. If you are talking about food packaging, there may be concerns about whether a material can leak into a food and perhaps be certain that that will not happen, so it is safe in terms of its use in the food aspects, but what happens to that material when it is thrown away? That is an

environmental issue, but it may be a factor that is very important in whether people want to use that sort of packaging. I think you need to tie that use up over the lifetime of the product. It could happen that with use of nanotechnology across the agri-food chain, if you are thinking about nanotechnology applications in spraying pesticides, you may see the benefits to the agricultural industry but there is also the possibility of contamination or detection of the material in food.

Q139 Baroness Neuberger: Moving on, and the large question first: is there a difference between using manufactured nanoparticles and using natural ingredients that have been modified at the nano scale?

Professor Morris: I think it comes down to the question of material that is not broken down in the body.

Q140 Baroness Neuberger: So with the persistent ones there is a difference?

Professor Morris: I think so.

Q141 Baroness Neuberger: The difference being mainly a difference in risk or a potential difference in risk? Or a potential difference in hazard, maybe.

Professor Morris: I think it is a potential problem in risk because you simply do not know how these materials will be accumulated, where they will be accumulated and what the consequences will be. I do not think you can extrapolate that knowledge from the size of particle.

Q142 Baroness Neuberger: Should we be making a distinction for regulatory purposes between these two types of nanoparticle?

Professor Morris: I think so, yes.

Ms Groves: I think so.

Professor Morris: If you are talking about labelling, the only concern is I think the label ought to be for materials that persist in the body and are not broken down.

Q143 Baroness Neuberger: Yes, this yoghurt with nanoplatinum, which is not on the market in the EU, I understand - has that been through any trials and is that labelled?

Professor Morris: I have no idea.

Q144 Baroness Neuberger: Could we import it? Do you think that the manufactured nanoparticles will turn out to have a lot of applications in foods or will their usefulness be quite limited?

Dr Kampers: The usefulness will be limited. In my view there is very little sense in putting expensive nanomaterials in a food that the body does not do anything with. So its use is very limited, but there are examples where there is improvement on the flowing characteristics of certain food products, and, also, as a carrier for vitamins.

Q145 Baroness Neuberger: So there would be applications in the food sector, and particularly the packaging applications or the clean surface applications, but much less in foods themselves?

Professor Morris: I think for the persistent ones, I would imagine, there would be very little use at all, but you can make nanoparticles that are broken down in the body which act as carriers.

Q146 Baroness Neuberger: Do you think that a single regulatory system should be used for health and safety purposes, or is that asking too much?

Professor Morris: I would like to see any regulation of particles emphasising the health benefits as well as considering the risk. At the moment, the trouble is you have a brand name, on the internet and it says: "Nanosilver – wonderful, marvellous", but if you actually had

some sort of brand where you used those particles which said: “This does give you health benefits but there is no perceptible risk that you can detect”, I think that would be an advantage. If there was some sort of voluntary labelling of where people use nanotechnology, that might be an advantage, but I can see the objections to its use.

Q147 Chairman: Can I ask a bit more about your view on the regulatory process? You drew this distinction between persistent nanoparticles and things that are not persistent in the body. Earlier on, we heard from Dr Butler that the key point was whether or not the properties of a material change as it approaches the nano scale (he gave a graphic example of the properties of silver, which is a nice example). I just wondered, within the regulatory system, do you think that the regulation should look at the total exposure to all kinds of nanoparticles over a period of time? The temptation would be to look at each food type or each application independently and give approval to something on an independent risk assessment for that particular product, but as far as the consumer is concerned, he or she may be eating 10, 20 or 50 different products as we roll forward in time, each of which has been separately approved but their exposure is as a result of an interaction and accumulation of all these different products. What is your view about how that should be tackled in the regulatory system?

Professor Morris: I think there are two aspects. One is, again, particles that are not broken down, but, again, I would have thought that is something that is going to be fairly rare in the food industry. Certainly if you are using nanocarriers then what you are trying to do is to enhance the delivery of something, and ideally what you would want to do is optimise it and, hence, you have lots of products that are enhancing the delivery of something and you could end up having too much of it, and that would be as bad as having too little. So by having lots and lots of products that, say, enhance the delivery of vitamins, you could actually have a problem due to an over-consumption of those materials. Again, it may come back to not so

much labelling but a recommendation that this gives you a certain percentage of your daily intake of that product, and at least then people are aware that if they take more of that there could be problems.

Q148 Chairman: That is placing quite a lot of expectation on the consumer to keep track of how much they are getting from different products.

Professor Morris: I think the problem is that if you do enhance delivery then you have to think about the consequences. Particularly if it is an orange juice, say, and you are enhancing the delivery of a vitamin, people might want to drink the same amount of the orange juice when they probably ought to drink a tenth. They have no way of knowing what their delivery is or what the optimum level of intake is. People do accept now labelling that says: "This product will give you one-tenth of your expected amount of that compound in a day". I think that would be acceptable.

Dr Kampers: In my view it is a product development issue. It is not typical to nanotechnology because nanotechnology is used as a technology to enhance the delivery. But I think when you develop a product that delivers more of a specific nutrient then you have to realise that this accumulation of different products can take place. So, in my view, it is the responsibility of the company that developed this product, to make sure that there are safeguards that people do not get too much of a nutrient in some way. So it is a product development issue more than a nanotechnology issue, in my view.

Q149 Baroness Neuberger: You have already said, to some extent, that we get into terrible definitional problems with this, but would you be able to have a go at defining nanotechnologies and nanomaterials in the context of the food sector specifically? I realise that Ms Groves, particularly, has already raised your eyebrows about this. I know it is hard.

Ms Groves: It is very difficult. My instinctive reply is to say that nanotechnologies are technologies which allow you to manufacture or structure particles at a nano scale – so less than 100 nanometres. Nanoparticles and nanomaterials could very well be large structures made up of nanoparticles. It is very, very difficult (and a lot of nanotechnologies are still very much emerging; they are still at the developing stage) to define them, other than by saying they produce nanoparticles. Then I do know that there are products, not in the food area, which use nanotechnology to create nano-sized particles less than 100 nanometres which then become larger particles (in a sense, that is what you have in the packaging) and, therefore, are not a risk in terms of their size. So you do get into: do you label those as a nanotechnology when, in fact, they are completely locked into a much larger structure? I am sorry, that is a scientist's answer.

Q150 Baroness Neuberger: I think that is one of our difficulties in looking at some of that. You have all made it very clear that you think we should, in a sense, worry more about things that remain in some sense in the body and are not broken down rather than whether something is a manufactured nanoparticle or something that is a natural ingredient. Going back to the regulatory theme, how would you distinguish that? How would you state that in terms of a regulatory environment?

Professor Morris: You mean: how do you define ----

Q151 Baroness Neuberger: Yes.

Professor Morris: I think with persistent particles it is fairly easy to define what are nanoparticles; it is when its properties change – for example, when titanium changes its transparency. So there I think you can say these are particles where they have been reduced in size and their properties have changed; they are being put into food packaging or they could be put into food because they give new properties.

Q152 Baroness Neuberger: You think there it is really easy?

Professor Morris: Yes. I think when you are talking about manipulating structures in food that are naturally there it is nanoscience, but the actual technology may be a conventional technology, which you understand.

Dr Kampers: If you boil an egg you will change the nanostructure of the egg. How much change can you allow to call it nanotechnology? It is a very difficult issue. On the other hand, it is not difficult because the ISO definition of nanotechnology and the OECD definition of nanotechnology are fairly good definitions; it is just that they are virtually useless from a regulatory point of view, and that is the issue. So the difficulty is in finding a definition that can stand up in a court of law, that provides you with sound criteria to classify whether something is nanotechnology or not. In my view, one of the solutions could be that you look not at the size but at the new functionality which has been created by exploiting nanoproperties. Then you could say that "this is a nanomaterial". If there is new functionality created by man, by using nanotechnology or nanostructured materials, then you have a nanomaterial.

Q153 Baroness Neuberger: Would you argue that that should be applied across all sectors or was that purely, would you say, in the food industry?

Dr Kampers: No, it should be applied to all sectors.

Professor Morris: I think there is an example of a natural nanoparticle where people have taken enzymes, which you can think of as natural particles, and modified their functionality. Then they would have to go to conventional trials if they were used in food. The difference there is the methodology and the procedures are well established to test whether those materials are safe, whereas with an engineered persistent material the methods are not there to assess it.

Q154 Chairman: Before we draw to a close (and I would like to give you a chance to make any other points you would like to make), I want to go back to an earlier question which Lord May asked about the timeline, because we are hearing, at the moment, some fairly mixed messages about what is available now, what is likely to be available in two to five years' time, and beyond. Recognising that it is always difficult to predict what is going to happen, particularly when it is in the future, what I have understood is that at the moment, as we speak, there are applications of nanotechnology in the broad sense in the food industry. We have heard about the nanoclay films that are used in beer bottles, for example, and we have heard about the metallised film in potato crisp packets that involve nanotechnology, and we were told in a seminar about fridges that are on the market with nanosilver linings, and I know from one of the submissions we had from a government department that there are 17 products on the market in Germany in which nanotechnology is used to encapsulate food products. These are mainly in the food supplements industry. So there are things going on now, and obviously with the internet there are things that you could buy in this country whether or not they are manufactured in this country. So that is my understanding of where we are now, and I would like to ask whether that is your understanding of where we are now. Perhaps you could be a bit more explicit about where you think we will be, say, in three to five years' time. Will we be in about the same place or will things have changed dramatically, in your judgment?

Professor Morris: I think in five to ten years' time there is a real prospect that nanoscience understanding of foods will have generated a range of new foods that have health benefits or protection against disease, improving lifestyle into old age. I think that is a real possibility. They will be prepared by conventional technology through an understanding of how to do it.

Dr Kampers: I sometimes compare nanotechnology in general - not in food - to electricity; we are at the stage now that we know how to make a light bulb, a resistor and a coil, but we

are in no way at the level that we can build a radio or a computer. The technology is very generic and that makes it very, very difficult to extrapolate into the future. However, if we look at what is happening now in food, I agree, within five to ten years' time we will see improvements in food safety, monitoring, we will see improvements in the sustainability of certain processes that are important to the food industry, we will see better packaging materials and increased shelf life, especially for fresh products, and we will see products that deliver specific nutrients to individuals. What we see in the further future is that we have to link up to the needs of the body – basically, the biochemistry of the body – and then deliver the right nutrients, and that is something that is much further on and is a very complex issue but, also, will require nanotechnology to deliver that part of the delivery end.

Dr Butler: In packaging, as Dr Kampers has just mentioned, I think we will have much more communicative packaging that will allow consumers to manage their food inventory better so that there will be less food waste, for example; there should be less examples of sicknesses from food-borne bacteria because there will be things like freshness indicators on packaging, ripeness indicators on packaging – ripeness indicators on fruit, for example, because we all know sometimes it is extremely difficult to tell whether a pear or a melon is ripe or an avocado is ripe. So I think there will be advances of that kind, and convenience and functionality, that will be underpinned by nanotechnology.

Ms Groves: I think your assessment of the state of it at the moment is right. Packaging was the first area that really developed nanotechnology for foods, and I think that will carry on. What Paul says is correct, too; I think we will be able to accurately judge whether packaged food really has gone past its safe use-by date or whether you can actually use it, or say: "That date has gone" and it goes into the tip. In the short term I think there will be developments and understanding of what happens in the gut which will lead to healthier foods, and there will probably be more food supplements out there on the internet available for people. I

think, probably, the next step-change will be taking the properties of packaging surfaces into the manufacturing and food preparation area, to make efficiencies and waste savings there and, also, make safer areas. Long term, I think, the idea of looking at manufacturing processes and how you structure foods to make them healthier or safer, because we are looking at nanotechnology, will develop better, more stable products.

Chairman: Thank you very much. Are there any additional comments that any of you would like to make before we close the session?

Lord May of Oxford: I cannot resist remarking that there was an obese character called Herman Kahn 50 years ago who coined the word "futurology", and I think, also, the phrase "mutually assured destruction". He prepared a list of the 50 great challenges confronting humanity, and in the top ten was a pill to control appetite; somewhere around 28 was worries about population growth, and I am reassured to see that maybe we are, at least, in that direction and moving.

Chairman: On that cheerful note, I draw the session to a close and thank our four witnesses for their help in exploring the issues that we have put to you today. Thank you very much for answering our questions. Copies of the transcript will be sent to you for correction before it is finalised, and of course if there are any points which you would like to follow up by writing to us we always very much welcome any additional comments in writing which will help us in our deliberations later on. Written material is published alongside the transcript, so you can add to our work in that way. Thank you all very much indeed.