

HOUSE OF LORDS  
MINUTES OF EVIDENCE  
TAKEN BEFORE  
SCIENCE AND TECHNOLOGY COMMITTEE  
(SUB-COMMITTEE II)  
**GENOMIC MEDICINE**

WEDNESDAY 30 APRIL 2008

DR COLIN MILES, PROFESSOR VERONICA VAN HEYNINGEN FRS,  
PROFESSOR JOYCE TAIT, PROFESSOR JOHN DUPRÉ and DR DECLAN MULKEEN

Evidence heard in Public

Questions 1 - 58

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WEDNESDAY 30 APRIL 2008

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Present

Colwyn, L  
Finlay of Llandaff, B  
Patel, L (Chairman)  
Perry of Southwark, B  
Sutherland of Houndwood, L

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**Memoranda submitted by BBSRC, RCUK, AHRC and ESRC**

**Examination of Witnesses**

Witnesses: **Dr Colin Miles** (Head of Molecular & Cell Biology Branch, Biotechnology & Biological Sciences Research Council (BBSRC)), **Professor Veronica Van Heyningen FRS** (Senior scientist, MRC Human Genetics Unit, Edinburgh), **Professor Joyce Tait** (Scientific Adviser to the Economic & Social Research Council (ESRC) on Innovation in Genomics, University of Edinburgh (representing the ESRC)), **Professor John Dupré** (Director of the ESRC Centre for Genomics in Society, University of Exeter – representing the Arts & Humanities Research Council (AHRC)) and **Dr Declan Mulkeen** (Director, Research Management, MRC Head Office, London), examined.

**Q1 Chairman:** Good afternoon. Can I welcome our witnesses and also those members of the public who have joined us. Thank you all for coming. I am afraid this room is not very satisfactory for such a session. First of all, you seem to be miles away from us and unfortunately we cannot bring your table nearer for technological reasons, I am told. I hope you can hear me and I will be hoping that these microphones are effective. Sometimes they are also a problem. For the members of the public, you have some information sheets at the back which give you information about the inquiry but also about the interests declared by Members of this inquiry. To our witnesses, thank you for coming. We note there has been a

change of representation from the MRC but we welcome you both, Dr Mulkeen and Professor Van Heyningen. You probably caught an early plane this morning from Edinburgh. Welcome to the others. There has been no change in your names. We have known that you were coming. What I would like to do is for you to introduce yourselves first and who you represent and if any of you has an opening statement to make – I do not know if one of you is going to lead and the others join in, but we leave it to you as to how you intend to do that. Then if you want to make any opening statement, please do so, otherwise we will go straight into some questions we have for you.

***Dr Mulkeen:*** Thank you very much. I am Declan Mulkeen. I am the Director of Research and Training at the Medical Research Council. We had not decided to make an opening statement. We thought it was better for you to question us as you see fit.

***Professor Van Heyningen:*** I am Veronica Van Heyningen. I am a research scientist at MRC Human Genetics Unit and I have been asked by the MRC to come and represent them, but I work on human genetics.

***Professor Tait:*** I am Joyce Tait. I am Scientific Adviser to the ESRC INNOGEN research centre based in the University of Edinburgh.

***Professor Dupré:*** I am John Dupré. I am a philosopher of science, particularly biology. I am the Director of the ESRC Centre for Genomics in Society (EGENIS), but I am here representing the AHRC as the grant holder.

***Dr Miles:*** I am Colin Miles and I am Head of Molecular & Cell Biology for the Biotechnology & Biological Sciences Research Council.

**Q2 Chairman:** Thank you very much. Does any one of you want to make an opening statement? I know Dr Mulkeen said he did not intend to.

***Professor Van Heyningen:*** One thing we have all been thinking about is that it would be really useful to have some sort of definition of what is meant by “genomic medicine”.

**Q3 Chairman:** Would you like to comment as to what definition might be more appropriate?

**Professor Van Heyningen:** I think I prefer a broader definition than just looking at human variation in relation to disease, because I think all that leads us into a great deal of important biology which underlies the disease mechanisms which we need to explore in much more detail so that the variation studies which we seem to be talking about in the questions are just the beginning.

**Q4 Chairman:** Does anybody else want to comment on that definition issue?

**Professor Tait:** I would also prefer a broad definition.

**Professor Dupré:** Yes, I think we are all of the same mind, and of course it is not only that it is very much the beginning but I think it is very unclear where the end will be, so we want to leave it as open as possible.

**Q5 Chairman:** Thank you very much for that and for bringing that out. I would like to go back and start with your submissions, the RCUK submission, which states that there are significant increasing opportunities for the translation of genomic information into improved therapies, and I would like to pick up on that theme and my questioning is related to that theme. The question I would like to ask arising for that is, if that is the case, what funding is allocated to such research and particularly to the translation of such research and are there gaps for missed opportunities in any of the funding opportunities, and what proportion of this funding is aimed at the translation of genomic data into useful information for healthcare and disease prevention and have the Research Councils done this ad hoc or have there been calls put out to support this kind of funding? I know that is a long question, but I hope you got it all?

**Dr Mulkeen:** I wonder if the best thing to do is to take that in stages. On the question of cross-council coordination, from previous spending reviews we have had cross-council lined up strategies on genomics and genetics which have covered everything from the need for increased investment in genomics through to increased investment in Research Councils in social sciences and legal, regulatory and economic issues. That coordination I think has served us well and from where we see it there is a good balance of effort across all the councils. The submission we gave you included some figures for spend, I think from BBSRC. The figure we think would best represent MRC's level of investment in genomics would be £50 million as a narrow definition or £78 million if you include areas such as the genetics of cell cycle, cell division control, which you may or may not feel is relevant to every area of human cell research. Within that £78 million per annum, MRC's investment has been concentrated to a fair degree in multi-faceted centres of excellence, such as the Human Genetics Unit in Edinburgh, such as Clinical Sciences Centre and newer centres such as the Genomics and Global Health Centre in Oxford, and these serve a number of different functions. They can be important linkers for activities. The Dominic Kwiatkowski Centre in Oxford links with infectious disease and global health research across a wide range of developing countries. They can be important training and career development centres and they can provide resourced for other areas. MRC has had a substantial increase in the last spending review in the funds available for translational research and we could say more about that later, but maybe the best way to structure the answer is for other Research Councils to say a bit about what their baseline level of investment in genomics is and what the activities are.

**Professor Tait:** Yes, I could say something from the ESRC perspective about their baseline levels of investment, but I think before that, picking up this point about translation, translational medicine and translational research is becoming a discrete funding area and particularly the big charitable foundations have research programmes in translational research,

translational medicine. There is a need to make a distinction between the process of translation within the public sector for application in the Health Service and the process of translation, which is quite different, in commercial organisations where you are looking to develop a profitable product at the end of the day. In Edinburgh we have a cross-college translational medicine master's degree being developed just now and RCUK has also funded research fellows in translational medicine. So specifically in translational medicine there has been quite a lot of activity and it is an important and enlarging area. I think the Economic and Social Research Council's funding of the genomics-related medical research is within the three genomic centres, INNOGEN, EGENIS and Cesagen, which averages out at about £2.7 million per annum, so it is a major investment for the social sciences. I think it is the biggest investment in Europe and almost the biggest in the world. It is very significant and it has really raised the UK's profile in this area. On top of that, the ESRC has specific programmes on stem cells and synthetic biology and various other specific technologies which are part of this translation process. So there is a very significant ESRC investment.

**Professor Dupré:** The AHRC does not have ring-fenced funding in this area, it is just entirely responsive, but the major investment would be the centre which Professor Graeme Laurie runs in Edinburgh, but there is also a grant that I hold and some of the work is mentioned in AHRC's report. These will be the main things which I think they are currently funding in this area, but there is no ring-fenced budget.

**Dr Miles:** From BBSRC's point of view, being responsible for the funding of basic biological research in all types of living organisms, the figures I have quoted in the submission refer to the gross level of investment in genomics we have had over the last few years and the data refers to investment in lots of different types of organisms, mostly dedicated through model organisms (of which I have given examples), but practically none of that research is involved in translation to human medicine. It is all about the basic biology of

those organisms and about the technology development for genomics but none really about translation to humans.

**Q6 Chairman:** We are told in other evidence that we have had that the science of genomics is advancing at a rate where soon it will be possible to translate it into healthcare and that therefore the healthcare delivery systems ought to be preparing for this. Is there investment made in preparing the healthcare delivery systems for that, or do you think it is pie in the sky that genomics and genetics are becoming so advanced?

**Dr Mulkeen:** It is certainly moving very quickly, but we think it is important to make sure that we reap a number of different benefits from the advances in genomics. Some of the benefits it will give us will be about understanding disease mechanisms and disease pathways in ways we could not understand before, and the way in which we turn that into a benefit for health might be a quite conventional way. It might be another small molecule drug because we now understand how the network of genetic influences turns into a disease mechanism. There will be other areas, say, in assessing the environmental risk. We have seen, as I say, the impact of genomics on psychiatric genetics and the ability to understand how individual variations in COMT receptors will influence the risk of cannabis and psychosis being linked, and there will be advances in drug safety science and toxicology. Then there will be areas where we can use what we learn in genomics to better characterise some types of disease and decide which treatments are appropriate. There will be areas where we can use that to identify risk and perhaps target screening and preventative measures of those most at risk. Then there will probably be a smaller subset where there will be therapies tailored from their first design stage to address a particular genetic sub-group of the population. There are projects which MRC supports in the human genetics unit which are starting to move to link genomic approaches to screening for colorectal cancer. The number of lines of research which have reached their stage of maturity is quite small still though.

**Q7 Chairman:** So when you said earlier on that the investment for MRC is £50 million, is this broken down into the different categories you have just mentioned, or is it in one key area?

**Dr Mulkeen:** Most of the research we are doing in that £50 million could have benefits in all of those areas. Once you understand the network of genes and effects, you can translate that. You have a lot of opportunities to translate that.

**Professor Van Heyningen:** At the moment, I think a lot of disease association studies, the genome-wide association studies, are finding associations with single genes but many single genes and we still do not understand how all those work together so that things like predicting risk are still a little way off. I think there is still a lot of work to be done and some of that is going to involve quite a lot of computing power, which I understand from one of my colleagues, Malcolm Dunlop (who is a colon cancer specialist and has done a lot of this work), is not available in Britain or Europe to get all those comparisons and interactions analysed.

**Q8 Chairman:** So what timescale might we be thinking about? A quick guess.

**Professor Van Heyningen:** Ten, fifteen years.

**Professor Dupré:** There is some use of polygenic genetic testing sort of at the medical coalface and which we have done some research on. It is evident there are some real challenges in getting medical practitioners even to kind of understand how best to do this. We have looked at one gene, which is the susceptibility gene for thrombophilia and we found that a lot of people who have had tests of this kind who did not actually know they had had a genetic test. There was a big socioeconomic class relation to how much people had understood what was going on. We have also been looking at the use of family history, which in many ways now is actually a much more effective way of looking at genetic susceptibility for polygenic disease, and there again have found there is a great deal of variation in the kind

of ways this information is processed, what kind of questions are asked, how they are understood, how patients have communicated as to the relevance of this. I think there is quite a bit that could be done before major medical technologies come on-stream in terms of seeing what happens at the patient-physician interface.

**Q9 Lord Sutherland of Houndwood:** You mentioned looking at the family history there. Is this being done systematically? I know about the Generation Scotland initiative in the four centres in Scotland. Are there other centres of that kind focusing on family history particularly?

*Professor Dupré:* I am not aware of it being used in a systematic way, but other panellists may be. We are exploring the possibilities for its use.

*Professor Van Heyningen:* In the colon cancer studies which are being done in Edinburgh they certainly get the initial entry into the system by having colon cancer at an early age, but then the families are investigated in some detail. So this is a sort of progressive analysis of risk and perspective risk as well in some cases.

**Q10 Lord Sutherland of Houndwood:** So that will be done after diagnosis rather than a national type survey?

*Professor Van Heyningen:* Yes. They come in through being affected and then, partly because the family information is so readily available in Scotland, they follow them up.

*Professor Dupré:* What we are looking at is prospective cardiovascular disease and there is a very good indication that this is helpful as part of a general risk assessment, but how you use it is open to some debate.

**Q11 Baroness Finlay of Llandaff:** I think my question focuses a little bit on your later answers, because I wanted to ask you about diagnostics. The diagnostic industry is playing an

increasingly important role in the translation of laboratory-based research into practical and cost-effective tests for clinically relevant genetic variations. I wonder if you could tell the Committee how the Research Councils themselves are supporting research into this area and if you can give us some examples of specific projects which are being funded by the Research Councils rather than those which are being generated through industry?

**Dr Mulkeen:** I will say a little bit and I think Colin will want to say a bit as well. We have issued over the last 24 months two calls for proposals on biomarkers looking at academic groups, hopefully in collaboration with industry in many areas, which can bring forward proposals for identifying ways of either identifying disease at an early stage or for monitoring the progression of disease and response to treatment. It is important to remember, though, that very often genetic understanding will lead us to understand the mechanisms of disease, that the right tests or the most economical and robust tests may be based on a bio-chemical or some other downstream consequence of having that genetic trait. So the number of biomarker projects which involve collaboration with industry on genetic tests rather than other tests is quite a small proportion of the total. Certainly what we are hoping to do is to get more and more industry interaction in this area, and with the increase in money we have got and are spending in resettlement for translational research diagnostics as well as therapy will be a key area for us.

**Dr Miles:** Although BBSRC has no current examples where we have got projects with the express intention of developing diagnostics, in the quite recent past we have supported a link programme with the MRC called Applied Genomics Link and the link programme, as you may be aware, is one where the companies and the public sector fund projects on a 50:50 basis. There is a number of those projects which might eventually feed through into diagnostic tests. Rather than go into each one of those individual programmes, what I have done is I have printed out some information for you and I will leave this for you at the end. It

describes half a dozen projects where there might be the development or leading to the development of a diagnostic test with the company, and all the companies involved in these seem to be SMEs. That is just for your information, but I shall leave that for you.

**Q12 Baroness Finlay of Llandaff:** Just thinking ahead and trying to be predictive, given that the biomarkers are probably much easier and more defined to pick up and your comment, Professor Van Heyningen, of not having the computing facilities to really do the complex genomics, do you think that genomics are realistically going to be part of future diagnostic research or do you think we will actually be looking at the understanding of the gene and then the biomarker that comes from it being a more refined test in terms of clinical diagnosis?

**Professor Van Heyningen:** I think probably under different circumstances for different diseases both of those scenarios will be correct, that in some cases we are going to have to carry on looking at the level of the gene, at DNA, but in other cases I think it will be much better to go back to perhaps very old-fashioned biomarkers, which can often distil the effect of multiple genes but actually it is the biomarker level that is the critical one. So I think the new knowledge is going to allow us to understand in much more detail what it is that we should be looking at, at relatively simple diagnostic levels in many cases but not in every case.

**Dr Mulkeen:** In looking at the overall landscape of the UK science base and its interaction with industry, I think we would certainly agree that this is an area where there is a lot of, as yet, unrealised potential both in genetic technology, biomarkers and other markers. It is an area where we would really like to see a lot more academic industry collaboration in the coming years.

**Baroness Finlay of Llandaff:** Thank you.

**Q13 Lord Sutherland of Houndwood:** I want to go back really to the Chairman's opening question about funding, but to expand that a little bit. That was specifically on translational research. The RCUK have told us that they believe significant levels of investment are required for relevant development of our biomedical capacity in this country, which we all recognise is very high. We have a very good reputation for our work in biomedical and biological sciences. The question is, RCUK have told us the investment is needed. Apart from asking for more money from RCUK, what are the Research Councils doing about this?

**Dr Mulkeen:** It is worth highlighting a few of the areas where we see the money going in the future. Continuing to build multidisciplinary and multifaceted centres of excellence and to keep the strengths we have got will be key. The whole genome association studies which MRC has funded and Wellcome has funded on a larger scale have put the UK in a very strong position. They create an opportunity and a need to follow through with more detailed sequencing using new generation technologies, and then following on from that more work on the biological function of disease. From an MRC and also an NIHR point of view there is a need to build up not just very large population sample bases and very large cohorts but also smaller, intensively phenotyped patient cohorts, because only by having the balance of both will we be able to really tease apart the networks of effects that we are looking for. There is a lot to be done on informatics and on human capacity and skills in these areas.

**Q14 Lord Sutherland of Houndwood:** Can I just push on informatics, because again Professor Van Heyningen raised this question quoting Malcolm Dunlop? One of the things which concerns us, obviously, is competitiveness and we look across the Atlantic and the volume of cash being spent in the USA far outstrips anything here, so we have got to be quick on our feet. Is there, for example, an informatics gap there that we need to think about plugging?

**Professor Van Heyningen:** I do not fully know what funding is available for informatics. All I heard from Malcolm Dunlop was that they have got all the data with new single gene association – and this is a European project – and there is not a computer even in Europe which can cope with the volume of association analyses which need to be done. He says that they have to put on some data and then take some off in order to be able to look at the associations. But I do not know where the money is coming from or what plans there are to expand all this, but I wanted to flag it up, obviously.

**Dr Mulkeen:** Both MRC and BBSRC had good settlements in the last spending review and we are very grateful for that, and we will be reviewing with some input from BBSRC how we help our research computer access some of the newer high-cost technologies. On informatics, there are important issues around coordination and cooperation as well and the skills base. That brings us on to areas like Connecting for Health, but it might be that, Colin, you wanted to come in on that.

**Dr Miles:** I was going to start at a very broad level and say that to me there are things which RCUK needs to do for the Government, if you like, to sustain the input of funding which is going on at the moment. It seems to me that there are three essential things which the RCUK needs to achieve. First of all, we need to maintain our ability to identify and exploit new areas of scientific opportunity. That seems to be one of the main things, if you like, of having a research-led organisation. We all have our own strategy panels, we all have our own committees whose job it is to do just that, and we have long-term visions and strategies, and we have ideas which have come out of that. In the submission you will have read about systems biology as an example of a new area which is coming out and you may also have read about synthetic biology, which at the moment is a new emerging area, one which is just about coming to the fore ready for research grant support for the Councils. We also have to respond to the needs of government, providing a strong research and training base, and that is

desirable because not only does it offer the opportunity to answer and address some of the questions the Government has and to provide advice and input to the Government, but also it is an opportunity to attract investment from the private sector, particularly external investment from the private sector, if we create the UK as a good place to do scientific research. I guess the final part from this is encouraging the development of a broader skills base to encourage people to think about how they might exploit the research, the results they are producing.

**Professor Tait:** Could I just add to that? The Economic and Social Research Council has just extended the funding of its genomics network through to 2012, so our funding is secured and we are actually going to continue to do very useful parallel work on the socio- economic and ethical aspects of these new technologies as they come forward.

**Q15 Lord Sutherland of Houndwood:** Whose responsibility is it to bring thinking together on this? Is it RCUK, whatever, this great body maybe, is it the director-general of Research Councils, is it the departments, or do you just have to get together as a good idea occurs?

**Dr Mulkeen:** The first responsibility is for Research Councils to get together sort of in twos, threes, fours or fives, as needed to address the question, and that is how most of the job gets done. From time to time around big spending reviews there are very big cross-cutting issues. RCUK will facilitate that process.

**Q16 Lord Sutherland of Houndwood:** So if you need a big enough computer, no one of you will provide that?

**Professor Tait:** Could I just add, from the point of the individual researchers at the academic end of the scale it is actually proving increasingly easy to collaborate with other kinds of researchers, so as social scientists it is increasingly easy to collaborate with medical and natural scientists and there are schemes which cross the Research Councils that we can apply to, and that is an increasingly improving situation.

**Lord Sutherland of Houndwood:** Good. Thank you.

**Q17 Baroness Finlay of Llandaff:** I just wanted to go slightly lateral to that but picking up on previous responses from both Dr Mulkeen and Dr Miles. With this investment and with partnership, how much of that do you envisage providing financial returns to the UK from developments in the long-term, because one of the problems with some aspects of industry is that actually their main basis and their shareholder basis and profits basis is outside the UK? So whilst we might do very high quality research and go into partnership with them for developing, when it actually comes to providing a commercial product the UK seems remarkably thin on seeing some of the profit from that very major investment, particularly when there needs to be money back into the system over something like a major IT investment.

**Dr Mulkeen:** On the whole the biomedical sector seems to have a good track record in turning UK science into high-skill and high-tech jobs in the UK and contributing to the balance of payments and we would hope that by investing in the way we are doing we would keep the UK as one of the best places in the world to engage in research in this area, and there are certainly opportunities. There are, of course, many major biomedical companies which are not yet investing in the UK as much as they could, but I think we have a good track record here and scope to pull in even more interest over the next decade.

**Q18 Baroness Finlay of Llandaff:** But does our legislative framework work counter to that and our regulatory framework on research?

**Dr Mulkeen:** I should probably hand over to colleagues from other Research Councils there. From where I sit, I do not have detailed involvement in the regulatory issues. I do know that other countries, including the USA, worry about their regulatory framework as well, so I

would not say that the UK was the only country in the world which had anxiety about how encouraging its regulatory framework was in this area.

**Professor Tait:** I can comment a little bit on the regulation and its impact at two different stages. There is the increasing tendency for biological sciences to regulate the research itself and in that kind of area there are increasing concerns about the lack of coordination of various kinds of ethical requirements and permissions which have to be acquired before one can even begin to do the research. Veronica has already mentioned that making an even modest change in an existing programme maybe to catch up with some new science which has emerged requires going right back to the beginning again, to the ethical processes. So if we are talking about the research, then I think there are things we can do to make it easier and more productive to do the research. I think there is another whole question about how one regulates the outcomes of the research as it is developed into products. I do not know if you want me to go into that just now or to save that until later.

**Chairman:** We will at some stage go into that.

**Q19 Lord Colwyn:** I want to ask you what the MRC have done to support national activities in genomics since the closure of the Human Genome Mapping Project in Hinxton and whether in fact it is important that we do do something in view of the superior spending in the States. Is it important that we do carry on with the work?

**Dr Mulkeen:** The MRC's investment, and I think BBSRC's investment as well, in genomics has been increasing steadily over the last decade. The volume of training in bioinformatics, the degree to which we are supporting links between genomics and clinical medicine, the investment in large population cohorts and increasingly small, wealthier-type cohorts and the development of methodologies for analysing and interpreting genetic data are all areas where we have seen a lot of growth. The centres of excellence that we support, such as the Human Genetics Unit, our centres in Oxford, provide a very strong coordinating role and they often

collaborate very actively across the UK, often brokering international collaborations. So we see it as quite a tightly knit community with very good cross-linkage between the various centres and a very good collective understanding of what is needed next to move the research forward.

**Professor Van Heyningen:** There are really many areas where the MRC has very new initiatives but also ongoing ones, but, for example, some new ones to set up, an MRC centre in cognitive aging and cognitive epidemiology.

**Chairman:** I am afraid there is a vote called, so we will have to stop while the Members go and vote.

*The Committee suspended from 4.15pm to 4.23 pm for a division in the House*

**Q20 Chairman:** Can I say that I think we can safely resume again. I think I stopped you in your tracks, Professor Van Heyningen.

**Professor Van Heyningen:** I think we were talking about what MRC has done since the end of the Human Genome Mapping Project. In addition to supporting several units of relevance to the broader genomic studies, for example the MRC Human Genetics Unit but also the Mammalian Genetics Unit at Harwell and Functional Genetics Unit in Oxford and many other individual grants, and there is an MRC Biostatistics Unit and Public Health Sciences which also all feed into the design of experiments and the way in which we use the information for public health sciences. As I say, they have just established a centre for cognitive aging and cognitive epidemiology under Ian Dreary in Edinburgh.

**Q21 Chairman:** Do you all feel that the current investment in genomic science is at the level that is required on the basis that science is advancing?

**Professor Van Heyningen:** No, I did not say that.

**Lord Sutherland of Houndwood:** It would surprise us if you did.

**Q22 Chairman:** You were trying to convince me, I thought, there?

**Professor Van Heyningen:** No, I think there is a lot more to do.

**Q23 Chairman:** I was trying to get you off speaking for MRC and get you on to speaking as a scientist.

**Professor Van Heyningen:** As a scientist, I think there is going to be a very great requirement for sequencing technologies and for the use of arrays in order to analyse patient samples now, individual patient samples, and I do not think we have got the capacity for that in the UK at the moment.

**Q24 Chairman:** Is it the capacity that we need to address?

**Professor Van Heyningen:** Yes. It is quite expensive at the moment, but the price will come down. But as the price comes down, there will be more and more calls to use the technologies, so ultimately I think it is going to be quite a lot of money.

**Q25 Lord Colwyn:** Is the cooperation such that there is no duplication of work in different centres?

**Professor Van Heyningen:** I am not sure I am fully conversant with that. There is a great deal of cooperation and collaboration between different centres, especially in the clinical genetics area and the use of patient samples. I think the UK really has a very strong record in collection cohorts nationwide and that is partly because we have a very good general health service system and we can identify patients on a broad front, but the optimal patients and families are collected and have been collected for a long time, and once collected if they are collected well they can be used again and again and really you get much more benefit from studying some of the same cases again as more information comes up, so that you can go back to families. There again, I think some of the legislative aspects might need to be looked at

because sometimes it is quite difficult to go back to families. Even though I think the families themselves very much want it, we are debarred from that by the kind of ethics permission which we receive.

**Q26 Lord Colwyn:** Having been involved with biotechnology and aware of the hundreds of thousands of pounds, millions of pounds which are spent on patents, can you remind me of the situation on patenting genomic information? Is it patentable?

**Professor Van Heyningen:** Well, yes. Malcolm Dunlop told me that they have patented (I suppose through Cancer Research UK because he gets quite a lot of funding from them) all the genes which he has just been involved in identifying. Actually, I talk about Malcolm Dunlop because I know him, but it is a big, big collaboration, an international collaboration. There is certainly a European arm, but he also interacts widely with North American researchers and I guess they have patented these genes which they have identified together.

**Q27 Lord Colwyn:** That is something you have to accept?

**Dr Mulkeen:** Patenting in the context of a function rather than patenting simply because I have discovered this.

**Professor Van Heyningen:** Oh, yes, the function.

**Dr Mulkeen:** If you are at the stage where people are patenting it at the moment of discovery without knowing what it was going to be used for, that would be a huge obstruction to progress.

**Professor Dupré:** I just want to comment on that. There is a real problem with patenting genes. So much of the tendency of the scientific development over the last few decades has been moving away from the notion that there is a thing there which has a linear sequence of consequences, so that when you identify the function you finally know what that gene is. Now we have realised that genes are just resources which are used in sometimes thousands of

different ways in the body. So there really is a very serious problem of creating obstacles to research by patenting, by intellectual property in bits at the bottom of the process. So I think there are real issues about how intellectual property should function that we really have not got very good answers to as yet.

**Chairman:** We might come to that in greater depth.

**Q28 Baroness Finlay of Llandaff:** I wonder if I could ask about biobanks, because their aim is to increase the knowledge of genetic and environmental issues and how they interact in health and disease and the hope is that this will underpin discovery of new ways to treat different conditions. I just wondered for which classes of diseases you envisage there will be new ways of prevention and treatment revealed and under what kind of timescale, and linked to that it would be helpful to know whether you feel there are any gaps in the legal and regulatory framework governing biobanks at the moment, either to help or hinder that process? Is there a need to unify common law and legislation on consent, privacy and benefit sharing?

**Dr Mulkeen:** Can I maybe start with the question of the scope of biobanks? MRC along with the Wellcome Trust and health departments is sponsoring Biobank (with a capital B), which is the first and largest of the world's initiatives in the area. It has got a target of half a million and it has passed the 100,000 mark after a year of recruitment. There are dozens, in fact hundreds of smaller scale collections which are very important and focused on individual diseases. The pooling of those, because some of them are historical collectors, is a very important issue. We need to invest significantly more in helping researchers who have those collections to pool, because the way you might curate and annotate disease types of information and the way you might have done the tests on your cohort or your biobank might be different to those of the research group you want to collaborate with. It is hard to point to

an area of human medicine that will not benefit from access to either DNA collections or pathological specimens, or repositories of infectious disease strains.

**Q29 Baroness Finlay of Llandaff:** I want to explore the regulatory frameworks when this coming together happens and then whether people have to go right back to the beginning again, and consent issues, and so on.

*Dr Mulkeen:* I will hand over to Joyce.

*Professor Tait:* I think there are several issues in these areas, particularly in biobanks and, I think, the challenge of getting the right balance between protecting the privacy of the individual and enabling the public benefit that is there to emerge, and certainly Graeme Laurie has contributed to the AHRC Centre's submission, pointing out that in the committee the chairs in Scotland is trying much more to get that balance right with a view to maximising the public benefit that arises from a genetic databank, whereas the committee which has a similar function in England is tending more towards the protection of the privacy of the individual. Both are equally valid aims and there is pressure for both, and I think it is something which needs to be considered rather than saying one is right and one is wrong. It would be very interesting to look at that comparison and see where the balance of benefit arises given the two different ways of approaching it.

**Q30 Chairman:** I would like to move on to the funding for translation and the new systems put in place, for instance the Office for Strategic Coordination of Health Research (commonly known as OSCHR). That is established to try and translate health research into healthcare and health economics. So the question therefore relates to whether that has altered in any way the funding of the funding councils now that there is another stream of funding. Also, originally it was the Department of Health and the old DTI which were jointly responsible but now the DTI does not exist. Has that produced a gap in the policy formulation or in the managing of

this, and are there tensions when setting priorities for spending on genomics and other health research areas between OSCHR, MRC and the National Institute for Health Research?

**Dr Mulkeen:** It is a complicated question. I will deal with the last part first. The level at which we discussed priorities with OSCHR at the time of the last spending review and the level at which we are discussing priorities with OSCHR does not go down to the question of, for example, the balance between MRC spend on clinical and population genetics versus mass models, and so on. There are certainly tensions. As you have heard, there are lots of things we ought ideally to be spending more on in the UK and there are difficult prioritisation decisions, but most of those are within MRC. Going back to what OSCHR has changed, I would highlight two main things. One is on informatics coordination, not so much the question of raw computing power to support bioinformatics and association and modelling of genes in system, but at the Connecting for Health end and radiating out from Connecting for Health, where under UKCRC coordination and latterly under OSCHR there is a committee which Ian Diamond, the Chief Executive of ESRC, chairs looking at the scope for e-health records research and looking at what are the foreseeable uses of the Connecting for Health initiative in research, especially in areas like patient outcomes, surveillance, extracts of information for epidemiology, and then charging a second group led by Alex Marcombe called the Connecting for Health Research Capability Programme with developing those. That is well funded by the Department for Health. You might want to check the exact figure with them, but I think it is in the region of £50 million available for developing those aspects of Connecting for Health. The area we are now talking about looking at, together with the National Institute for Health Research, which I think will become a major issue for all of us in medical research over the next year or two, is the more translational area of informatics, looking at how we provide the support systems and expertise which will draw together proteomic, genomic, all the other “omic” data with the data around intensely phenotyped

subgroups of patients the richer datasets that you would not reasonably expect to go into Connecting for Health and making sure that that network of information can connect well with Connecting for Health when appropriate and can be exploited well in clinical trials informatics. I would highlight that as one of the areas where we probably will need to spend quite a lot more over the next couple of years. The other area where OSCHR has made a huge difference, of course, is in helping the Treasury decide to put a lot more money into translational and experimental medicine. That has helped us fund the second of the calls for biomarkers that I mentioned. It has helped us fund the initiative which has just completed on intensively phenotyped patient subgroups and it is also helping fund the developmental pathway scheme which will be launched tonight actually, which will provide more milestone-based funding for medical researchers who want to move new ideas further into clinical application or to add value to them to get them exploited. That scheme should be particularly useful in helping translation in the more complex areas or areas which are higher risk because they are scientifically innovative and not necessarily the most popular area for private sector investment at this stage but which might be very important in the future. Those will be the two main areas where, as I say, OSCHR has made a difference in the first year. There is more to come.

**Chairman:** Thank you very much.

**Q31 Baroness Perry of Southwark:** I am sure you recognise that to the ordinary public the most important thing is whether all this genomic medicine will actually translate into interventions which will help their own health. My question really is, how will the Research Councils evaluate whether any newly identified low penetrance susceptibility genes will be useful in identifying these practical interventions?

**Professor Van Heyningen:** I think this is a very difficult area because we are so much at the beginning of this adventure in a way. As I say, it is going to be some time in most disease

areas before we can use the collected data to give any sort of risk assessment to individual patients because there are so many genes involved in common diseases. I myself work on much more simple Mendelian diseases and there we are using genomic information to tell people what causes their disease at a much higher rate, but those are much less frequent abnormality diseases. So I think for common disease I am sure that the whole synthesis of the interacting pathways will give a lot of information. I do not know how we are going to gauge the efficacy of the advice which can be given to patients. I think there will be new approaches to disease management, therapy, but also prevention, and of course interaction with the environment is a major aspect of all this. So I actually think that a lot of the effort is going to have to be at the social science level, because we can already tell people that they are at increased risk if they smoke, but it has taken about 50 years until we have abolished smoking in public places, so the timescale is much longer than one expects.

**Q32 Baroness Perry of Southwark:** Do you think there is a danger that people will find this new development the answer to all their problems, that they will not have to bother with lifestyle and environmental issues and that scientists will sort it all out for them, so to speak? How are you going to tackle that as Research Councils?

**Professor Van Heyningen:** I think that is a real danger, but it might not be a task for the Research Council. I really think that early education and getting information – not indoctrination but really trying to get people to understand from an early stage how important lifestyle is, that would be very useful.

**Professor Tait:** The ESRC does have some research from the Cesagen centre which it set up indicating that if a person is informed about their genetic predisposition to a disease and about the lifestyle changes they can undertake, they are much more likely to seek medical solutions to their problem rather than lifestyle changes. So they are more likely to want a pill to fix this problem than to say, “I will change my lifestyle.”

**Q33 Chairman:** So how do you change that perception?

*Professor Tait:* I think Veronica is right. I think at the school level, if you can get to pupils. It is not really the Research Councils' function to spend a lot of time and effort on this, although we do quite a bit of it. I think a concerted effort to get to the young people early –

**Q34 Chairman:** But it is your function to try and change the policy?

*Professor Tait:* Yes, exactly.

*Professor Van Heyningen:* Yes.

**Q35 Chairman:** So what are you saying about what changes in the policy are required, or regulatory policies required?

*Professor Tait:* I do not myself know enough about education at the school level to say how that needs to change, but I do think there are changes which could be made in terms of how you make the science that people are learning relevant to their everyday lives and teach them science in the context of their own lives in a way in which they can then connect with it and make changes and maybe also change their parents' lifestyles as well to some extent.

*Professor Van Heyningen:* I was going to add that I think there is a perception around, which is obviously not very well informed, that the drugs can cope with everything, but most of us around here know that there are no drugs which do not have some side-effects. Aspirin has been around for a long time. It has lots of beneficial effects, but it still has dangerous side-effects and you cannot just take even aspirin on a routine basis. I think most of the population just do not understand this, but I do not know how the MRC is empowered really to tackle these aspects of popular perception.

**Q36 Chairman:** No, the MRC might not be, but the question is whether you feel it is important that somebody tackles it?

**Professor Van Heyningen:** Yes, definitely.

**Professor Tait:** Yes.

**Professor Dupré:** You should not assume that there really is a very good solution to this problem and partly, I suppose, we have to be careful in assuming what people actually want to get out of this. I think we have this situation really with statins. I think it is pretty clear that people do take statins as an excuse for not moderating their diet and it may not be anything that a medical expert would recommend, but it still may actually be something that people are making rational decisions about in a certain sense.

**Q37 Chairman:** But we did make it freely available, did we not?

**Professor Dupré:** Obviously, yes. That is something that we could consider.

**Dr Mulkeen:** Could I just add on the point of there being no easy solutions to the question of behaviour change, in 10, 15 or 20 years' time, or whenever large scale use of genomic-based tests becomes part of healthcare, the costs of gathering the genetic information will be much lower than the costs of actually interpreting it, which in turn will be lower than the cost of communicating that to the patient in a useful way. What Research Councils can do is help to build up not just the sociological side that understands how people react to this information, but also perhaps some of the methodologies that will allow healthcare systems to choose where it is worthwhile doing this. You could imagine a failure of translation which was not about not having information but being swamped by information with a lot of unnecessary test being done which were not actually at the end of the day improving people's lives and prioritising in the smartest way is going to be quite a challenge over the next 20 years.

**Q38 Chairman:** What the Research Councils can do, should do or will do?

**Dr Mulkeen:** We will certainly be building up the area of methodology and one of the other challenges which OSCHR has given MRC is to develop a new methodology research

programme which will not just meet the needs of MRC science but will be able to meet the needs of NICE, MHRA and industry, and we expect that as we consult on what questions people are going to need help with areas like this will be pretty high up the priority list.

**Q39 Baroness Perry of Southwark:** Is there not for the research community, and the medical research community particularly, an ethical problem for you in that you need to in a sense convince the public in order to continue to get funding from Government, which responds to public pressure, that there is a magic pill or a magic solution, or a magic genetic finding which is going to solve all their problems, while at the same time you are conscious yourselves that this is not going to be the answer to everything? You have a kind of balance of ethical difficulties for yourselves, do you not, here?

*Professor Van Heyningen:* Yes.

*Dr Mulkeen:* We try very hard in our communications policy to avoid what you see in some other countries where every time a new gene is discovered researchers are under pressure to rush out and sell this to the public and the media as the breakthrough that will solve all the problems. I think, looking at comparisons around the country, we do a pretty good job in the MRC and across the Research Councils of moderating that expectation.

**Baroness Perry of Southwark:** The media still tends to translate it into solutions only a year away!

**Q40 Lord Sutherland of Houndwood:** Clearly, knowledge carries responsibility. You know you have responsibilities, what you do with that power. I want to move on to the electronic storage of medical information and clearly for genomic studies that has a very important potential. I do not want to ask you at the moment – we will probably move on to this – about the ethical and legal issues because these are clearly very important, but just to start with the technicalities. How this information is recorded and how it is made available

will clearly have a big impact on your capacity to do the kind of research and answer the questions you want. I just wondered where, if at all, are discussions taking place between the research community, whether it is RCUK, and, say, the NHS or the Department of Health on this, because clearly there is a common interest in getting the interface right?

*Dr Mulkeen:* I was explaining the OSCHR programme of work around e-health. Part of that, which will move us forward quite a lot, is that we are starting with a map. Quite a lot has been invested in technology, the development of skills in this area. For example, there was a Cross-Research Council e-Science initiative three or four years ago that EPSRC, BBSRC and MRC have participated in. What we need to do is map that, map other initiatives that have happened in individual centres of excellence and start to identify gaps, best practice and future investment needs.

**Q41 Lord Sutherland of Houndwood:** But it is not just the centres of excellence. When I see my GP tapping away when I talk it makes me think, “What am I saying to him?” But at that level they are all recording information and is anything being done to ensure that that is user-friendly?

*Professor Tait:* I do not know enough about this.

*Dr Mulkeen:* Within Connecting for Health that data says a lot has been done but, as I mentioned earlier, as you move down to some of the smaller scale activities we need to think not just about the IT system but about the time and expert input needed to curate these well so that when you see a series of test results in ten years’ time you know what the test was, not just the results.

*Professor Tait:* There is another initiative, the UK Clinical Research Collaboration, where the ESRC, MRC and the Department of Health are collaborating with, among other things, the aim of making sure that this kind of question is addressed across these institutions.

**Q42 Lord Sutherland of Houndwood:** Is it having beneficial results, this collaboration?

*Professor Tait:* I am not sure if there are any beneficial outcomes yet. It has been going for about two and a half years.

**Q43 Lord Sutherland of Houndwood:** By “results” I do not mean cures, I mean that actually people are doing the right thing?

*Professor Tait:* I think people are beginning to do the right thing. I am not sure there are any concrete outcomes.

*Dr Mulkeen:* The National Cancer Research Institute got off the starting blocks a couple of years before the UKCRC and in its focused area of cancer it is seeing real benefits in the way data is curated and shared in particular. Sharing, of course, does raise some ethical issues as well as practical information.

**Lord Sutherland of Houndwood:** Indeed, yes. Thank you.

**Q44 Baroness Perry of Southwark:** In the RCUK’s submission we were told that one of their concerns is that the rate of change in scientific areas of research is going to far outpace the governance, legal and ethical-related research. Can you tell us how academic, legal and social science research feeds into policy making? You yourselves have said how important it is to have these areas still funded generously. The ESRC and AHRC I am sure have a view on this. How does it happen at the moment? How does it feed into policy?

*Professor Tait:* It is feeding into policy partly because we are very strongly encouraged and motivated by various performance measures from ESRC to do just that, so it is very much in our interests to do that, but we are also a fairly pragmatic research group that wants to see the outcomes of our research applied in practice. So we have been contributing the outputs of our research on the interactions between innovation and regulation and the impact of regulation on slowing down the innovation process and completely structuring the commercial sector in

a way which is sometimes counter-functional. We have been feeding that into, for example, the OECD. We have done one or two reports for them. We are talking tomorrow to three of the major multinational companies in the UK about how we can get this kind of question addressed as to how would you effect change within the regulatory system that might be constructive.

**Professor Dupré:** As Professor Tait just mentioned, it is something we are very strongly urged and motivated to do, and quite rightly, but there is a problem in some of the kind of work we do in that it is just exceedingly difficult to measure these kinds of impacts. It is easy enough to talk to people, just as we are talking here, but demonstrating exactly – particularly I am representing here the work I am doing for AHRC, which is analysis of the development of the science. I think there are many ways in which that filters down and I have interaction with colleagues at BBSRC which I hope is productive and I hope eventually that has policy relevance and economic impacts in terms of possibly benefiting that work, but to trace that down and see exactly what difference it makes is very difficult. So I think there are real problems in answering this kind of question, but we spend a lot of time thinking about it.

**Q45 Baroness Perry of Southwark:** Is there a project anywhere which is looking at the kind of regulatory mechanisms that would work in the future or would be desirable in the future?

**Professor Tait:** I think on what would work and what would be desirable, one of our conclusions from earlier research about six years ago was that carrots work better than sticks, incentives work better than disincentives, so you will get change in industry behaviour much more quickly if you give them incentives to do something desirable rather than a disincentive to do something undesirable. The other key factor in this was that if you have a blanket regulatory approach which applied equally across all products regardless of the properties of those products, that is much less beneficial than one which discriminates among products on

the basis of their properties. You see that in drug development where fast tracks have been developed for drugs with particularly publicly desirable properties. The Orphan Drug Act is another example of that operating very effectively, but what we would say is that all of that makes it easier for multinational companies to develop the kinds of products which the public wants to see coming out of the multinational companies. It does not yet free up the regulatory system in a way which allow a small company to take a product all the way through to market and would allow the much more innovative lifestyle sector more in comparison with information and communication technology. If you look at the difference over the last 50 years in the various revolutions, the technology revolutions which have happened in information technology, and compare that with the initial promise of the life sciences and the really rather modest outcomes that have happened as a result of all this public investment, our conclusion is that it is the very onerous, long-term and expensive regulatory system – which means that only a big multinational company can afford to develop the technology, which means that their strategies can rule the roost and any small company which has got an alternative way of doing something or something that would maybe undermine the pharmaceutical industry market has very little chance of taking an innovative product through to market. I think the key to changing that is a much more fundamental revision of the regulatory system, and that is what we would like to talk about.

**Q46 Baroness Perry of Southwark:** Are you quoting from a specific study which was done?

**Professor Tait:** It is a whole series of studies we have done, talking to small companies about how innovation takes place, what their aspirations are and what they would really like to do. We have been doing that with agrochemical companies, then biotech companies and now pharmaceutical companies. You talk to small companies and their aspiration is to be bought

up by a multinational at the end of the day. That is what they are aiming for. They are not aiming to grow big themselves, and it is a big problem in the life sciences.

**Q47 Baroness Perry of Southwark:** I think we would find it very helpful if you could point us to some references to that.

*Professor Tait:* There is in the Research Councils UK submission a list of references, yes.

**Q48 Chairman:** You have several references. Can I go to this issue: there are obviously possible beneficial and detrimental impacts of genetic tests and yes, the Research Councils' business is to promote science research and not maybe go in that direction, but clearly when Lady Perry referred earlier on about genetics for common diseases, particularly those with low penetration you, Professor Van Heyningen, answered by saying that that is going to create problems. But there are other issues – and Dr Mulkeen mentioned this – about who explains about the validity of these tests and who should have the knowledge about them, and that leads on to education and therefore those professional organisations responsible for education, such as colleges. So who interacts with them? Who says, “At what stage do we need people who are trained to give information in a way the general public may understand about the relevance and the implications of genetic tests”?

*Professor Van Heyningen:* There is an NHS National Genetics Education and Development centre in Birmingham and they train not clinicians but people who are involved in other aspects of medicine, and they have a series of programmes for that. I think there is quite a gap, or at least I do not know the details of how clinicians these days are being educated in aspects of modern genetics because now it is not going to be geneticists and clinical geneticists who are going to be giving out information in the very near future but general physicians, and surgeons even.

**Chairman:** Even, yes!

**Q49 Lord Sutherland of Houndwood:** Especially even!

*Professor Van Heyningen:* I do not know whether there is good training for them. As you know, there is a great deal of discussion about medical training in general, but I think some of this could be developed. Some of the curriculum aspects could be developed much more centrally to make sure that they all get a good basic education in their own medical schools or go centrally for some courses.

**Q50 Chairman:** Does it need to be medical people? Does it need to be someone who is also medically trained?

*Professor Van Heyningen:* As I say, there are non-clinical people who are already getting some education, and that should probably be expanded.

**Q51 Chairman:** Do you know how we compare with other countries?

*Professor Van Heyningen:* No, I do not know.

**Q52 Chairman:** We are told in the evidence and also in the seminar we had that genomics, and therefore its implication on medicine, and therefore genomic medicine (in the wider definition that you use), is going to impact a lot upon the population, the way we assess risks about their health, the way healthcare is delivered and the systems of delivery of that healthcare, and that we need to think ahead and have the systems in place, or at least some thinking as to what systems we require. We also need to do some thinking about what regulatory mechanism we are going to require to be able to test for these genetic tests and develop treatment for these genetically-based diseases, what ethical issues it throws up and what legal issues it throws up, and that we need to be ahead of this game and be leaders because that would have a wider impact on the population and society but also on economics?

*Professor Van Heyningen:* Yes.

**Q53 Chairman:** Are we leaders, and if we are not where are the blocks?

*Professor Van Heyningen:* I think Britain does punch perhaps above its population size in terms of contribution.

**Q54 Chairman:** But that is not leading, though, that is just punching above your weight!

*Professor Van Heyningen:* Well, that is one measure of leading, is it not? I think British science has contributed a lot to many of the advances we have seen so far and I think it is still at the forefront, but it does need a lot of further support.

**Q55 Chairman:** All right. What about this translation into healthcare and healthcare systems and are there regulatory and ethical issues to be addressed that we are not addressing, are there legal issues to be addressed?

*Professor Tait:* I think we are leading in the joining up of all these different questions and not treating them as separate entities. I think we do have a very strong leadership role there. I am not asking for more money. I think the big investment which has already been made through the Economic and Social Research Council has been a large part of enabling that joining up to happen. I think there is still a task to be done in the creation of intelligent customers for the products from the science out there in the Health Service. I am not sure that that is going to be quite as easy as we imagine. I think there are going to be a lot of entrenched ideas that will persist for quite a long time in the community of applying the healthcare. We are close to being leaders. I think there is an equally strong leadership position developing in the Netherlands and I think maybe some Scandinavian countries are maybe even ahead of us in Europe. I really do not know how we compare with America. I think America is a rather diffuse body. Maybe Canada. Yes, Canada is an area where I think there is also strong leadership.

**Professor Dupré:** I would agree entirely with that and I would have thought, in terms of being joined-up, that we were still quite well ahead of North America. This really is a very important issue and given how rapidly the science is developing and how rapidly it is throwing up social issues, legal issues, ethical issues and philosophical issues the amount of connection between the different approaches – perhaps I am an optimist, but I would say we were slightly ahead even of the small Northern European countries you mentioned, but really I think we are leaders in that regard.

**Professor Tait:** Yes.

**Professor Dupré:** And obviously that would be pointless if we did not have some excellent medical and biological research going on too.

**Q56 Chairman:** Listening to you, we have now joined up with all these issues and we are addressing them together, so if I were to ask you what one strong recommendation you would like to see in our report what would that be?

**Professor Tait:** I would vote for a really creative look at the regulatory system and how it could be moderated and diverted, changed in a way which would actually open up the whole genomic healthcare area to more creative use of the science that we are actually developing.

**Q57 Chairman:** Who would you think should be responsible for that?

**Professor Tait:** I think it should be a collaboration. I think it should involve heavily the regulators and industry, all sizes of companies, and I think there is a role for academics who have been studying these problems. I think it also has to be international. You cannot do this at the UK level, it has to be at least at the European level, and at the moment I think actually the food and drugs administration in America is ahead of the EMEA in thinking creatively about this, so it would be nice to bring them in, too.

**Q58 Chairman:** You are allowed to dissent from that, so does anybody dissent from that and would have another recommendation?

**Dr Mulkeen:** Can I dissent slightly, not in an opposite direction? As well as addressing regulation, I think the culture for innovation and the environment for innovation in healthcare and communications about healthcare is important as the positive side as well as stopping the undesirable, and as the pace of research picks up over the next decade I think we will need to see a more proactive and strategic approach to innovation and prioritisation of that innovation in health systems.

**Chairman:** Thank you very much. Thank you all. You have been most helpful. This is our first session and we have learned a lot and no doubt we will pursue some of the things you have brought out when we take other evidence. Can I say to you that if you have further thoughts which you would like to send to us, that will be most welcome and that will also form part of our evidence and therefore will be published, but I encourage you, if you have any further evidence, to please let us have it. The document you have, Dr Miles, we will take and also regard it as further evidence. So thank you again, all of you, for coming. We appreciate it very much.