HOUSE OF COMMONS

Science and Technology Committee

Oral evidence: GM foods and application of the precautionary principle in Europe, HC 328

Wednesday 19 November 2014

Ordered by the House of Commons to be published on 19 November 2014.

Written evidence from witnesses:

- Nuffield Council on Bioethics
- STEPs Centre
- Professor Paul Nightingale
- Innogen Institute, University of Edinburgh
- HM Government

Watch the meeting

Members present: Mr Andrew Miller (Chair); Stephen Metcalfe; Pamela Nash; Graham Stringer

Questions 215-303

Witnesses: **Professor Paul Nightingale,** Deputy Director, Science Policy Research Unit, University of Sussex, **Professor Andy Stirling**, Co-director, STEPS Centre, University of Sussex, **Professor Joyce Tait**, Director, Innogen Institute, University of Edinburgh, and **Sir Roland Jackson**, Member, Nuffield Council on Bioethics, gave evidence.

Q215 Chair: Can I welcome the panel to this session? It would be helpful if, for the record, you could start off by introducing yourselves.

Professor Nightingale: I am Paul Nightingale, a professor of strategy at the University of Sussex and deputy director of the Science Policy Research unit. I am giving my own personal opinions here and not representing either organisation.

Professor Stirling: Hello; my name is Andy Stirling. I am a co-director of a thing called the STEPS Centre, which is an ESRC-funded centre at Sussex, and the Institute of Development Studies.

Professor Tait: I am Joyce Tait, director of the Innogen Institute at Edinburgh University. That was previously an ESRC-funded research centre. My comments are based on the research done by that research centre over a period of 12 years.

Sir Roland Jackson: I am Roland Jackson. I am here as a member of the Nuffield Council on Bioethics. I think it is also relevant to this inquiry that I am executive chair of Sciencewise, which is supporting the forthcoming public dialogue on food supply challenges, of which I think the Committee is aware, led by GO-Science and *Which?* I am also the independent chair of BBSRC's Bioscience for Society Strategy Panel.

Q216 Chair: Welcome to all of you. Can I take us back in time a bit? In 1999, the Nuffield Council concluded that there was nothing morally objectionable about GM crops and that there was a moral imperative for making these available to the developing world. Has anything happened since then to change that view?

Sir Roland Jackson: Since that was our recommendation, I think I should start. Nothing has happened to change that view in principle. The conclusions from the work included the fact that there is an ethical imperative to look at the potential of this technology—or these technologies, because they are a basket of technologies—but, critically, alongside a whole range of other potential technologies and, indeed, non-technological solutions to wider problems. Although that report was framed around GM, I do not think one should see it purely in that context now. I would certainly refer you to our later report on emerging biotechnologies, which puts the whole thing in that bigger context.

Professor Tait: One thing that has happened in the interim is a great deal of evidence supporting that conclusion. There is now, if anything, very much stronger evidence that the crops are safe for people and the environment. I agree with Roland that GM crops are just one of a number of technologies that can contribute to food security in the developing world. The problem is that it is the only technology that seems to be consistently under attack without any risk-related justification for that.

Professor Stirling: To reinforce what Roland said, one thing that has changed is an increasing recognition in policy circles that these matters are not just about whether or not to choose a particular technology—in this case GM—but how it compares. The Nuffield Council report in 1999 about whether or not GM is ethical has been completely reframed, as Roland said, by last year's report from Nuffield saying it is about choosing between alternative strategies. That message is reinforced, for instance, in the chief scientist's report coming out later today.

Professor Nightingale: My view would be that a couple of things have changed. The science has developed massively and become much more sophisticated. That is not just GM but also a wider range of plant-related technologies. There have been advances in a range of areas. Of those, the key thing related to GM is that it has not lived up to its initial promise. If you were to go back to the 1990s, there was a lot of hype about GM, but, if we look at the products on the market today, we have not seen the huge developments that were promised.

Q217 Chair: The EU, in particular, has taken a stance in relation to GM crops. Has it had any impact on the developing world? If so, would you like to comment?

Professor Tait: Where GM crops have been grown there have been very large impacts. For example, GM cotton in South Africa has improved the prosperity of small farmers, who have been able to make an income from the use of GM cotton, whereas they could not grow that before because they could not afford the insecticides needed to protect it from insects. There have been a few other examples. Burkina Faso in Africa, I think, also grows GM cotton and benefits from it. There are a lot of potential benefits. One of the reasons we have not seen the promised benefits from GM crops is the very severe restriction on their development and use which has taken place in the interim period. A great many potentially useful developments from GM crops have just not taken place because of the restrictions on research in this area, the regulatory restrictions on their use and development in Europe, and the perception in Africa that, if they grow GM crops, they will not be able to export them to Europe. A lot of mixed incentives in that area have prevented development of the technology.

Professor Stirling: One effect of the concern about GM specifically, which is not unique to Europe, has been encouraging a relatively greater degree of exploration and investment in alternative plant-breeding technologies, such as marker-assisted breeding. As Paul said, those technologies are among those yielding some of the most productive possible applications for sustainable food production. You could say that concern over GM of all kinds has to a degree encouraged alternative strategies which are bearing greater fruit.

Professor Nightingale: My view would be that this is very uncertain; we just don't know. We do not know what would have happened in history had the regulation been different. There is anecdotal evidence both ways. On the one hand, other technologies have been pushed, but we do hear anecdotal evidence that people are concerned about markets. I would question that, in that the crops we are talking about there are not ones that would work in European markets because of the climate. Cassava is not really an issue. They are not really export crops, and there is a very large export market in the United States and the rest of the world. It is uncertain, but I am not entirely convinced that it has had a massive impact.

Sir Roland Jackson: There is now a growing issue about what counts as GM. That came out to some extent in the first part of the oral evidence. There is now an increasingly wide range of genetic techniques that can be used in crop development. There is clearly a legal definition under EU and UK regulation about what counts as GM, but that is becoming increasingly problematic. That is why a lot of people have been giving evidence to you about the potential desirability of moving more to a trait-based regulatory system that looks at all of these potential technologies, and the traits and products they produce and the way in which they are used as a better basis for a regulatory system. A lot of the things we are talking about here are not just about regulation but conversations that need to happen well before the regulatory decision.

Q218 Chair: Reflecting on your response, Professor Nightingale, when we had GM Freeze in front of us, they said there was a lack of investment in these alternative technologies. They described them as Cinderella technologies. If that were the case, the kind of developments you have described would not have occurred, notwithstanding that we would all agree about broader investment in science.

Professor Nightingale: Given that we would all agree about broader investment in science, there is a limited amount of money, so, clearly, there is less money in the pot. The allocation of resources at BBSRC and so on is a matter for them. I cannot really talk about the day-to-day decisions, but what I think they were suggesting—I read the transcripts—was that the other technologies do not have the political support of GM, so there is not a big lobby push for marker-assisted breeding. I think that was what they were arguing, but these are quite small amounts of money, given the size of the UK economy.

Professor Stirling: One of the things that came out of last year's Nuffield Council report was the importance of considering lock-in in research systems as well as technological systems. There is quite a lot of prima facie evidence that there is a degree of lock-in with GM technology specifically, notwithstanding that there are alternatives showing great promise, for instance, shown by the way policy discussions like this are framed almost exclusively in terms of GM or not. When attempts have been made to relook at the research system and find out the relative proportions of resources being allocated to different strategies, it is extraordinarily difficult. The House of Lords a few years ago concluded that it really was not satisfactory. The evidence is so poor that we cannot answer the question: to what degree are we supporting GM in this sector, for instance, or other strategies? There are reports, notwithstanding that difficulty of the evidence base, that show there is a degree of lock-in in this sector.

Professor Tait: Marker-assisted breeding is a useful technique, but it cannot do what GM can do. Quite a few beneficial developments cannot take place without GM technologies, and also some of the newer ones currently being discussed around gene editing and synthetic biology. They are useful but limited. A lot of the scientists who have used marker-assisted breeding have done so because they could not use GM. They would have used GM and got to their goal faster and more easily without having to go down the marker-assisted breeding route. So it is not a total replacement for GM.

Q219 Chair: Sir Roland, referring to the reports of 1999 and 2003, to what extent have the recommendations made by Nuffield Council been implemented?

Sir Roland Jackson: In policy terms, 1999 is quite a long time ago, and so is 2003; so I am not sure it is too helpful to look very specifically at each of those recommendations. One of the interesting ones in relation to this discussion was the recommendation in the first report that there should be an independent body, which effectively became the Agriculture and Environment Biotechnology Commission, that had broader oversight of this area and brought societal values and perspectives into the discussion, which that body did. It was abolished about five years later. I think we are still suffering from the fact that, within the innovation ecosystem, well before we get to discussions and decisions about regulation, we do not have the systems and bodies that naturally allow those sorts of

discussions to happen. The constitutions of our research councils and bodies like Innovate UK make it quite difficult—they do try—structurally for those conversations to happen.

Q220 Graham Stringer: Has the EU's application of the precautionary principle helped or hindered innovation in agriculture generally?

Professor Tait: The position has changed over time. In the beginning when we were first considering how to regulate GM crops, it was appropriate to be precautionary, because we did not have very much information about their risks and benefits. As they have been developed and used in other parts of the world and we have learned more about them, it would be very reasonable to relax the precautionary principle and make the regulatory system adaptive in the context of the new knowledge we now have about GM crop development. That is where it falls down. The problem is not so much the application of the precautionary principle through the European regulatory system; it is the political overlay on regulatory decision making that takes place through the European Parliament that prevents crops that have been approved through the European regulatory system from actually being grown and used in Europe.

Professor Stirling: It is very important that you phrased your question, rightly, in terms of agricultural research in general, because—

Q221 Graham Stringer: Did I phrase the question rightly or correctly?

Professor Stirling: You asked what the effect had been on agricultural biotechnology. What is important about that is that too often there is a tendency to answer a question like that solely in terms of GM and say whether or not precaution has helped it. If we look more broadly, as your question requires us to, it is a question of not just how fast a particular technology is going, but steering innovation in particular directions. The European Union's use of precaution in various bits of legislation bearing on GM has helped to a degree to steer innovation, not just its pace but direction, and to encourage to a degree—I would say not enough—some of the technologies I mentioned. For instance, in other sectors—acid rain, energy, chemicals—Germany, which has applied the precautionary principle for longer than any other country, because it comes from Germany, arguably has one of the most effective innovation and industrial systems in Europe, in conjunction with having applied precaution longer and more strictly. I think the evidence is that precaution helps to steer innovation in more productive ways, but as Paul said, the jury is still out specifically on agricultural biotechnology at the moment because it is early days.

Professor Nightingale: It is important to make a key distinction between the rate and direction of innovation. If you focus on just the rate of innovation and think of it as a single thing that goes in one direction, the precautionary principle will, almost by definition, constrain that. If you broaden out and think about the direction of technical change—there are various different options, some of which are more acceptable to the public than others—the precautionary principle has been applied to constrain a subset of technologies that a significant minority of the population of the EU do not want. That has

acted to prevent a science push model that says, "We've got this fantastic technology; let's push it through," even though a large section of the public do not want it. In some ways you could argue from a directional perspective that it has not constrained innovation but encouraged it, by pointing out to people that you should not adopt a science push perspective but look at what the market wants. That is a key driver of success in innovation.

Sir Roland Jackson: If you look at our evidence, you will see that to some extent we have challenged the application of the precautionary principle within the EU regulatory system. That is not to challenge the principle itself, but to say that to consider as a principle primarily of risk management and regulation only one application at a time, quite late in the innovation process, is a problem. Regulation is essentially about whether something can be done within a certain rule set. It is a legal decision; it does not say anything about whether it should be done, or whether there are better alternatives, or whether it even addresses an important challenge. That is why in our evidence we have talked about a precautionary procedure that says that those discussions which should be guided by the ethical virtue of a cautionary approach should take place well upstream of regulatory decisions.

Q222 Graham Stringer: In a second I will come back to what Professor Nightingale said. Can you expand on how the precautionary principle differs from what you describe as a precautionary procedure?

Sir Roland Jackson: It may be a question of linguistics. Whether you call it a precautionary procedure, responsible research and innovation, anticipatory governance or something like that, I think the concept is the same. It is taking a deliberative approach and bringing in diverse voices and perspectives well before you get to questions of lock-in of particular research or innovation trajectories. It is about having those conversations up front.

The other implication is that, because we are so fixated on regulation, we pile all that political and social discourse on to the regulatory system, which is why you get political debate and discussion following on from scientific risk assessment in these decisions. If we had an innovation system that allowed those discussions earlier, which probably means different ways of operating the research councils and Innovate UK, for example, we might have a different discourse and make choices that the regulatory system would then find easier to deal with.

Q223 Graham Stringer: Do the other members of the panel agree with that?

Professor Nightingale: Yes, very strongly.

Professor Stirling: Yes, I agree. There is a tendency completely to misunderstand the precautionary principle where there is a fixation on risk assessment as the appropriate approach. What is crucial about the precautionary principle is that it reminds us that

uncertainty by definition is not tractable to risk assessment, so we need to do other things. There is really no conflict between a principle that reminds us that where there is uncertainty you need to do different kinds of things than hitting everything with a risk assessment hammer. Therefore, the principle triggers that attention, and the sorts of things the Nuffield Council and many others have talked about—precautionary approaches and precautionary procedures—are followed. We are not necessarily in conflict. The principle simply reminds us how important uncertainty is. I would encourage members to look at the evidence received from various parties criticising the precautionary principle and simply check whether uncertainty has been mentioned. It is remarkable how often precaution is subject to really quite colourful criticism without mentioning uncertainty at all, because it is not regarded as being relevant.

Q224 Graham Stringer: There are very few things in life that are certain. Is it right to deal with that uncertainty by ceasing development and redirecting investment towards other alternatives?

Professor Tait: It is a good idea to have a robust system of bringing forward novel technologies so that there is competition among them when it comes to the early development phases. If you make a decision based on public engagement in the very early stages of development, where the public are not really going to understand what might happen with this new technology, it is going to be 10 years before it appears in the marketplace. People will change their minds over 10 years about what they want to see happen. If you make decisions at the very early stages about not developing particular technologies, at that point you will impoverish the innovation system and remove a range of options that might otherwise turn out to be very useful—for example, in combination with other technologies that are also coming along.

To give an example, EPSRC chose not to invest research money in theranostic development. These are nano-devices that could be both diagnostic and deliver therapies. That decision not to invest in the devices would knock off a whole range of other innovative developments in the techniques that would depend on those devices for delivery. You have to be very careful that you are not knocking out some kind of nodal technological development that could be extremely useful in 10 years' time, but it would be very hard to get the public to think outside the box in those ways. Making decisions about new technologies based on upstream engagement is not a very good way to develop technologies for the future. You need a robust array of future technologies from which society can build the best combination of technologies, because they generally do not stand as isolated innovations.

Professor Nightingale: Can I come in to defend the research councils and Innovate UK? One of the big areas in science policy right now is trying to better align the research system with the needs of society. Those needs are very diverse. They can be about environmental protection. I am concerned about jobs, and I am happy for companies to make profits. The research councils and Innovate UK have attempted to improve the alignment of the research system. I would strongly support what they are trying to do. It is a difficult process. I agree there are problems to be solved, but it is a step in the right

direction. In doing that, they have to look at a portfolio of investments, decide which ones they think have the most potential for the UK and come to you and justify their choices, but in making choices in a portfolio they are by definition going to shift resources towards some areas of research and away from others. That is something people will complain about, but from a science policy perspective it is a good thing, as long as they are correct decisions.

Professor Stirling: The question is also specifically about whether it is right to ban things and prevent development. It is important to recognise that there is no instance of the precautionary principle that unequivocally requires banning. All it does is require greater scrutiny in cases where there are potential harms and uncertainty. It does not require banning—just more scrutiny, which can have the effect of slowing down a particular technology. If you look at the story of asbestos, benzene, CFCs and chlorine chemicals, in each of these areas the precautionary approach was initially held to be obstructive in the way Professor Tait has identified with respect to the particular technology, but in retrospect it can be seen to have fostered not only more environmentally benign technologies but also ones that industry now regards as more effective anyway. It is not about banning just as a reflex; it is about greater attention, which often can have other benefits.

Q225 Graham Stringer: Professor Nightingale, perhaps you could fit the answer to this question in with what you were going to say. You mentioned in your first answer public opinion and the precautionary principle. I am not quite sure how public opinion fits in with the precautionary principle. Perhaps you can expand a little on that.

Professor Nightingale: I would agree with you. The precautionary principle is part of a toolbox of regulatory tools that we have and it is focused very much in its application on risk. The concern of the public about GM, and the work of Nick Pidgeon and other academics who have looked at how the public think about GM, is that it is not just risk. As people have said, the evidence about GM has shown that Frankenstein foods are not really an issue. Public concern has not gone away because people are concerned about other things, such as concentration in the market, the impact on developing countries' farmers and so on, and we do not really have data on that to inform a public debate.

Q226 Chair: Professor Tait's evidence was the exact opposite. She gave some evidence that said, "Here is a good outcome for African farmers."

Professor Nightingale: There is anecdotal evidence both ways.

Q227 Chair: It is either an anecdote or it is evidence.

Professor Nightingale: To my knowledge, a proper, robust analysis of this has not been done anywhere where I would feel happy coming to this Committee to say, "This is the evidence, and I am prepared to put my reputation behind it." On the good and bad effects, my experience from looking at this recently is that there is evidence either way. I am not

in a position to give you any solid advice about which way it goes. There is a lack of robust evidence, but it relates to a broader concern about the politics of the development of technology, in that there are non-risk concerns being pushed through a risk-based regulatory process that produce the strange distortions we see, which I think the Committee is concerned about.

Professor Stirling: Professor Tait gave an entirely legitimate interpretation of one strand of evidence on this, but in this area, as in many others, the evidence does not speak with one voice; it does not unequivocally determine one particular decision. I would point to other interpretations and equally scientifically valid evidence—for instance, marker-assisted selection which Professor Tait mentioned. The most promising technologies for developing countries at the moment, including scuba rice developed by DFID, come from those alternative plant-breeding strategies. I think the evidence does allow other interpretations to be drawn equally legitimately.

On the question of the relationship between the precautionary principle and public attitudes, Professor Nightingale is absolutely right about public attitudes being broader, but in one important respect precaution does chime with public attitudes. The general public tend to be concerned with uncertainty in a more open sense, whereas the regulatory establishment tends to use risk assessment to a more exclusive degree. To the extent the precautionary principle reminds us that not all forms of lack of knowledge can be addressed just by risk assessment, it is in keeping with public concerns about new technologies and you need to think more broadly than just risk assessment alone.

Professor Tait: There is one potentially interesting experiment that we have not done in a democratic sense. We have not actually got large amounts of GM food on the market in Europe, which we could have. It would be really interesting to conduct that experiment. It would be labelled as GM if it was on the market in Europe. The public would have a choice. In a democracy, if something is widely regarded as safe, we generally allow the people to choose whether or not to put it in their shopping trolleys. It would be interesting if that was allowed. It is quite anti-democratic, given that at least 20% of the European public would like to have GM crops on the market for their use, that that is not available to them. It would be a really interesting experiment to conduct. My hypothesis would be that more than 50% of the European public would buy GM crops if they were available and labelled on supermarket shelves.

Sir Roland Jackson: To respond to that before I come back to the point about public engagement, in our evidence we pointed out the ethical value of choice. So, were GM foods to be available, there should be a choice for consumers about whether or not to buy.

Coming back to public engagement and precaution, I do think public engagement and, obviously, wider stakeholder engagement has quite a role to play. Here I think research councils have done quite a lot already. For example, BBSRC's early discourse around synthetic biology has influenced the way the research council thinks about it and its funding programmes. In this particular context you talked about agricultural strategies. A cross-council programme like the global food security programme is an ideal way to look at these issues without privileging one particular technology or another. The global food security programme itself carried out a public dialogue quite early in its formation. Again,

that came out with some quite interesting and sensible public perspectives. That threw questions back to the researchers which brought up the question of GM but in the context of other technologies and alternatives. That is a very productive way of proceeding. I see a balanced amount of that kind of public engagement as part of the precautionary procedure.

Professor Stirling: Professor Tait is absolutely right to highlight the importance of democracy in innovation as elsewhere, and I strongly support that. It is a somewhat idiosyncratic view of democracy to see it solely in terms of a right to choose a particular policy. Normally, democracy is not seen in terms of a particular policy and whether or not we can choose it, but the degree to which we can choose across a range of possible policies. Therefore, in that respect, democracy and innovation encourage us to look at portfolios in the way we have been talking about.

Q228 Stephen Metcalfe: I hope I am listening to you very carefully, Professor Stirling. I think the general wider argument you are making is that the debate we are having is too binary; it is about GM food, yes or no. What I think you are trying to say to us is that we need to broaden that argument—that there are other technologies—and look at GM in relation to those. That seems to conflict with perhaps some of the public statements you have made previously where you are saying that GM locks out innovation. Can you expand on why you think that exploring GM as a technology locks out exploring other technologies?

Professor Stirling: The important thing about lock-in and crowding out is not specific to GM; it is a general feature of technology and innovation in general. It has come out in the Nuffield Council report and many other studies, so it is not a concern unique to GM. An alternative to GM, if it were brought in on a large scale, would potentially show that as well. So GM, in that event, might say, "Hang on, chaps; let's take a closer look at this." Therefore, it is not a particular argument against GM; it is an argument against allowing a research system to become too dominated by any single option. One key requirement is that we have information about the degree to which the research system is, indeed, disproportionately resourcing an option. I mentioned earlier the House of Lords Committee, which said that, unfortunately, we do not have that information.

Q229 Stephen Metcalfe: I am not sure I understand how the emphasis on GM is locking out the other groups who are exploring other areas.

Professor Stirling: There are many different mechanisms—it would take a long time to go through all of them—that are very well understood and explored, but one simple one is resources. Resources are limited: £1 million spent on that option is, by and large, £1 million not spent on another option within a particular sector. There are obviously complicating factors, but by and large that is the kind of process; it is quite straightforward really.

Q230 Stephen Metcalfe: To go back to Mr Stringer's point about the precautionary principle, I think you said that that would guide innovation away from GM and towards

alternative technologies, such as marker-assisted breeding. Can you expand on that? Is that not just doing the same, flipping the coin round the other way?

Professor Stirling: Because of the uncertainties that Professor Nightingale rightly mentioned, my evidence to you would not be that precaution would definitely have one effect or another. My evidence to you is that precaution definitely allows us to steer innovation, in general, more thoughtfully than just proceeding via risk assessment alone, for reasons that Sir Roland Jackson said. That is the essence of my point. I do think there is good evidence that other technologies display a lesser degree of uncertainty than many GM products, so to that extent one might expect precaution to encourage greater attention to those other technologies.

Q231 Stephen Metcalfe: Is your objection to the technology itself or the way it seems to have dominated and been commercialised and developed?

Professor Stirling: Thank you for asking the question in that way, and also for the very good summary of my view that you gave at the beginning, which was accurate. I am not objecting specifically to GM but the way in which the debate is being conducted, which is unduly and irrationally fixated on GM or not to the exclusion of a balanced consideration of a variety of alternative innovation trajectories.

Q232 Stephen Metcalfe: I have just been given some numbers showing the amount being spent on research into GM and other alternatives. You said that GM dominated the research market. That does not seem to reflect the numbers I have here, which show that about £4 million is being spent on GM crop research and £70 million on other technologies.

Professor Stirling: It would be very interesting to go through those figures with you. It is quite complicated, because a lot of the technologies are generic and there are all sorts of different interpretations. I am sorry I have said it now a number of times already, but the House of Lords Committee when looking at the research priorities, including GM, did draw the conclusion that the evidence base was insufficient. It is quite remarkable that we do not have robust data. One can find anecdotal data in there. Reports that have tried to look at that have drawn the conclusion that there tends to be a predominance of GM at the expense of other technologies, but it is problematic. As I said at the beginning, it is uncertain.

Sir Roland Jackson: I suspect those figures come from the evidence given by BBSRC earlier, or that sort of source. Obviously I cannot speak on behalf of BBSRC, but the point was made in their evidence and by Professor Ottoline Leyser that a lot of fundamental research these days in bioscience and plant bioscience requires GM techniques. That is broadly supported by almost anybody.

The particular investment in bringing those techniques to the development of a crop trait that you might commercialise is relatively small; it certainly is in the UK. Maybe we do not have the precise figures and maybe there needs to be a bit more work done there, but looking at the balance would be interesting. For example, I know that BBSRC is very

conscious of other approaches—for example, the importance of soil science in which it has huge research capability. There is an issue to be teased out there. Maybe we do not have the whole of the evidence, but I do not think there is a massive spend on GM application per se from the UK research base.

Q233 Pamela Nash: Good morning. I would like to look at risk and explore further some of the issues we have already looked at. Can I ask about the regulation generally of new technologies? How do you think this should vary in accordance with our understanding of the potential consequences and the probability of them happening? I know, Professor Stirling, that we already have extensive evidence from you already. It would be of interest to know what the other witnesses think first before I ask you.

Professor Tait: I referred earlier in these discussions to the need for the regulatory system to be adaptive if it is precautionary and very strict in anticipating negative impacts at the beginning of the development of the technology. Once we get more information about the relative safety of that technology, we should be able to adapt the regulatory system so that it takes account of that relative safety and does not impose unnecessary regulation on following developments coming through into the regulatory system. That adaptation is not yet happening in the regulation of GM crops and related products in Europe. A very interesting precedent is going on just now in adaptation of the drug regulatory system by the European Medicines Agency and also the Food and Drug Administration in the United States to adapt it to make it easier and faster to develop new antimicrobial drugs to deal with the problem of antimicrobial resistance, for example. That has been happening very effectively, to the extent that the pharmaceutical industry no longer sees the regulatory system as the main problem preventing it from developing new antimicrobial drugs. I think that, if we adopted a similar process in the area of agriculture, we would see a flourishing of a lot of innovative technologies around crop development in a way that is not happening at the moment.

Professor Nightingale: In terms of the regulation of new technologies, my position would be very strongly the default position, which should be to let the market decide. If consumers reject technologies, Government should not subsidise industry to try to force them on to the public. Our traditional view, as I said in my submission, is that if the public reject a technology the problem is with the technology, not the public. There seems to be something very strange going on with GM, in that we are ignoring market forces. I would suggest that for the vast majority of technologies we let consumers decide.

Q234 Pamela Nash: Consumers often depend on Government and regulatory processes to protect them and inform their purchases and their decisions. Should it not be the other way round?

Professor Nightingale: There are two areas where that does not apply. One is where there are potentially dangerous products and lack of information on which consumers can make informed decisions. Pharmaceuticals would be the classic example. There I think it is very important for Governments to come along, and I think they play a really important role in supporting innovation. Without the trust in products by Government independently saying,

"This is safe," there would be problems getting those products on to the market. Another area of concern is products where there is a risk of irreversible and significant harm, and in those instances we should apply the precautionary principle. First, let the market decide; secondly, if there is a risk of harm, or difficulties with information, it should be regulated; and, thirdly, it is only under conditions of irreversibility and significant harm that the precautionary principle should be applied. So, if there is no risk, the default position should be to let consumers make their own choice.

Sir Roland Jackson: I am not sure the market has been given the full opportunity to decide at the moment, which is probably part of the issue. It is interesting to go back to the very first GM food product marketed in this country, which was the Flavr Savr tomato. That was marketed alongside a non-GM variety and was clearly labelled. That gave customers choice. That was eventually withdrawn after other political discussions intervened and the whole of GM became the issue that it currently is.

Professor Stirling: All markets are structured by institutions in one way or another, so it is not a question of either/or but what kinds of institutions structure the market. Following Professor Tait's remarks, the pharmaceutical industry has been following something remarkably like precaution long before it was called that. It is an area in which a particular degree of caution about adverse effects, for good reasons, has been in place, and has not noticeably restricted innovation. It is one of the most important areas of innovation we have.

One of the effects of regulation is also to help with lock-in. There is a very well established understanding that, if regulation is based too much around the risk assessment of particular technologies, it does not restrict them but has the effect of locking them in. We see that in all sorts of chemical regulation where it is difficult for new entrants to come in. It is a complicated business. Regulation of a particular technology does not necessarily restrict it; sometimes it can make it difficult for others to come through. One of the reasons why that is important is that, in an area like the one we are talking about, the innovations—GM and others—are not just technological. There are also all sorts of organisational innovations in developing countries around seed selection, open source sharing and agricultural extension. There are all sorts of innovations that, according to the international agricultural assessment a few years ago, offer some of the most promising innovations for sustainable food production that are not technology based. They all require technologies of various kinds, but, if we have an unduly technology and regulatory-focused approach, we can miss out these other kinds of innovation that often offer bigger promise.

Q235 Pamela Nash: How could we improve the regulatory process here and in the EU?

Professor Nightingale: That is a very big question. The regulation at EU level in this area is a very complicated process that is extremely political. Particularly in relation to GM, certain nations have very strong political views and that complicates the process. I could study European regulation on this for 10 years and still come here and not be able to tell you anything really that informative about it. It is very difficult to unpack what is going on in Europe in this area.

Q236 Pamela Nash: Is there not a way to improve it immediately then, if it is unnecessarily complicated?

Professor Nightingale: I cannot think of an obvious solution to what seems to be quite an intractable problem, but it is the nature of democratic decision making in institutions that are not particularly democratic.

Professor Tait: The kinds of initiatives happening in the health-related area just now that I mentioned are the fast-tracking of drugs that will meet particular societal needs. You see that happening in the case of Ebola at the moment. Precedents have already been put in place for things like developing drugs for AIDS, for example, where there is an urgent societal need. These precedents are now being adapted to make them effective in Ebola. How can we bring these products to market, not in an unsafe way, but in a way that prioritises that development rapidly over all the other developments coming through the pipeline, so that it does not have to wait in the queue? That queue-jumping approach to regulation is a very effective way of fast-tracking something—a very effective way.

If there was a GM product that, for example, would avoid 26 sprays of fungicide on potato crops each year, there would be every justification for fast-tracking that through the European regulatory system. That kind of thing—avoiding a large number of insecticide sprays—could take place, building on the precedent that has already happened in the drugs industry.

Sir Roland Jackson: Another way of looking at it is that, if you have a major issue like this in a democracy, one of the solutions is to reframe the problem and look at it from a different and broader angle. Although a solution is not immediately practicable, to look at the whole issue in the context of global food supply and global food security, ask the questions in those terms, and have those discussions well before you think of restructuring regulatory systems, seems to me to be a possible way forward.

At the moment, within both the regulatory and innovation Government systems we hear very strongly the voice of academics of all disciplines and particularly private sector business. We do not hear so clearly in an integrated way the voice of the rest of civil society. It tends to have to shout from the sidelines, because it is not involved in Government structures. Although it is engaged through processes like stakeholder dialogue and public dialogue, it still is not inherent in the system that those voices have a place at the table. I think that is one of the reasons we have the problems we do. It is very difficult to have those conversations, but people need to start having them systematically and to see how that feeds through into choices about the way we address big global challenges like food security.

Q237 Pamela Nash: Looking at your written evidence, is there a way we can improve this process and regulation to take greater account of uncertainty and ignorance as well?

Professor Stirling: Sir Roland's point is crucial, because public engagement in more serious forms in the way he has just been proposing also has the effect of putting scrutiny

on regulatory systems to be more diligent; so it can have the effect of the regulation being prompted to take more account of uncertainty.

With respect to European regulation, with which you began your question, it is not self-evident that simply because there are different outcomes in different places the system is dysfunctional in the way that Professor Nightingale suggested. It is the case that not only are there different attitudes, opinions and values in different sectors, which are legitimate reasons for different outcomes—because a science does not tell us what to do and so values are relevant, even where we have a good science base—but the ecological and agronomic settings in European countries are very different, such as whether or not there are weedy relatives of a particular crop. In the case of Austria, with its alpine agricultural systems and a lot of organic farming, its market position would be seriously compromised by any kind of perception of cross-contamination. This is not just prejudice; it is quite hard-nosed thinking going on, leading, perfectly legitimately, to different conclusions in different ecological settings.

Q238 Graham Stringer: I do not know whether you are the fourth or fifth panel we have had. I find that the discussion around the precautionary principle is difficult. That may be partly because some of the criticism of it is really a criticism of monopoly capitalism, not genetic modification itself. Do you think the debate would be helped by separating out religious objection and objection to multinational agribusinesses from the scientific debate?

Sir Roland Jackson: I do not think you can separate them out.

Professor Nightingale: These are political choices. If political choices could be answered by science, they would not be political choices; they would be scientific questions. I am afraid there is no way of getting out of this. In these sorts of applied areas they will be politicised because of the impacts. The social distribution of risk and rewards from the introduction of different technologies affects people in different ways, and they value them in different ways. This is the problem of democracy. It is imperfect, but it is the best system we have.

Q239 Graham Stringer: I agree with that, but what I am asking is: are those debates about monopoly capitalism, which is a debate one should have in an open society or religion, hiding behind the scientific debate?

Professor Nightingale: Yes; I think that is exactly the issue.

Professor Tait: There is a kind of perverse political outcome at play here, in that the more onerous you make the regulatory system, the more difficult it is for small companies to get through that to the market. That is why in the life science areas, where we tend to have really rigorous regulatory systems, very few small companies are able to develop dramatically new technologies and take them all the way through to the marketplace. If you look at the amount of radical innovation that has happened in information and communication technologies, where there is very little regulation on new companies bringing stuff forward, you have had several generations of radical invasion coming in and

completely changing the innovation ecosystem with these technologies. You have not had the same degree of radical innovation coming through in life sciences, for the reason that there are very onerous regulatory systems that prevent small companies from developing their ideas in any way other than through a multinational company.

So the small companies active in this area are all serving the innovation strategies of the big multinational companies. What gives the big multinational companies that dominance is the regulatory system that has been frequently made more strict and time consuming in response to public pressures. The same public also say, "We don't want big multinational companies to dominate this area." The whole area would be very much more able to meet the general perceived needs of the public in terms of what GM crops could deliver if more small companies were able to deliver products directly into the market other than through the big multinationals. It is a circular argument, but I think the pressure point where you can achieve change is through the regulatory system. If you can bring down the costs sufficiently, small companies will be able to operate in that area and deliver totally unexpected and new innovations that are very relevant to societal needs, but it cannot happen in the context of a strong, robust and time-consuming regulatory system.

Professor Stirling: Whether small or large, it is a fact of life, and it is not necessarily a bad thing, that corporate decisions—commercial private decisions on which technologies to invest in—will be driven by considerations that do not necessarily match the public interest. For instance, there will be a tendency to invest more in IP-intensive technologies where you can accrue royalties on the patents. There will also be incentives to invest in technologies in the field of GM where you are selling a pesticide and you can develop a crop that has an association with it. Those are incentives in the private sector, small or large. While not decrying that, there is a reason for public policy wanting to say, "Hang on a minute. Let's make sure the market works in a way that doesn't necessarily let those technologies that happen to provide those benefits from dominating."

You ask about separating science from politics. I think that, in the end, there are very specific ways of interrogating the science that are crucial. Science is important, but it never gives us the sole answer, and in GM there are scientific grounds for asking questions that are not asked elsewhere because the processes raise scientific issues that are not raised elsewhere.

Q240 Graham Stringer: That being irreversibility.

Professor Stirling: There are a number of ways in which the process of GM inserts particular constructs into plants that may vary very differently. For instance, a very large fraction of the population has food sensitivity. We have not got tests for picking up in advance those proteins that can sensitise us. At the moment, a large number of people all over the world avoid foods that they have learned from experience they are sensitive to, but in GM, uniquely, the same construct is inserted across different varieties of crops. They may be staples, but you do not know which construct it is, even if it is labelled GM. As to routine risk-mitigation strategy, this is not necessarily a reason for not developing it, but it is a reason why GM of various kinds does have scientifically-grounded reasons for asking other questions. In the end, the issues are political as well and we cannot fully

separate them out. We have to recognise that we need to link all these things and interrogate them together.

Sir Roland Jackson: I am not entirely sure how different those questions are. It does depend on the particular application of GM, trait or whatever. I do not think we should assume that plant and crop breeding by non-GM technique does not also lead to unintended consequences, because there are plenty of examples of when it does. I come back to not fetishising GM in this particular case but looking at the genetic change on a case-by-case, trait-by-trait and context-by-context basis, making decisions on that basis rather than a general assumption that GM has a particular set of problems associated with it, which I am not sure it does.

Q241 Graham Stringer: We had that debate with a previous panel about whether specific targeted genetic modification was in any way different from randomised cross-breeding modification.

Looking at the scientific side of the debate, what additional knowledge would need to be available for you to draw the conclusion that universal precaution was no longer necessary to be applied to GM? Is there any level of knowledge that you think would give us the green light not to use the precautionary principle?

Professor Nightingale: The precautionary principle is conditional: if it is irreversible and there is potential for long-term significant harm. What it asks is that, under those conditions of uncertainty, let's keep our options open, go out and do a bit more research and find out what we can. As that has taken place over the last decade or so there have been changes in our concerns. I am not sure that with the precautionary principle there would be some evidence and you would stop, because we would never have that degree of certainty. I imagine there would be situations where we would have concerns and do research, which would show that those concerns are not really an issue. We would then put it on the back burner and allocate our resources somewhere else. Science is not able to prove with certainty that something is not risky, but we live most or all of our lives in conditions of high levels of uncertainty. As long as we keep options open and have monitoring surveillance, it is not really an issue. I think GM will always have to have a precautionary approach just in case something bad does happen that is unpredictable, like Rumsfeld's unknown unknowns, but as concerns are raised or reduced the allocation of resources should follow that.

Sir Roland Jackson: Not just GM—all plant breeding of that nature is uncertain. We will never remove all uncertainty; we will certainly never remove all ambiguity about the other issues that people bring to the discussion, so, again, this single-minded focus on GM is not terribly helpful.

Q242 Chair: Let's push you a little further, Professor Stirling. What additional knowledge would convince you that a GM crop is as safe as a conventionally-bred crop?

Professor Stirling: With respect, the thrust of our evidence has been that that kind of question is not the appropriate one in a democracy.

Q243 Chair: But it is an appropriate question because I am asking it from the Chair here, so I want an answer to it.

Professor Stirling: You have absolutely every right to ask the question and I will answer it, but to ask such questions specifically about GM without attending in a balanced way to the variety of options available can lead to problematic results. I will answer your question; that is what I am here for. For reasons that have been given very eloquently already, there is no level of knowledge that can be guaranteed to justify any particular option, GM or not.

Q244 Chair: We accept that. I want to push Professor Nightingale. He said that if there was no risk we should let the consumer decide. Actually, there is no foodstuff where there is no risk. You would kill the Scottish whisky industry overnight if you really meant that, and you do not intend to say that, do you? What do you mean?

Professor Nightingale: The introduction of the first GM tomato paste was done in a well-managed way. The companies involved did it well. As a consumer, I went to a supermarket and trusted it not to sell me something that was dangerous. I bought that product. It was uncertain, but I do not have time to worry about every single risk I am confronted with, and I delegate it to supermarkets to be responsible for looking after those risks and trust them to do it. So far I have been very happy with that. Other people have different levels of trust and are more concerned. I think that in a democracy we should respect those views, but the evidence from Nick Pidgeon's work suggests there are people out there for whom no amount of evidence will cause them not to be concerned.

Q245 Chair: What would convince you that a GM food is as safe as a conventionally-bred crop? I do not understand why you draw distinctions here.

Professor Nightingale: I have a background in toxicology, so I could go into this in a bit of detail. I am not sure that, for me, the issue has got anything to do with risk. That there are products on the market that I am likely to come into contact with when I go to the United States and eat excessively is something that I am not concerned about.

Professor Tait: This argument is about convincing a minority of the public. If you are talking about the level of risk of GM crops currently available to Europe potentially, they are well past the point where there is any regulatory justification for keeping them off the European market.

Q246 Chair: Taking your earlier answer, I take it you would accept that, when applied appropriately, the regulatory system, guided by the precautionary principle, should take account of not only risk but benefit.

Professor Tait: Yes, I would agree with that.

Q247 Chair: Can we all agree on that?

Professor Nightingale: Yes.

Professor Stirling: Yes.

Sir Roland Jackson: Yes.

Q248 Chair: We have heard in evidence on a few occasions discussion about golden rice; we have your example of cotton. Are they examples where market decisions should be determined by the balance of risk versus benefit?

Professor Tait: Yes, I would agree. There is also strong evidence of potential benefits from many GM crops.

Q249 Chair: I do not want to put words into his mouth, but I think Doug Parr said to us that under his watch he would not accept golden rice because he did not believe there was a risk-versus-benefits argument there. Are the four of you putting yourselves in a different position?

Professor Tait: I would say quite strongly that where people continue to emphasise uncertainty and risk at the point where there is sufficient evidence to satisfy most regulatory authorities that the product bears no additional risk, over and above those presented by other competing products, and oppose the use of that product, you are dealing with an ideological opposition to that particular technology. The question then becomes the extent to which you allow an ideological perspective held by one portion of the population, no matter how large, to dominate the choices available to the rest of the population.

Sir Roland Jackson: In the case of golden rice, the issue is primarily one for countries like the Philippines or Bangladesh rather than the UK. We are not going to be growing it on the Somerset levels any time soon.

Q250 Chair: I agree, but perhaps with a few degrees of warming.

Sir Roland Jackson: That is a serious point about making pronouncements in the UK about something that should be subject to social discourse in the countries and communities within which it might be planted, harvested and used. There is principled support for golden rice because there is a very obvious benefit, but there is principled objection on the grounds that it may delay or crowd out other, and arguably better, solutions for a wider range of nutrients. That is a discourse that must be had in places other than here, as far as I am concerned.

Professor Stirling: On the point that Professor Tait made about ideological opposition, if we simply look at any given area of innovation like this as if it is all about one technology or nothing, it is easy to see that concerns or scepticism—by the way, scepticism is a crucial quality control principle in science and has the same effect in society—about a technology gets called ideological opposition when it is simply a legitimate expression of concern, and democracy is about allowing those kinds of expressions to be made without calling them ideological opposition.

The question you raise about benefits is absolutely crucial. Precaution in European jargon raises what is called the fourth hurdle, looking at benefits in the ways that risk assessment does not do. Conventional regulation does not do this. Precaution, coming out of the German regulatory tradition, has encouraged us to look at this fourth hurdle of benefits, but it is not just a question of giving attention to benefits—it is scrutinising them. When, for instance, the case of golden rice is looked at—it is a complicated issue and is not over yet—there are questions to be raised. The benefits are not simply whether you have successfully included a trait in a crop but how agronomically successful is that trait. There is a lot of concern at the moment that it is not such a clear-cut case of benefits as some would maintain, but the jury is out on that. It is not a question of listening to claims to benefits and simply saying, "Let's go for it," but scrutinising claimed benefits across a range of different options. It is not looking at just one option and saying, "Has it got a benefit?"—"Yes"—"Great. Go ahead." It is more about looking critically at the claims of benefits from different sources.

Professor Nightingale: The key issue is that you would not push and look at just one technology in isolation; you look at an entire portfolio of options. As people have said, you look at costs, benefits and risks, and looking at just the risks on their own is going off half-cocked. The key issue for me, consumers and the UK is that the benefits just are not there. All this debate is rather academic if the technology is not producing products that deliver benefits to consumers.

Q251 Chair: The technology has produced a benefit to consumers. According to Professor Tait, we use that cotton and, taking Professor Tait's argument, not only has this benefited the cotton workers but it makes it a more ethical product from our position as a consumer, does it not?

Professor Tait: The reason there are no benefits in the UK is that we are not allowed to grow the crops in the UK; so nobody is developing them for the UK. We do not know what benefits might have arisen.

Professor Nightingale: My counter-argument would be that you are allowed to grow them in the United States. There has been a huge amount of money and research put into this in the US and there are not the constraints we are debating now. In that counter-factual situation, compared with the UK, the vast majority of GM crops are the old technologies, which are to do with pesticides and insecticides. The promise we were offered years ago that if you eat some cauliflower you will be cured of cancer is not very realistic, is it?

Q252 Chair: Let's leave aside the silly examples. Take the very serious one about pesticides. Don't you see that as a benefit?

Professor Nightingale: I see reductions in pesticide use as a major benefit.

Q253 Chair: So there are examples where the technologies could produce societal benefits.

Professor Nightingale: Yes.

Q254 Chair: The core of my question—I think you were all nodding—is that there are circumstances in which those risks versus benefits show up on the benefits side of the equation, and therefore the regulations ought to empower people to develop this technology.

Professor Nightingale: Yes.

Professor Stirling: There is one crucial point to consider with respect to that question, which is our vulnerability when we fixate too narrowly on a particular claimed benefit. For instance, CFCs had a benefit. They replaced other kinds of gases in propellants and refrigerants. Methyl tert-butyl ether replaced lead. There are lots of examples where we make the mistake of thinking we are replacing something because it has a benefit but do not look at the range of options for getting the same benefit.

Q255 Chair: You are absolutely right historically, but would you not agree that the world has moved on a bit from some of those examples? You cited asbestos earlier. A number of major companies ought to have been taken to task even more than they have been already in respect of their knowledge, but surely the regulatory process today is sufficiently robust to provide oversight of the development of technologies that have that kind of risk.

Professor Stirling: If it is precautionary and it requires us to look at a range of options, not just whether a particular option has a benefit but how that benefit compares with others that might yield the same benefit better. I do not think that regulation at the moment does that sufficiently.

Q256 Chair: You were saying earlier that we had to look at it more in the round. I tend to do so, representing and living in the second biggest hazard site in England. There are huge risks that are managed risks. We do not just simply trust the scientists and engineers to manage those risks; the regulatory structure provides that oversight. I see very little difference between managing those risks and managing risks in plant breeding.

Professor Stirling: The chemical sector, which I think you are referring to, is one where the benefit of not saying, "Does this chemical which replaces another have a benefit?", but instead saying, "What would be the best way to replace this chemical?", is most clear. Take as an example HFCs compared with CFCs. HFCs are a bit less problematic. Then we go for them and realise later, "If only we'd gone for hydrocarbons instead." It is the

chemical sector that has taught us the lesson: don't just ask whether this particular option has a benefit, but compare the benefit to a range.

Chair: Keep the door open.

Q257 Stephen Metcalfe: Do you think that the way this debate has been conducted over the last 15 to 20 years has allowed the public to apply value judgments to the debate in differing degrees across Europe, leading to some resistance perhaps to the cultivation of GM crops in Europe? Do you think that is a fair summary? We have gone beyond the science and have lost that, and it is now about values.

Professor Stirling: There is no stage at which a debate on any technology does not involve values. For axiomatic reasons that one can show from first mathematical principles, science is not able to deliver an unequivocal policy prescription. It is always a matter of values as well at every stage in the debate. We may perceive that to be the case, but it is and always will be the case that values are as important to science. Science is crucial and has to be taken very seriously, but values will always come in in how you interpret the science.

Sir Roland Jackson: That is what comes out of all the public dialogues that Sciencewise has supported in areas of emerging technologies, with some quite common messaging.

Professor Tait: There is also an issue here as to where and how one takes account of values. I think that is important. Values are a crucial part of the political process. What we have done since about the 1980s is mix up values with science and risk assessment in a way that has been very unhelpful. The broad spectrum of societal desires would have been better served by a process that allowed scientific judgment to comment on the risks on a scientific evidence basis and then apply the value judgment beyond that process. Therefore, you have a clearer understanding of the nature of the scientific evidence without it being contaminated in that process. It is rather like how the Intergovernmental Panel on Climate Change—the IPCC—operates. I know my colleagues will say that science is always contaminated by values. I think you are right.

Professor Stirling: It is enriched.

Professor Tait: But science does have a process of gradually weeding out the value contamination that does not accord with scientific evidence. Scientific evidence does make progress. Evidence that is contaminated by a value judgment made by scientists generally gets challenged and put right in the long run. That process is more difficult when you do not have a clear separation of political and value-based judgment.

Professor Nightingale: Do you mind if I counter that? I would disagree with that quite strongly. There are instances where you see, exactly as Andy said, that science is enriched by values. A classic example would be the development of pharmaceuticals where people have values; they want to relieve suffering and make people healthy. That is a benefit to the science and it does not go away, and that should be supported. Pharmaceuticals is an area where there are massive risks and there are benefits. It is uncertain, and it is an area

where all sorts of values need to be pushed against one another—for example, cost compared with lives saved. In that case, the public support very strongly the introduction of genetic technologies, and the regulatory system, while imperfect, seems to be working much better than it is with food. It is possible to deal with these values and still have them enriched. Important values would be the reduction of pesticides to save the environment and relieving the poverty of farmers in developing countries. These are important values that should not be excluded but supported.

Professor Stirling: With respect to Professor Tait, the idea that science can and should be allowed to deliver an unambiguous prescription for policy is itself rather an extreme value position. It is a doctrinal position in favour of science not as a body of knowledge that is open and includes scepticism, but something in which we should have faith.

Even with respect to risk—the most tractable condition of uncertainty, as it were, in certitude—in the ways Professor Tait just laid out, in order to interpret a risk assessment, even if we assume it is complete, you still have to know what level of safety you are going to require. That is a value judgment, and all the better for it. It is not a contamination; it really is something we should celebrate. But, of course, science in this area is not just about risk; it is about uncertainty. One might want to ask Professor Tait: under uncertainty, how can science be interpreted in a value-free way? What effect does an insistence that it can be interpreted in that way have on the quality of the debates and the technologies, if we simply insist that there is no such thing as uncertainty and no values? There is just what science tells us. We make ourselves very vulnerable to ad hoc outcomes from science.

Q258 Stephen Metcalfe: Do you think that the greater the level of uncertainty, the greater the level of values applied to an argument? Given the way this debate has been conducted, because of the higher degree of uncertainty, people are perhaps filling the void with values that may not apply. Leading on from that, how do you regulate a technology when so much of it applies to values? Can you begin to do that in one place, or do you need to do what Professor Tait said, which is to separate the science and then make the value judgment at a later point?

Professor Tait: I think you are saying what I was suggesting. It is not that we make the decision without including values; it is that we make it clear where and how we are including a value-based process in the decision making, making that very open and clear. We make it clear that the science says this, as we currently can have an understanding of the situation, and we feel that certain value judgments should be taken account of. That is what politics is all about; that is the political part of the process.

A few years ago the International Risk Governance Council developed quite an advanced approach to looking at these kinds of questions where value judgment comes into play. Part of the political process that takes place is that those who, for a value-based reason, do not want a particular technology to be included in the package available to us will always emphasise uncertainty. Uncertainty then becomes part of the political process. It is treated differently when it is part of a political process compared with its treatment as part of a scientific process. Science seeks to minimise the uncertainty by doing more experiments to

find more answers to the questions you are asking, whereas the political process in certain circumstances will seek to maximise the level of uncertainty in order to make a political case. That is why I am trying to keep these two aspects separate.

Professor Nightingale: Exactly as you say, the issue is about uncertainty but also ambiguity about value judgments. We can have highly risky, difficult decisions in the regulation of pharmaceuticals, but there it is clearer as to what the benefits are: it is about saving people's lives. If you are talking about organic farming in Austria, it is much harder to define the benefits and risks, and I agree that, by definition, that makes the decision-making process more political. I think the solution to that, as I think everyone would agree, is: first, rather than fixate on one technology, have a portfolio of different options; and, secondly, open up the decision-making process as far as possible and support people who are not normally part of that, including questions about the definition of what should be in the portfolio. That was applied on the first introduction of the tomato paste. It has not been applied since. It is applied in other areas and seems to work successfully. It would then avoid the obsessive focus on GM and risk, and we could have a more informed debate about costs and benefits.

Q259 Stephen Metcalfe: Is there anything actively you wish to add to that?

Professor Stirling: Values are not just invoked when we oppose a technology but also when we promote it. It is equally a value-laden judgment to promote a particular technology to the exclusion of others.

Sir Roland Jackson: A lot of plant bioscientists and crop scientists take a very value-laden approach to this, in the sense that they want to make and believe they can make a real difference to people and the environment—crops and so on—through using GM techniques. That is a perfectly reasonable stance to take—and a very welcome one. They really do believe they can make a difference. That comes up against all the issues we discussed here, and then people need to be able to talk about the values driving them and the impacts in these broader terms.

Stephen Metcalfe: Thank you very much indeed.

Q260 Graham Stringer: We have talked a lot about public engagement. I do not think there is any disagreement that, at the end of the day, when you have a body of scientific facts and you want to make changes in how society is regulated and what laws we have, the public must have some understanding of that body of scientific fact. How do we improve public engagement and understanding of science in general and, in this case, GM foods? How can we improve that interaction?

Professor Stirling: There are several things.

Q261 Graham Stringer: I know it is a big question and we are short of time.

Professor Stirling: I will just pick up a couple. One is to recognise that developments in the area of innovation are as much a matter for democracy as other areas of policy, because it creates a demand for the outcomes of these kinds of processes. Where we think it is simply about science and risk it is not really clear why we would do this. It sounds like political correctness or just cynical justification, when in fact the choices of technologies are equally a matter for democracy as anything else. If public debate and Parliament were to be clear about that, we would immediately see the value.

The second and last point I would make is that public engagement is no more able to give us the answer than risk assessment. We should not get too romantic about it. It has all the same kinds of propensities to give certain answers in certain conditions. I think that the way to handle that is to see public engagement not as a way to crank out a consensus answer, but to help us understand better the kinds of values that lead to one conclusion and those that lead to another. The devil is often in the detail, and public engagement can help us explore and open up a space in which there are more accountable decisions. The two things would be: recognise it is about democracy, and use participation to open up and not close down.

Sir Roland Jackson: I would agree with that. In a sense, any democracy just requires continuous conversation. The fact that so many scientists, particularly those in the plant bioscience community, are coming out and talking, and explaining it personally and through the media and so on, is absolutely vital. Equally vital is what comes back from those discussions and how people, individually and institutionally, reflect on what comes back from the public or more organised groups of stakeholders. There is no shortcut, but it is another example of the fact that this scientific and innovation enterprise is indissolubly connected to that wider societal conversation. I think scientists are now picking up that challenge.

Q262 Graham Stringer: Professor Stirling, you were not very happy about the terms of reference of this Committee's inquiry into GM technology. Is there anything that you think we have missed, or you would like to add, or would advise us on in our conclusions?

Professor Stirling: Thank you for asking that. Yes, we were concerned about the terms of reference being unduly framed around GM in an imbalanced way compared with other options. As you would expect, I have been following the proceedings quite closely, and I have seen the Committee move beyond that framing in ways that I certainly would welcome. Thank you for inviting me, for instance, to speak on the consequences of the evidence we gave. The way I have seen the inquiry being conducted does attend to the kinds of issues and concerns we raised at the beginning. For instance, the discussion we have had today very much addresses that. I cannot see, as a result of that move in the remit, that enormously important issues have been left out. Thank you for being broader.

Chair: Can I thank the panel for their attendance this morning? It has been a very interesting session? We will now move straight on to our second witness.

Examination of Witness

Witness: **Professor Sir Mark Walport**, Chief Scientific Adviser to HM Government and Head of the Government Office for Science, gave evidence.

Q263 Chair: Sir Mark, welcome back to the Committee. Thank you for appearing before us for the second time in two weeks. On this occasion it is a totally different subject. I know you have been following our inquiry. I do not want to detain you too long, but there are a few key questions we want to follow up. The first is simply to ask what involvement you have had in the development of Government policy regarding the use of genetic crop technologies, and food security issues more generally.

Sir Mark Walport: As you know, my job is to provide scientific advice to the Prime Minister and members of the Cabinet. Part of that advice, at the request of the Prime Minister and the Cabinet, has been to provide advice on GM technologies. We did this through working with the Council for Science and Technology and wrote a letter to the Prime Minister, which was published on 21 November 2013. Alongside that, we commissioned Sir David Baulcombe, a very distinguished plant scientist, and a group of his colleagues who had been involved in writing a previous Royal Society report on agricultural technologies, to produce a report for the Council for Science and Technology. That was published a little bit later, in March of this year. We have provided a quite significant evidence base to enable the Government to formulate their policy.

Q264 Chair: Do you consider that policy to be an evidence-based policy?

Sir Mark Walport: I do consider that to be an evidence-based policy—indeed. The science is clear, and I am happy that the Government have taken on board the science.

Q265 Chair: Looking elsewhere, in Scotland, the Scottish Government appear to be saying that the cultivation of GM crops "could damage Scotland's rich environment". Is that statement evidence-based?

Sir Mark Walport: I do not provide advice directly to the Scottish Government; I advise the UK Government. Scotland has a chief scientific adviser. That is not the same as the position taken by the UK Government. I can comment only on the position taken by the UK Government.

Q266 Chair: Is there any part of the geography for which you are more directly responsible where that comment would apply?

Sir Mark Walport: I think the application of the science applies to the whole of the United Kingdom from a scientific perspective.

Chair: Thank you very much.

Q267 Graham Stringer: I do not know whether you are, Sir Mark, but I am profoundly depressed by the EU's decision not to replace its scientific adviser. Have you made any recommendations, and what do you think that we as MPs or a Committee can do about that situation?

Sir Mark Walport: I was in Brussels last week. The UK position is absolutely clear that scientific advice is important at the level of the EU Parliament and EU Commission. The important thing for the UK Government to press for, which I believe is the policy, is that there should be strong scientific advice within Brussels. I do not believe that they have finally determined what the position is on that, and it is something we need to press for strongly over the coming weeks.

Q268 Graham Stringer: As I understand it—correct me if I am wrong—this position is not going to be replaced. It was inadequate in itself. We have had the person before the Committee. She made it very clear that she was under-resourced, so there is a real loss here. Is it sufficient—I do not think it is—for the Government to take just a generalised view, with which nobody would disagree, that policy should be evidence-based? Should not the Government be pressing that that position be replaced and better resourced?

Sir Mark Walport: I think you have put your finger on the issue. The important thing is that the strongest scientific advice permeates all levels of all Governments, as far as we are concerned, because we work with many Governments. As you rightly point out, the resources available to Anne Glover were insufficient to enable her to have the maximum impact, though she did an extraordinary job and I would like to pay tribute to that. It was a pleasure to work with Anne Glover during her tenure. She did a lot in terms of assembling scientific advisers from around Europe at a recent conference in Copenhagen. But I think she would also agree that the resources were inadequate.

It is possible to debate whether having a reporting line just to the President of the Commission alone is sufficient. My role is to report to the Prime Minister and Cabinet—the Government as a whole. So the UK needs to press for a system of scientific advice that provides advice to all of the key participants in Brussels. The job needs to evolve, and I do not think it is clear what the Brussels position is on that. All they have said is that the position in its present form is not going to be replaced. There is still a lot to play for in pushing to get very strong scientific advice coming into the Commission.

Q269 Graham Stringer: If you are going to make direct representations to the Commission, will you make them available to this Committee and the House of Commons?

Sir Mark Walport: The short answer is that I had a meeting. I do not think a verbatim record was taken of it. I think the Government's position is clear on this. They believe it is important that there should be strong scientific advice in Brussels.

Q270 Graham Stringer: But that is not in writing.

Sir Mark Walport: I have not written so far; plenty of others have. There has been a very strong response from the UK.

Q271 Graham Stringer: You mentioned the Baulcombe report. I think the implications of what you said were that you supported the conclusions.

Sir Mark Walport: Yes.

Q272 Graham Stringer: That is right. What has been the impact of the Baulcombe report?

Sir Mark Walport: The Baulcombe report was very widely covered at the time it was launched. There was an event at the Science Media Centre that I attended. It was covered in the national newspapers—*The Times, The Guardian,* the *Financial Times, The Independent*, *The Daily Telegraph,* the *Daily Mail*, BBC, Sky, Reuters and the technical press—and it has been widely cited since its publication as a reliable source of evidence. It has been used in DEFRA by Ian Boyd and DEFRA policy teams. It is a widely respected report from a distinguished group of scientists. We commissioned it because we wanted the best scientific advice from the relevant experts, and that was what we got.

Q273 Graham Stringer: Are there any gaps in the current evidence base on the potential impact of the cultivation of GM crops?

Sir Mark Walport: That turns on a more general point. One of the issues is that we tend to talk about this as though it was a generic technology, which we should not do. Whether GM technology is a good or bad thing is not a sensible question; it depends on how it is applied. The question in every case is: what gene, what organism and for what purpose? Therefore, as each crop emerges, there are particular scientific questions which are resolved during field trials and other trials, and during the regulatory process. It is not that the scientific knowledge is ever complete. It depends on each organism and gene, but it is important to recognise that humans have been genetically modifying crops in random ways by breeding for millennia. Corn is descended from a plant called teosinte. Its genome has doubled; it has undergone millions of mutations, and we rightly consider the product safe to eat. If with modern technology we alter a single gene in a single well-defined place without leaving any other transgenic material at all, somehow this is considered potentially unsafe to eat.

Q274 Graham Stringer: We have received a great deal of evidence saying just that. Does the Council for Science and Technology have any further plans to look at GM?

Sir Mark Walport: We are not doing more work at the moment. Work has been done by others. EASAC—the European Academies Science Advisory Council—has also produced a very good report in this area. I am not sure that further scientific work of the sort found in the Baulcombe report is needed at the moment. This is still a fairly fresh document. While the science changes that fast, the basic principles of the science are not changing.

Q275 Graham Stringer: Was the recent triennial review of the Council for Science and Technology a useful exercise?

Sir Mark Walport: Yes, it was a useful exercise. It reinforced the importance of the council and its status as an NDPB, and it encourages us to be more proactive.

Q276 Graham Stringer: Why did it take so long? I understand it took 18 months.

Sir Mark Walport: I am not the person to ask that question, I am afraid; I do not know. I do not think anything mysterious was going on behind the scenes.

Q277 Graham Stringer: But you will be responding to its findings.

Sir Mark Walport: Yes, but largely working on them.

Q278 Stephen Metcalfe: Your first themed report in your new role is being published.

Sir Mark Walport: Yes. I will leave a copy behind.

Q279 Stephen Metcalfe: Fantastic; thank you. That is very useful. You can remind us of the title: "Innovation: Managing Risk, Not Avoiding It". In selecting that title, does that mean the Government are too risk averse in their approach?

Sir Mark Walport: No, not at all. I think it reflected the fact that during the first 20 months of my tenure in the role as Government chief scientific adviser I have repeatedly encountered issues around how risk is managed in relation to innovation. GM is an extremely good example, and it is one of the things that stimulated the production of this report. Some of your previous witnesses have contributed chapters to it. The issue is that innovation is sometimes seen as creating new risks, as opposed to innovation that is required on many occasions to reduce the risks we face.

In the context of genetically modified crop plants, it is about providing alternatives that will defend crops against pests; it is about growing crops more effectively in harsh environments. There are all sorts of benefits in making them nutritionally more effective. I do not think we have had the best discussion about risk.

One thing we may come on to is that this is a discussion as much about values as it is about science. We sometimes confuse the two. We pretend that the debate about genetically modified crops is a debate about science when the reality is that the science is very clear. It is really a debate about values. People with strongly held personal beliefs believe there is something wrong in humans modifying nature in some way.

Q280 Stephen Metcalfe: Does your report explore that?

Sir Mark Walport: The report explores that theme in detail. It explores different issues in relation to innovation. There are some innovations where the issue is who pays for it. That is sometimes an issue with vaccines, for example. There is the issue of what I have characterised as "my pain, your gain" where an innovation creates something in someone's immediate environment that appears to benefit others but not them. There is the whole issue of science and values and unintended consequences. We explore all of this in some detail. If we are to have the best conversation, we ought to be clear as to what we are talking about.

Q281 Stephen Metcalfe: I very much look forward to having a look at it. It is the process that interests me. Is it your report, or is it the Government's?

Sir Mark Walport: It is my report.

Q282 Stephen Metcalfe: Has anyone in Government seen it or signed off on it?

Sir Mark Walport: It has been seen, but it has come out only today. I do not think people have read it, but it is my report.

Q283 Stephen Metcalfe: But does it need to be signed off by the Government? Is it their policy?

Sir Mark Walport: It is not Government policy. In that respect it is analogous to the report produced by the chief medical officer each year. She produces two reports: a statutory report on the health of the nation and a themed report, for example, on antimicrobial resistance. This is along those lines.

Q284 Stephen Metcalfe: She made a very stark statement when introducing her report to us 18 months to two years ago about the risks of antimicrobial resistance. What are the key themes we should take from yours? Are you going to try to trump her and say we are all doomed?

Sir Mark Walport: Certainly not. The key message for this is that we need innovation to solve many of the problems the planet faces—everything from infectious diseases, to climate, to how we feed the planet and how we protect the environment. We need innovation to do that. In order to do that, we need the best discussion—we need a better discussion—about the terminologies so that people do not confuse risk and hazard; we need to understand when people are having two different conversations, one about science and one about values, or changes in their immediate circumstances; and we also need to have a discussion about regulation to make sure that is also fit for purpose.

Q285 Chair: Although it is nothing to do with this inquiry, out of interest, you and I have discussed before—in fact we shared a platform—school practicals before you started in your

current role. One of the themes of that discussion was the lack of training of teachers in managing risks. Do you explore that theme?

Sir Mark Walport: If that is a health and safety discussion, that is a very different matter. It is part of the educational system; it is how we frame numbers. There is a good chapter by David Spiegelhalter in the book about that. We sometimes see that x doubles the risk of a particular cancer, say. That sounds very bad, but if it changes it from one to two in a million that looks rather different. How we frame the discussion is very important as well. All of these issues are raised in here. There is no magic bullet answer to this, but we will have the best discussion only if we understand the terminology and are accurate when we use terms like "risk", "hazard" and "uncertainty". All of these things really matter.

Q286 Stephen Metcalfe: My final and slightly flippant question is: what would you like the headlines in the newspapers tomorrow to be about your report?

Sir Mark Walport: That is very interesting. One of the challenges is that this is not a topic that is simply captured in a three-word headline. It is not "Chief Scientist proposes magic solution for innovation".

Q287 Chair: Give us 140 characters and then we will tweet it for you.

Sir Mark Walport: Okay, someone here can tweet it. I suppose the title captures it: "Innovation: Managing Risk, Not Avoiding It".

Q288 Pamela Nash: Sir Mark, I would like to ask you a bit more about the precautionary principle. What is your definition of the precautionary principle, and when do you think it should be applied?

Sir Mark Walport: There are many definitions, so I do not think adding another one would be helpful. That is one of the points in itself. This goes back a long way. The Rio declaration said: "In order to protect the environment, the precautionary approach should be widely applied by states according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

I think the relevant one in terms of this discussion is the EU definition as a precautionary principle. I have got it from the EU website. I do not think it would make best use of my time to read it all out to you. There are some quite important things. When it comes to the evaluation of the precautionary principle, it "shall be informed by three specific principles: the fullest possible scientific evaluation, the determination, as far as possible, of the degree of scientific uncertainty; a risk evaluation and an evaluation of the potential consequences of inaction." That is extremely important, because there are potential consequences from doing something but equally consequences from not doing something, and sometimes the two are not considered. The EU says it quite nicely. Then it refers to "the participation of

all interested parties in the study of precautionary measures, once the results of the scientific evaluation and/or the risk evaluation are available."

You cannot argue with the precautionary principle; it makes sense. It basically says, "Do a full evaluation of the science before you make a decision," but it also says you must think about the consequences of both action and inaction. The issue is not the principle itself but its application. I am afraid the precautionary principle has been used as a method of putting a red stop light in front of innovation rather than recognising that innovation is something where you need to consider both the benefits and risks. Sometimes there may be an amber light and it may be necessary to collect more evidence; on other occasions it may be that the balance of not doing something is worse than doing something.

Q289 Chair: In the context of GM foods, what are the inactions?

Sir Mark Walport: The inactions are, for example, that a blight-resistant potato developed in this country is not at the moment undergoing further development. That is a serious problem. The consequences of inactions are that we are potentially, particularly in Europe, denying access to technologies that will help to feed people in ways that damage the environment less.

Q290 Chair: And globally.

Sir Mark Walport: Globally, much of Europe is an outlier because, as you will know, GM crops have been grown around the world for at least 18 years, and on a large scale. The imported foodstuffs that feed our animals are largely GM to a significant fraction, so Europe is not benefiting as much as it can from these innovations.

Q291 Pamela Nash: Is it fair to say, Sir Mark, that you think there has been damage to the reputation of the precautionary principle because it has been misused and invoked in situations where it might not have been?

Sir Mark Walport: The danger is that the precautionary principle is becoming a misinterpreted couple of buzzwords. As I say, you cannot argue with the principle; it makes complete sense. Look before you leap; think about what the consequences are, and what the consequences of not doing something are. I am afraid it has become terminology politicised with a small "p".

Q292 Pamela Nash: In your advice to the Government, is the precautionary principle something you still use and advise Government on? Are there any examples when you have done so?

Sir Mark Walport: It is a general principle that makes sense, but the issue is entirely how it is applied. That is what matters.

Q293 Graham Stringer: You said before that you thought this debate was really about values and not science. How do you and the Government go about informing the public of what the science is so they can use their judgment on the value judgments?

Sir Mark Walport: First, it is about presenting the science in a clear fashion. One of the consequences of Sir David Baulcombe's report was that there was a lot of clear presentation. If you looked at the media that followed the report in March, much of it was very good and balanced. If you look at public attitudes to GM in the UK, the British social attitudes survey in 2008 found that 35% of the UK population were opposed to GM; in 2014 it had fallen to 28%. Most people do not have strong views about GM crops in food. That 2014 survey showed 36% thought the benefits of GM outweighed risks; 36% had no strong feelings either way; and 28% thought the risks outweighed the benefits. Therefore, 72% of the public either had no strong feeling or thought there were benefits. We have to be quite careful about over-interpreting very strong statements about public opinions. I think that the debate when the CST letter and the Baulcombe report came out was considerably less febrile than the debate a number of years ago that preceded the GM Nation consultation.

Q294 Graham Stringer: Do you think we need more public engagement?

Sir Mark Walport: You can never have too much public engagement, but it is about the right sort of public engagement. In this report Tim O'Riordan writes very nicely about public engagement, as does Nick Pidgeon. It is about trying to have a conversation with people who do not start necessarily with very strong preconceptions, because so much of this is a value-based discussion. We have to be a bit more honest about when we are talking about science and when we are talking about values.

The broader European point is that, inevitably, values about individual innovations vary between nation states. The question is: should the values of one group of countries trump the values of another? That brings us to the principle of subsidiarity on GM, which I hope we are moving to, where GM foods can be regulated at European level but individual countries can choose to opt out of growing them.

Q295 Graham Stringer: Apart from the report, where would you direct a member of the public who wanted to learn more about the science and regulation of GM foods?

Sir Mark Walport: The Royal Society has good literature on it. If you look at Rothamsted and John Innes, the plant science community itself is good at producing documents. The Science Media Centre has held events. I do not think there is any single core of public engagement materials on GM, as far as I am aware. There is an awful lot of material out there, and sometimes one of the challenges is to recognise the status of different documents.

Q296 Graham Stringer: Do you think that the Government, over the period you have just described, have got better at communicating science? If so, in what way have they got better?

Sir Mark Walport: I think we have all got better. This is not something just for science; it is for the scientific community as a whole. We have moved from the traditional deficit model of public engagement, which basically says, "You don't know. We're going to tell you," to a much better situation where we engage in questions and answers. I think we are getting better at it. As we have discussed before, if you look at science in the media, there is much more of it than there was. There are now many professional science journalists who make every effort to report accurately.

Just going back to the Science Media event around the CST letter and Baulcombe report, the quality of the journalism was good. That probably reflects to some extent the fact that attitudes are, if anything, more positive about GM. At the risk of being repetitive, one has to recognise that there is the science and we have to communicate it clearly, and then there is the values discussion, which is a different one.

Q297 Chair: We understand that currently GO-Science is conducting a food security research project with Which? What is the project about, and what does it hope to achieve?

Sir Mark Walport: It is another aspect of public engagement. We are now broadening it to food security. If you asked a lot of people, they would not believe that in the UK there are any issues with food security. Our shops are full of food; food comes from every continent on the planet, apart from Antarctica. It is not something that is high in people's minds, and yet there are issues with food security. We have seen price surges in staple crops around the world. The supply lines for food staples cannot necessarily be absolutely guaranteed. There are some important plant diseases. There is a wheat rust, Uganda 99, affecting other parts of the world at the moment. There are challenges to plant and animal health, as I think we would all recognise. It is a partnership with Which? that came out of work of the Food Research Partnership.

Q298 Chair: Who asked whom?

Sir Mark Walport: We talk to each other.

Q299 Chair: It evolved.

Sir Mark Walport: It was a discussion. I do not know. It is another public engagement exercise.

Q300 Chair: Will I have to log on to the website of Which? to find out the outputs, or are you going to tell us?

Sir Mark Walport: The outputs will be made publicly available—

Chair: Oh good.

Sir Mark Walport—following the principle of open access. I am cautious about giving you dates because I will get into trouble if I come back and they have not been met. It will be during next year.

Q301 Chair: How do you intend the guidance from that report to feed into Government policy?

Sir Mark Walport: I am not sure that it is guidance from a report. It comes back to the fact that public engagement is not a done and dusted thing; it is a continuous process.

Q302 Chair: We have talked about this on other occasions. There could be implications for research councils, encouraging them to look at how they measure impact, and public engagement by young scientists. We could go back to the classroom and look at issues there; we could look at how we support the Science Media Centre. There is a whole raft of potential Government inputs.

Sir Mark Walport: I think that is right. I suspect the answer is: all of the above. What this will tell us is how we, the public, think about different issues connected with food and food technologies. This is not specifically about GM; it is about a whole range of agricultural and food technologies and how people think about food security. It is difficult to know what the lessons will be until we have done it, but studies like that will inevitably tell us, for example, where people find out about things.

Q303 Chair: In terms of this particular inquiry, there have been some industrial consequences as a result of concerns about European-wide regulation. What engagement did your science team have with the companies that have subsequently pulled out of European research in this field?

Sir Mark Walport: The short answer is that there are people from companies represented on groups that I engage with, but in relation to GM I did not have direct meetings with specific companies who were saying they were about to pull out of x or y. They have been part of the mixture of people that we have spoken to.

Chair: Thank you very much for your attendance this morning.