Thursday, 16 June 2016
(10.00 am)
PROFESSOR INGE SCHMITZ FEUERHAKE (continued)
(Assisted by interpreter)
Cross-examination by MR HEPPINSTALL (continued)
MR HEPPINSTALL: Just before we continue with the cross-examination, Dr Busby has informed me this morning that Professor Howard has to be away for 4.30 because he has a flight at six o'clock, whereas Professor Hooper is not flying off today. So he asked that Professor Howard goes before Professor Hooper, which is fine.
MR JUSTICE BLAKE: Good. Right.
MR HEPPINSTALL: Could you take out volume SB7, tab 123, please. Sorry, Professor, do you want to --
A. Am I allowed, my Lord, to make some very short corrections to my speech yesterday?
MR JUSTICE BLAKE: It was a speech, was it? Well, it was meant to be an answer to a question, but, yes, if something has arisen that you have reflected upon, tell us what it is if you would like to qualify.
A. Yes. The main approach of Dr Heppinstall is that --
MR JUSTICE BLAKE: He is asking questions, so --
A. Yes -- is that we do not consider the arguments of the other side. And this is not generally true in my work. It is true that we should have mentioned, commented this

paper, this genetic paper of -- which was new yesterday.
MR HEPPINSTALL: The Mark Little paper.
A. Mark Little and others.
MR JUSTICE BLAKE: Yes.
A. Because they indeed support the present opinion of the ICRP, not fully but to a high degree. But we did not know about this work, unfortunately, and our peer reviewers of our paper didn't evidently know it.
MR JUSTICE BLAKE: So you didn't know about the paper.
A. Yes.
MR JUSTICE BLAKE: When you say "we", who is "we"?
A. The other author, as you know, is Dr Busby and a German author Pflugbeil.
MR JUSTICE BLAKE: Yes.
A. Then the point of the Hiroshima dosimetry, the fallout dosimetry.
I was not prepared to discuss the theme, although I have worked by myself and cited myself in the 1980s upon it.
MR JUSTICE BLAKE: Yes.
A. I know, of course, the calculations of the RERF. I have a thick book. Okajima is the editor of the things. I did not know this report of Okajima and Halle, which is a newer one, I think.
I made a great publication in the conference

proceedings of ECRR in the 1980s where I referred to their calculation. At that time they talked about 5 millisieverts. But what we did not admit yesterday, what is also in the papers of Professor Sawada, is that we have another parameter to show that this estimation is too low. Because the geneticist, Japanese geneticist Abe and others, published by the RERF, ABCC at that time, his study on chromosome aberrations in the A bomb survivors.
This was not done not in city group, you know they --
MR JUSTICE BLAKE: Well, is this coming to the end of your clarification? Because I don't want to go off into a whole new tangent at this stage in the proceedings bearing in mind in particular I want you to complete your evidence so you can get your flight. So --
A. Yes, I -- five minutes.
MR JUSTICE BLAKE: No, I'm afraid not five minutes. A minute, please.
A. The last remark: the chromosome studies showed that the so-called zero group, which is 2.5 kilometres away from the hypocentre, they calculated zero dose but the Abe group measured a significant elevation, an increase of chromosome aberrations in those people and we derived a dose of about 20 millisieverts. 20 millisieverts is

not negligible. We know that from the British study on Muirhead and so. In the workers, their mean dose there was 20 millisieverts and they found increased cancer rates.
MR JUSTICE BLAKE: Right.
A. Thank you.
MR JUSTICE BLAKE: Thank you.
MR HEPPINSTALL: Turn now to SB7, tab 123. This the Rowland study that you mention at page 9, section 8, of your report.
A. Yes.
Q. It's actually published -- there are two documents in this tab. The first is the published summary of the work which appears under the first named author, Wahab, and then if you turn five pages you get to the report that was actually presented to the New Zealand Nuclear Test Veterans Association where the first named author is Rowland and of course we know that Rowland was the leader of the project.
Then we get the rest of that report.
A. But what is the question?
Q. I am just --
MR JUSTICE BLAKE: We are getting there. Just pause.
MR HEPPINSTALL: You mention these papers in your report. So I presume you are familiar with them, Professor?

A. Yes. This elevation of chromosome aberrations, yet you must know this, that the translocation method is not very sensitive. It represents -- if you find a significant increase you find a huge internal dose.
MR JUSTICE BLAKE: Well, hang on, let's wait for the question otherwise we're not going to be able to proceed in an orderly fashion.
MR HEPPINSTALL: So you're aware that this chromosomal analysis was carried out on New Zealand test veterans who were on two boats which were sailing around the South Pacific seas during the British test. You are aware of that context?
A. Yes.
Q. So you are further aware that one would imagine that by and large they would have a shared collective experience in that sense, because they are on two boats.
A. Yes. I'm aware of this.
Q. So can we just look at the dosimetry that Rowland came up with at page 34 of the Rowland paper rather than the published paper.
THE INTERPRETER: Sorry, which page?
MR HEPPINSTALL: Page 34. This is not of the published paper but of the report. The numbers are at the bottom.
MR JUSTICE BLAKE: This is --
A. Page 34?

MR HEPPINSTALL: So there are two documents behind the tab. The first is the published paper, then you move into the report which is presented --
MR JUSTICE BLAKE: 34 is the table you wanted to take us to?
MR HEPPINSTALL: Yes.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: So have you looked at this table before, Professor?
A. No.
Q. No?
A. I read the paper, but this is a report.
Q. Well, if we just see how far we get. If we look at the dosimetry we see that the coded veteran is given on the left-hand side. Then we get the results of the chromosomal analysis, the scoring. Then we see that that has been translated into dose in grays.
A. Yes.
Q. We then get the 95 per cent confidence intervals for the dose. I think we then get some information about the dicentric rings that were noticed. Then we get a dose based on that dicentric analysis which is a different dose. Then we get the confidence intervals for the dicentric analysis. Do you see that?
A. Yes.
Q. Now, if we look at the -- well, let's just ignore the

dicentric work because, as you can see, not much work was actually done and therefore a lot of the results are nil. But if we look at the mFISH chromosomal analysis we see that that's translated into a range of doses, don't we? If we look down that column --
MR JUSTICE BLAKE: You are looking at dose --
MR HEPPINSTALL: It's the fourth column from the left.
MR JUSTICE BLAKE: Yes, yes. Called "Dose in grays".
MR HEPPINSTALL: Yes. So if we look down that column we see we have a lot of zeros, but then we have a great range between 0.1 grays and all the way up to 1.15 --
A. Yes.
Q. -- gray. Now, don't you find that analysis very surprising, Professor, when these sailors all had the same shared experience on two boats?
A. That's not surprising, I think. Because they breathe otherwise, they behave otherwise, these -- these studies were made years after that.
Q. So you think that some of the chromosomal aberrations were not biomarkers for exposures at Christmas Island but biomarkers for other exposures?
A. No, no, that's not my point but that you have that is a problem of internal dosimetry, that you have individual differences, great differences in the metabolism of the fallout you breathe.

Q. But can it really be credible, Professor, that a veteran --
A. I must not --
MR JUSTICE BLAKE: Hang on for the question. Wait, don't get in there too quickly.
MR HEPPINSTALL: Can it really be credible that the spread of dose is quite so wide as what we are looking at here?
A. Yes, unfortunately.
Q. But you understand that 1.4 gray, or 1.4, I think, NZTVO26 --
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: -- that's 1,400 millisieverts, Professor.
A. Yes.
Q. How can it be that a New Zealand sailor several hundred miles from the detonation could have been exposed to a dose of 1,400 millisieverts?
A. That is because of the system. Internal dosimetry with chromosome aberrations quantitatively is only possible if you know where the locations are, which tissues were irradiated and only in the case of homogenous irradiation, you can make a quantitative -- you can go through this curve. That is unfortunately the problem. If you -- we know the lymphocytes are investigated. The lymphocytes circle in the whole body and the heavy metal things, uranium, plutonium, thorium, they

concentrate in the lymph nodes. So it is possible that you get a very high rate of exposed lymphocytes in the nodes. Huh? You don't know where the location is, where the irradiation occurred.

Q. Is it right that translocations can be caused by a number of things not just including radiation?

A. No, that's not right. You normally can decide by the pattern, you see if it is caused by the pattern of the distribution in a cell. You must look at single cells as a distribution of the types of chromosomes of aberration. You have certain types of aberrations, not only translocations.

This will give you an information if chemical -- how is it called? -- mutagenes are -- mutagenic substances are involved or if ionising radiation is involved.

Q. It -- sorry, go on.

A. It is a qualitative method to find this out.

And the chromosomes produced by ionising radiation are such types which are originated by a double strength break in the DNA, and this --

THE INTERPRETER: Frequency.

A. -- frequency, this frequency is relevant in order to decide to differentiate against other agents.

MR HEPPINSTALL: Professor, the authors of this work are far more reticent and uncertain about their conclusions than

you are. Let's look at page 42, the bottom of page 42, where it says:

"Chromosome analysis of ...(Reading to the words)... exposure is a well-established technique. The dose estimates in cases of accidental overexposure ..."

Now, you're aware, aren't you, that in those circumstances of accidental overexposure the mFISH takes place very quickly after the accidental exposure?

A. When was it? I forgot.

Q. Well, these New Zealanders were there at the time of the test in 1956/57. This mFISH is taking place over 50 years later. What I am putting to you is what they are talking about here, where mFISH is used, for example if a nuclear worker is accidentally overexposed and it's done within weeks of that overexposure.

A. Yes, it's possible, yes.

Q. The reason for that, Professor, is because if because there are other things that could have this effect, for example other radiation exposures that you might have in an X-ray or a CT scan, if you leave it 50 years some account has got to be taken of all the events in one's life where you might have been exposed to ionising radiation.

A. Yes.

Q. Including living on Planet Earth and receiving the sun's

radiation. Do you agree?

A. You mean that these people could have been exposed by other things --

Q. Yes, in the intervening 40 or 50 years.

A. You must know that perhaps a CT, which is a very heavy X-ray, produces a very tiny effect. It produces, one CT produces, it is on the --

THE INTERPRETER: Upper body.

MR HEPPINSTALL: Upper body.

A. A significant elevation in dicentric chromosomes but not in translocation. The translocation method is less sensitive.

And if you propose that these high rates can be produced by other agents, other X-rays also, that is nearly impossible but because they represent other methods what should it be? A normal x-ray could it not be. A heavy, heavy burden by what? It's not very probable, I think.

Q. If we just go on in that paragraph:

"The introduction of fish has proved invaluable to ...(Reading to the words)... in humans.

"An attempt was made in the current study to reconstruct possible radiation dosage in the Operation Grapple veterans. Possible exposure estimates are listed in table 1. We acknowledge that there are many

uncertainties surrounding this estimate, which should be used only as a guide."

Now, isn't that the true position, Professor, that this is only a very tentative attempt at reverse dosimetry?

A. This attempt is very, very relevant to show that there was an exposure and that there was a rather high exposure. But I repeat, it's not possible in an in-homogenous distribution of the isotopes in the body to make a quantitative approach. But it is important to know if they have been irradiated. If you find no significant elevation you do not know if they have been irradiated to some degree.

Q. Now, if we just go back to the published paper where that dose information was not published and if we look at page 84 within the published paper.

MR JUSTICE BLAKE: Internal page 84.

MR HEPPINSTALL: Yes. They are on the bottom-left. If you go back to the front of the tab.

MR JUSTICE BLAKE: The first document at the front of the tab, you should get to this page.

MR HEPPINSTALL: Page 84.

MR JUSTICE BLAKE: You are in the right territory.

A. Ah yes, I see.

MR JUSTICE BLAKE: Yes.

MR HEPPINSTALL: At the bottom of page 84 in the first column there's a passage that starts:

"The significantly higher translocation frequencies in the group of veterans compared to the controls suggest that this may be a consequence of their participation in Operation Grapple."

You agree that the right verb to use is "may"?

A. What is it in English?

THE INTERPRETER: Careful. Prudent.

A. This is a very careful comment on their own results. I repeat: the method is radiation-specific to a high degree. You can decide what source was the origin.

Q. They say:

"However, since a statistical association is not necessarily proof of a causal relation possible confounders need to be considered."

A. Yes, that's a common comment.

Q. Then in the next paragraph they deal with the way that they try to deal with smoking.

A. Yes.

Q. Then in the next paragraph they note that there might have been a confounding factor specific to service on naval vessels. Do you see that?

"Although one might consider chemicals from fresh paint or similar agents, it is difficult to conceive of

such factors causing the highly significant and lasting increase in translocation of frequencies."

So contrary to what you were saying earlier, Professor, there are other agents that could create the same effect. That's what the authors are saying.

A. Not the same effect but not the same pattern in the cell.

Q. Then the authors say:

"Whether radiation exposure during Operation Grapple or contaminations incurred by the naval personnel can have been the causative factor is not easily answered."

That is the case, isn't it, Professor? This a very difficult area where the conclusions are very difficult to draw and it's very important to be tentative and provisional, isn't it?

A. The conclusions are not very different to draw because you have not a single work on this topic. You have a variety of researchers who did such studies, and they come to a result. And we look at the whole story. All findings compilation is important.

Q. If we look at the conclusion at page 86 it said:

"In summary, a sample group of New Zealand naval personnel who participated in Operation Grapple shows three times the frequency of total chromosome translocations ...(Reading to the words)... Our analysis

of potential confounding factors leads us to the view that this highly elevated frequency is most likely attributable to radiation exposure."

A. That's it.

Q. Well, they are carefully not saying "radiation exposure in Operation Grapple," are they, Professor?

A. They are very careful because they know that they will be criticised if they say they are very sure that it is radiation.

Q. Indeed, and they go on to say:

"Further clarification might be attained by a similar study on British or Fijian participants in Operation Grapple."

Don't they?

MR JUSTICE BLAKE: I think what is being put to you is they seem to be saying here that it is radiation but not necessarily radiation arising from this particular Operation Grapple.

A. I declare that that's nearly impossible to have such an elevation in a normal life with accidents of --

MR HEPPINSTALL: So you have no such reservations and indeed you express no such reservations in your report?

A. I report, I refer on works of other researchers and I draw a conclusion looking over the whole field of information.

Q. I just want to show you the New Zealand test veteran epidemiology at B14/235, and we've extracted it. I think it may already be on your desk.

MR JUSTICE BLAKE: Yes.

MR HEPPINSTALL: This is commonly known as the Pearce Report. This is the New Zealand-sponsored epidemiological study into 528 New Zealand veterans.

A. What report is it you mentioned?

Q. Have you considered the epidemiology of the New Zealand test veterans, Professor?

MR JUSTICE BLAKE: Well, the Pearce Report I think we were told.

MR HEPPINSTALL: Yes.

A. No, I'm not an epidemiologist.

MR JUSTICE BLAKE: So you are not familiar with this --

A. I did not follow up the statistics they did.

MR HEPPINSTALL: All right, well, we'll leave that there then if you are not familiar and you are not an epidemiologist.

I just want to touch on some additional new --

MR JUSTICE BLAKE: Where do we slot this in? Just into the also ran bundle?

MR HEPPINSTALL: Yes, SB22. I think the SB22s are on their way to you.

MR JUSTICE BLAKE: Yes, well, I started mine.

MR HEPPINSTALL: I'm very grateful.
MR JUSTICE BLAKE: Yes, sorry, carry on. I'm conscious of the time. When have you actually got to physically leave this building? At 11 o'clock or before?
MS BUSBY: 11 o'clock.
MR JUSTICE BLAKE: Do you think we are going to finish in time?
MR HEPPINSTALL: I hope so, yes.
MR JUSTICE BLAKE: We all share the hope.
MR HEPPINSTALL: We do.
You touched upon the radiogenicity of pancreatic cancer and CLL yesterday which is not something you put in your report so I just need to very quickly deal with that. You should have another loose document which is taken from E3/12 which is the UNSCEAR annex on pancreatic cancer. Could you just turn that up, please.
A. Yes, that is 2000.
Q. It is 2006, you are right.
Panel C, this is extracted from, as I say, E3/12. There is an interesting introduction which includes criteria for good quality --
MR TER HAAR: Sorry to interrupt. Could I just tell the Tribunal this is to be found also in supplementary bundle SB21, tab 30.
MR JUSTICE BLAKE: Jolly good. We have it here.

MR TER HAAR: The only reason I mention it --
MR JUSTICE BLAKE: We have to get on, Mr ter Haar.
MR TER HAAR: I am anticipating saving time later. I will be cross-examining on this. It might be helpful if the Tribunal were to have that copied because it's fuller and it means you will have all your notes in the same place. But it's a matter for the Tribunal.
MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: It has "Criteria for good quality epidemiological studies" at the beginning. That's why I left that section in as it may be of interest. If we turn forward we get to internal page 68, pancreatic cancer.
THE INTERPRETER: We have 67 and 69. 68 is blank.
MR HEPPINSTALL: Oh. I have a 68. We may have to revert to -- anyway, it's not crucial because all I want to put to you is -- well, on another page, page 70, do you have page 70?
THE INTERPRETER: No.
MR JUSTICE BLAKE: Perhaps Mr ter Haar's suggestion is looking stronger by the moment.
MR HEPPINSTALL: It is looking quite a good one.
MR JUSTICE BLAKE: It's just am very anxious, I am trying to manage the process --
MR TER HAAR: It's SB21, tab 30.

MR HEPPINSTALL: Tab 30, thank you very much.
A. I can refer shortly on pancreatic cancer.
MR JUSTICE BLAKE: Hang on, we are having difficulty getting the information for you to comment on upon.
MR HEPPINSTALL: It's the double-sided copying trick.
THE INTERPRETER: SB21?
MR HEPPINSTALL: SB21. Is SB21 up there yet? Tab 30 and turn to page 68.
We see that UNSCEAR 2006 starts its examination of pancreatic cancer at page 68. It reviews the epidemiology as we talked about yesterday. And then its summary is at paragraph 226, page 70, and the conclusion is:
"There is little, if any, evidence for associations between pancreatic cancer and radiation dose whether in relation to external or internal low LET radiation or to internal high LET radiation."
Do you agree, Professor?
A. No, I don't agree. I told you already that there are data which refutes this conclusion. Because the main reference you know for this board is the A bomb survivor, and what we must learn or consider about pancreas cancer is the following.
Pancreas cancer is a rare event. In former times -- I know that because I have worked in the nuclear

medicine for some years -- when nuclear medicine was a new discipline, and I knew from that that in former times, until the 1970s, was rather to diagnose. The pancreas is very small and it is hidden in the organs of the body, and you couldn't really detect it by conventional X-ray diagnosis. And the nuclear medicine people they were very proud that they were able to have a kind of imaging now with radioisotopes. So -- and but if one has -- if the cancer develops, people die very soon. This is the case up to now.
And so you may have -- you may have -- probably you may have missed the cases in the A bomb survivors.
MR JUSTICE BLAKE: So your comment is that you don't agree with UNSCEAR because they may have missed pancreatic cancer in the A bomb survivors? Yes?
A. They -- no, they take references which are not complete because we have other findings --
MR JUSTICE BLAKE: Well, that's another point --
A. Now in --
MR JUSTICE BLAKE: I am just trying to get in summary form what your answer is, and I am just trying to make sure I have an accurate record.
In respect of the A bomb survivors which UNSCEAR have used for comparative data I think your answer is that there may have been pancreatic cancers that were

missed. You were then going on to say there were other studies which they didn't refer to?
A. Yes.
MR JUSTICE BLAKE: Right, we are going to have to keep it that tight, I'm afraid, otherwise we are not going to get anywhere.
MR HEPPINSTALL: Now quickly, please, chronic lymphatic leukaemia, SB2, tab --
A. Let me correct this.
MR JUSTICE BLAKE: I'm afraid --
A. It is true that UNSCEAR -- that the A bomb survivor studies, the first one did not see any case, but later on, Preston 2007, it's one year after the UNSCEAR report, they saw not significant but they saw an increase.
This is -- I wrote about that.
MR JUSTICE BLAKE: Right, okay. We are going to have to move on to CLL.
MR HEPPINSTALL: SB2, tab 2.21, the report of Dr Haylock in these proceedings which presumably you considered. I want to look at his conclusion, please, on chronic lymphatic leukaemia.
If you turn three pages you get to his section on chronic lymphatic leukaemia. And his conclusion is, he runs through LSS, INWORKS, Zabolstaska, the Chernobyl

clean-up workers, and then his conclusion is:
"Thus the overwhelming weight of epidemiological data from the LSS and other large scale epidemiological studies of low dose exposures provide no evidence that CLL is likely to be inducible by radiation exposure."
Do you agree?
A. What -- likely?
Q. "... no evidence that CLL is likely to be inducible by radiation exposure."
A. This is not right. From when is it, this? 16? Oh, he is not updated. He is not on the stage of knowledge. Because this was a point which I talked about. The common paper with Richardson and people, they fought in the United States for years to show that CLL is radiogenic, and they -- in this paper is explained why the A bomb survivor study didn't find it. Because CLL is a very rare disease in Japanese people. It's not quite as rare as in Europeans --
MR JUSTICE BLAKE: I think you told us that yesterday.
A. Yes.
MR JUSTICE BLAKE: So are you telling us that -- just pause.
A. Yes.
MR JUSTICE BLAKE: Are you telling us that since this statement was written in January 2016 there has been some important new information upon this topic?

A. Yes, but it is not correct. Because --
MR JUSTICE BLAKE: Sorry, are you telling us that there's some information subsequent to January 2016 or are you making a different point?
A. I make a point that this is accepted, perhaps for example in Germany as a radiogenic cancer because of the US studies, and it is accepted by what is the -- the NIOSH compensation board. They accepted as a radiogenic cancer and they made a paper upon that --
MR HEPPINSTALL: Professor I --
A. -- and Mr Haylock evidently doesn't know that.
Q. Professor, I've deliberately not gone to the US information because I think that's a question of legal submission --
A. It is in the international literature.
MR JUSTICE BLAKE: Try to keep your answers -- you are running out of time.
MR HEPPINSTALL: Last question. SB6, please, tab 89. This is your paper that you published with Dr Busby and Sebastian Pflugbeil.
A. Yes.
Q. Now, yesterday, early in the morning, there were submitted some articles which are listed in table 1 at page 3 of 13.
DR BUSBY: They haven't yet been submitted.

MR HEPPINSTALL: I'm not going to go them. But you listed, table 1 --
MR JUSTICE BLAKE: Just listen to the question.
MR HEPPINSTALL: -- you have submitted -- well I've received copies in any event of Hoffmann, Lasjuk, Feschenko, Kulakov, Petrova, Wertelecki and Akar. You've handed those in, as I understand it, to the Tribunal.
A. Yes.
Q. The table 1 is entitled "Increase of congenital malformations after exposure by the Chernobyl accident".
A. Yes.
Q. It's true, isn't it, Professor, on a reading of those papers they are far more tentative than you are being. They are suggesting further investigations into those congenital malformations and they are nowhere near as certain as you are in this table?
A. This is a common comment of those preliminary studies. This is not the main subject of our report here because this was published by us already in 2009 in a paper Busby/Schmitz Feuerhake, and these observations were done shortly after the accident. And they were exceptional because people in several countries very far away observed a step that had data before the accident, they had data after the accident. And this was our concern that this should be known. Also Hoffmann has

made a compilation and he questioned, was Chernobyl the origin of this, the cause --
Q. Just pause there because I want to ask you: none of the confounding factors, like lack of folic acid, alcohol abuse, or other health factors in these regions which are mentioned in these papers, they are not mentioned in your review at all, are they?
MR JUSTICE BLAKE: Listen to the question first.
MR HEPPINSTALL: You haven't mentioned any of those confounding factors which the authors of these papers mention, have you?
A. They have looked in a different way. Somebody has doubt, some clearly not. What I said yesterday, we look at the whole story, we compile the information and if you there and there and there find the same known effect of radiation you will not find a common -- other -- you know that they have been exposed, you will not find another common confounder, certainly, yes.
MR HEPPINSTALL: No further questions, my Lord.
MR JUSTICE BLAKE: Thank you. Dr Busby.
Re-examination by DR BUSBY
DR BUSBY: I'm conscious of the time also and I really won't be asking many questions.
MR JUSTICE BLAKE: Well, you can't because we are now 17 minutes to 11 o'clock.

DR BUSBY: Well, yes.
MR JUSTICE BLAKE: Sorry, that's where we are at.
DR BUSBY: I only have really one main question and that has to do with these papers.
MR JUSTICE BLAKE: Which papers?
DR BUSBY: The ones that Mr Heppinstall was just talking about.
MR JUSTICE BLAKE: We don't have them.
MS BUSBY: They are just there.
DR BUSBY: They are there. We just want to ensure that this is an opportunity to let your Lordship know that they are there. (Handed)
MR JUSTICE BLAKE: We haven't obviously read them. But put the question.
DR BUSBY: But in fact if your Lordship -- if the Tribunal is prepared to go to the paper that Professor Schmitz Feuerhake mentioned, which is the SB --
MR JUSTICE BLAKE: Can you just put the question, Dr Busby?
DR BUSBY: I was talking to you, my Lord.
MR JUSTICE BLAKE: Yes.
DR BUSBY: Well, the question is that the papers that you have in front of you that Mr Heppinstall has just mentioned, these are all papers on which you rely in the recent genetic radiation risks paper, you rely on those, so they are papers that you rely on?

MR JUSTICE BLAKE: We have that already, yes.
DR BUSBY: Well, that was the question, my Lord. There we are.
So the second question is that you were taken to the HPA paper yesterday which was presented, and it doesn't have a tab because it just came in yesterday. This was the HPA paper which is by Mobbs, Muirhead and Harrison, HPA/RPD066.
MR JUSTICE BLAKE: Yes.
DR BUSBY: That was the one that was to provide a summary of our current understanding of radiation risks at low doses.
A. Yes, yes.
DR BUSBY: That one.
A. I'm afraid I don't know what it is.
Q. No, we'll get you one. Just so that you know what we are talking about. (Handed)
MR JUSTICE BLAKE: Yes.
A. Yes.
DR BUSBY: So this is -- I wanted to ask you if you had any caveats, if you had any concerns about this paper, about the conclusions? I mean there's a lot in here about fallout studies and Chernobyl studies, and so on, risks from internal measures and so forth. If you had any warnings about --

MR JUSTICE BLAKE: "Do you have any comments or reservations about this paper?" is the question.
DR BUSBY: Yes, any reservations about it.
A. I'm afraid I -- I cannot go in any details.
MR JUSTICE BLAKE: No.
DR BUSBY: I quite understand. Okay.
A. You mean the critics to the uranium findings -- I think it's not possible. Well, the argument is I was asked if the ICRP risk figures are correct, are they a severe underestimation, and I see not in this paper that this thesis of mine is -- [German word).
MR JUSTICE BLAKE: Contradicted?
THE INTERPRETER: Represented.
DR BUSBY: Addressed?
A. Regressed. I don't find any argument why it is regressed.
MR JUSTICE BLAKE: Are you familiar with the paper before yesterday?
A. No.
MR JUSTICE BLAKE: You are unfamiliar with it.
A. No.
DR BUSBY: I think that's as far as it can go, my Lord. I'm happy to leave it at that. Thank you very much. Thank you.
MR JUSTICE BLAKE: Well, we've just achieved the conclusion

of your evidence, a few minutes later than I planned but we've done so. Thank you very much for coming. That completes your evidence. I hope you get a safe flight back.
THE WITNESS: Thank you very much.
MR JUSTICE BLAKE: Thank you. Thank you for your help as well [to the interpreter]. It was worthwhile having you there.
(The witness withdrew)
MR JUSTICE BLAKE: Are we ready to move on to the next witness now?
DR BUSBY: Yes, my Lord.
MR TER HAAR: While that witness is coming forward, can I just mention that on Monday you asked about whether my clients' claims were being pursued by the widows or other people. There should be a table now before you which shows you, I hope -- I handed it to your clerk --
MR JUSTICE BLAKE: It is constructively before us.
MR TER HAAR: If not, we will make sure you get it. That tells you which of my clients are dead, and where their widows are also dead. I think that is the information you asked for.
MR JUSTICE BLAKE: Dr Rayner, I think, has it.
DR RAYNER: Yes.
PROFESSOR CHARLES VYVYAN HOWARD (affirmed)

MR JUSTICE BLAKE: Thank you. Now, are you content to stand during your evidence or would you prefer to sit down?
A. Well, I prefer to stand.
MR JUSTICE BLAKE: Right. If you need to sit, please do so, as long as we can hear you and you are able to keep your voice up.
A. Yes, thank you, my Lord.
Examination-in-chief by DR BUSBY
DR BUSBY: Professor Howard, you have a copy of your report there?
A. Yes, I do.
Q. This is your report, and you stand by it. Is that right?
A. That's correct.
Q. Is there anything that you wish to add or correct in your report?
A. I did consider -- there's something that's not in my CV, my Lord, which is possibly relevant. I did serve as a medical officer in the Royal Naval Reserve for 15 years and during that time we did cover nuclear, biological and chemical warfare.
MR JUSTICE BLAKE: Thank you.
DR BUSBY: Thank you.
Cross-examination by MR HEPPINSTALL
MR HEPPINSTALL: You are an emeritus Professor in the

University of Ulster as I understand it, Professor?
A. That's correct.
Q. Is it right that Dr Busby has also held a visiting professorial office or role within that university?
A. That is correct.
Q. Were you involved or did you procure Dr Busby holding that office?
A. I proposed him as a visiting professor, yes.
Q. Did you work with him at the University of Ulster?
A. We -- he helped -- I had a PhD student called Andreas Alsaesser whose work is part of my report and Dr Busby did give some assistance in co-supervising Dr Alsaesser.
Q. Given that Dr Busby is representing the appellants in these proceedings why is this information not contained in your report, Professor?
A. I wasn't sure that it was relevant. It didn't occur to me to mention it.
Q. If you arranged for Dr Busby to have a position at your university, you had a prior relationship or professional friendship with Dr Busby?
A. I've known Dr Busby over a period of some 20 years, I think. I was trying to recall the other day when we first met. I think it was in the bar at a scientific meeting and we discovered that we both came from a military background. His father I think got the

Military Cross and was actually in a Hiroshima prisoner of war camp and my father got the Distinguished Service Cross at Suez. He was a pilot. That's how we got to know each other and then we discussed science and that has gone on over a number of years.
Q. Did you not think it appropriate to disclose that relationship and prior involvement with the representative of the appellants whom you are here to give evidence on behalf of by way of a potential if not actual conflict of interest, Professor?
A. I didn't -- it's public knowledge. These positions are public knowledge, and I didn't consider that that was necessary -- I didn't even think of that.
Q. Is it public knowledge that you procured Dr Busby's appointment to the University of Ulster?
A. Well, that would be available if it was asked for.
Q. Don't you think you have a duty to be honest about it and to tell this Tribunal rather than having to have the Tribunal enquire into that matter?
A. I don't think it has any effect on my report, my Lord, and if I should have done that then I would've been happy to do so but maybe I'm naive in these matters. I didn't consider it material to my report.
Q. The bottom of page 3 of your report, please. You discuss Professor Catovsky's report to this

Tribunal in respect of Mr Battersby case and chronic lymphatic leukaemia, and as we go over the page you make a criticism or you say:

"It is strange that Professor Catovsky did not refer to the key Zablotska paper in his report."

Do you see that?

A. Yes.

Q. Do you know the date of Professor Catovsky's expert report?

A. Well, I -- that was 2011, I think.

Q. What's the date of the Zablotska paper, Professor?

A. It's 2013, yes.

Q. So do you withdraw your comment that it is strange that Professor Catovsky did not refer to the paper in his report?

A. In the supplementary report, I think that was the same year.

Q. What's the date of the supplementary report?

A. 2013.

Q. 7 January 2013. When did the Zablotska paper come out?

A. I don't recall in detail.

Q. Do you withdraw your statement that it's strange that Professor Catovsky did not refer to the Zablotska paper?

A. Yes, under those circumstances I do.

Q. Did you check any of the facts that we've just gone

through before making that statement?

A. Can you qualify that?

Q. Did you look at the dates of Professor Catovsky's reports and the --

A. Yes, I did. I'm -- I must have made an error. I apologise for that.

Q. That allegation was made by Dr Busby before the Upper Tribunal. Did Dr Busby pass to you that information when you were writing your report?

A. Dr Busby outlined the areas where he wanted me to cover --

MR JUSTICE BLAKE: I think it's being put to you: did Dr Busby -- the question is: did Dr Busby point out that there was a failure by Professor Catovsky to mention the key Zablotska paper? I think that's the question.

A. No, I don't think so.

MR HEPPINSTALL: Can we look at what Professor Thomas says about the Zablotska paper, please. SB2, tab 2.18.

A. Is that in this thing here?

Q. You probably have SB1 open at the moment. You need SB2. (Pause)

A. Sorry, what was the number?

Q. It's 2.18. She turns to Mr Battersby's case at page 10.

A. Yes.

Q. In the second paragraph there, 2.12.2, she mentions the

Zablotska paper, and she starts the sentence at the bottom of page 10:

"It should be noted that in both the recent study ..."

Which I think is Gudzenko. Are you aware of that one, the more recent update on Zablotska?

A. I'm not sure that I have read that.

Q. Do you just want to look at reference 20?

A. Reference 20 in?

Q. In this paper.

MR JUSTICE BLAKE: The page --

A. Ah yes.

MR JUSTICE BLAKE: Page 13, reference 20.

A. Yes.

MR HEPPINSTALL: So you've not considered the update on Zablotska?

A. No, I haven't.

Q. Well:

"... and in the previous study reported by Zablotska, the numbers of cases of CLL diagnosed are small. In the 2013 study of over 110,000 Chernobyl liquidator workers over the period 1986 to 2006 there were 137 leukaemia cases a total of which 79 were CLL and with dose estimates."

So it's right, isn't it, that the Zablotska paper is

very tentative in its conclusion because of the low statistical power of the study, because of the very low numbers of CLL cases actually within the study?

A. Yes.

Q. Now, I think you also rely in terms of chronic lymphatic leukaemia on the conclusions of the US Government body NIOSH; is that correct?

A. That's correct.

Q. Perhaps we could look at those, please. Again this in the original bundle as D3/10 but we've extracted it. (Handed)

A. Thank you very much.

Q. I have temporarily lost my copy, Professor. (Pause).

We'll try and do it from memory. So if we look at these -- I find these federal registers of the United States Government quite difficult to follow, but we have here at the first page the Department of Health and Human Services setting out its guidelines for determining the probability of causation under the Energy Employees Occupational Illness Compensation Program Act of 2000.

So as I understand this, Professor, this is the discussion of the US Government's decision to admit CLL into its Occupational Illness Compensation Program. You understand that to be the context?

A. Yes.
Q. And NIOSH, which I think is the expert body, sets out its reconsideration of CLL from page 15269 onwards.
A. Yes.
Q. And we see that it set up a panel of experts for the purpose of deciding whether or not it should be treated as being admitted into that program. And if you look at the third column on page 15269 you see about a third to halfway down, and I think because this has been used in previous hearings it was highlighted:
"The consensus among the panellists ...(Reading to the words)... with respect to CLL's association with ionising radiation and additional research was required to definitively answer this question."
Do you agree that that was the conclusion of the expert panel?
A. Yes, that's what's written there. But again I mean you've already pointed out the fact that this is statistically quite a problematic area because of the rareness of the illness and --
Q. Well, let's try and take this a little quicker. So are you aware that in order to qualify under this scheme there has to be a non-zero risk of radiogenicity?
A. That's as I understand it, yes.
Q. So anything, anything above zero will count for the

purposes of this statutory compensation scheme. And it's that basis that, notwithstanding the conclusion of the experts, it's that basis that the US Government decided to admit CLL to the scheme?
A. I think we have to add to that, my Lord, that we shouldn't be surprised if radiation caused CLL. I mean, it's a malignant disease and radiation is a known cause of malignant disease.
So the logical basis for including it is there.
And I think everybody admits how difficult it is to actually measure these things because of the multifactorial nature of the disease. But the fact that the United States and other countries have decided to compensate sufferers is in my -- therefore, to me means that the weight of scientific evidence is moving in the direction of accepting it as a radiogenic disease, which is a logical conclusion.
Q. Well, Professor, are you sure about your answer that the United States Government has decided to compensate for chronic lymphatic leukaemia in all cases?
A. Not in all cases but it's on a list of things to compensate.
Q. It's on a list but let's look at the criteria you have to satisfy, 15272, please, second column.
You're aware, are you, that to get on the list

there's got to be something above zero risk but to get compensation the probability of causation has to be 50 per cent or more?
A. Yes.
Q. The same as the British occupational exposure scheme. You're aware of that?
A. There's a balance of probabilities.
Q. Yes. So we see that a CLL risk model was developed in that second column about halfway down. It starts:
"The CLL risk model was quantitatively tested by calculating the probability of causation results for males between 20 and 40 years of age, hypothetically exposed to 1 sievert of high energy gamma ...(Reading to the words)... because of the same risk coefficient ...
"The results of these ...(Reading to the words)... exceeds 50 per cent only at the 99 percentile and then only for times and exposure greater than 15 years for men initially exposed at age 20."
So you can only cross that boundary, if we're looking at a high dose of 1000 millisieverts -- 1 sievert -- where you were exposed at age 20 and the onset is 15 years thereafter. So it's a very limited window in which compensation is actually awarded, isn't it?
A. Yes, it is a boundary that has been crossed, though, and

I think also in this particular case we're not dealing with external radiation, we're considering internal radiation and the previous witness has been presenting data which shows that you can get malignant disease and other conditions at lower doses than 1 sievert.
Q. Mr Battersby's latency period is well over 15 years, isn't it?
A. It is.
Q. Now, are you able to help us with whether or not uranium binds to DNA? Is that within your field of expertise?
A. Well, I'm -- like most pathologists, I'm a microscopist, and in fact my chair was in bio-emitting. I've done a lot of high resolution electron microscopy and indeed I was the President of the Royal Microscopical Society --
Q. Forgive me, is that a "yes"?
A. It's entirely relevant because when you put tissued into an electron microscope, a beam of electrons is focused at it but you won't see anything unless you have some contrast. And the way we contrast that tissue is by staining it with heavy metals. One of the heavy metals is uranium, it's delivered in the form of uranyl acetate, and it's been shown by many people that this then binds to tissues and that includes DNA. What happens then is that the electrons are defractured by

heavy metal atoms and so you see the structure in negative relief.

So if that didn't happen then the whole field of electron microscopy would have probably failed to progress.

MR JUSTICE BLAKE: Right, so your experience as a pathologist with expertise in microscopy -- I was just trying to read my own writing; both of which are challenging tasks at this stage -- leads you to the conclusion that the uranyl acetate has this function of binding, but I think the question was more generally: do you have expertise about the properties of uranium outside its transformation into a uranyl acetate and biology?

A. I don't have any direct research experience in that field, no. But I mean we know that uranium ions or uranium oxide will bind to phosphates and there are plenty of phosphates around in the body, including -- I mean DNA is a highly phosphorised molecule. So it's not surprising that it does.

MR HEPPINSTALL: Let me put this to you directly, Professor. The Secretary of State's position is that whilst uranyl acetate may bind to DNA, uranium does not. There's no evidence that it does.

A. Well, I mean there will be some ionisation, whether it's

from uranium particles or whether it's as an acetate. And there's also a chemi-absorption of proteins on to the surface of particles. There's another process that's possible.

Q. Hang on, Professor, your words are: "There is unequivocal evidence also that uranium has a strong chemical affinity for DNA."

Then we get reference 4. Reference 4 is the Huxley paper, which is in the bundle, "Preferential staining of nucleic acid containing structures for electron microscopy", which I think you agree is only about uranyl acetate staining?

A. That's a salt of uranium. The thing that's producing --

Q. Just pause, Professor. How can you say "There is unequivocal evidence that uranium has a strong chemical affinity for DNA" by citing a paper about something else?

A. Well, it's not about something else. It's about the fact that we can see things down the electron microscope because uranium, the atom uranium has bound to structures and is causing a negative image because of absorption of electrons. If that didn't happen we would not see it and we do, so we know that it's there. That's the whole basis of being able to image biological structures down the electron microscope.

MR JUSTICE BLAKE: So in your view there's no significant difference on the topic of the binding properties between uranium and uranyl acetate?

A. Yes.

MR HEPPINSTALL: Professor, what evidence is there that any of these veterans were exposed to uranyl acetate?

A. We don't know what they were exposed to exactly because I haven't -- that information is not available. But a major component of hydrogen bombs is uranium and they will have been exposed to nanoparticles containing uranium, various isotopes.

One of the things I've done in the last 15 years, my Lord, is to study what happens to nanoparticles. I've had two large grants from the EU to look into the fate of nanoparticles within the body.

So we have now demonstrated that if you inhale particles in the range 1 to 100 nanometres, that's nanoparticles, then they are delivered preferentially to the alveolus at the bottom of the lung and then they travel around the body by the same mechanism that viruses do. They travel -- on cells' surfaces there is a continuous process going on called endocytosis, where a little pocket is formed, it grabs anything around it and transports it across the membrane. It's been demonstrated that particles inhaled in this way will be

delivered to the brain, the heart, the lungs, the liver, the kidneys and the reticuloendothelial systems, being bone marrow, where they are also preferentially taken up.

So given exposure, particularly by inhalation, we know there will be distribution throughout the body.

Now when a particle lodges in some part of the body we don't know exactly what the chemistry is, but in a small particle with a very, very high surface area there will be a tendency for myo interaction and it's very low solubility but that's not to say there is none and solubilisation could occur.

So I think that exposure, given the fallout to which the vets were exposed, will inevitably lead to body-wide contamination of small particles.

Q. What do you do to uranium to turn it into uranyl acetate?

A. Uranyl acetate? Well, you have to react it with acids.

Q. React it with acids. Did that take place at Christmas Island or Maralinga?

A. The body contains acids. There's a thing called a metabolism going on and biotransformation of internalised materials usually occurs. They don't just stay as they are when you breathe them in.

Q. Professor, please try not to make up things as you go

along. Your statement says this is unequivocal evidence also of uranium's strong chemical affinity for DNA. You cite the Huxley paper. You do not say that somehow uranium fallout, assuming it's there -- and the Secretary of State doesn't necessarily accept it's there, but accepting it's there -- went through some sort of process, outside or inside the body, to turn it into a chemical form whereby it might be able to bind with DNA. None of that is in your report, Professor.

A. Well, the answer is it's never been studied so we don't actually know the answer to that question. However, the experience is with internalised metals that they will undergo some form of biotransformation and become more bio-available. I think that's a general statement I can make there but you're right, nobody's ever done the research to really know exactly what exactly happens to internalised uranium particles.

However, we should on the current basis of all our knowledge about these things assume that some form of biotransformation will occur.

MR JUSTICE BLAKE: Does that qualify for the term "unequivocal evidence", that state of affairs in your view?

A. Well, the unequivocal evidence is what we see down the microscope.

MR HEPPINSTALL: Professor --

A. We're going round and round in circles, I know.

Q. Let's see what you do say. You say:

"The ICRP risk model does not incorporate either of these facts into its calculations of the effects of exposure to uranium and that the existence of such effects could plausibly explain many anomalous genotoxic effects found in those exposed to uranium."

Is the reason why it isn't incorporated because you've just told us there's no evidence for uranium coming out of fallout and turning into a chemical compound that could bind with DNA?

A. We -- I don't -- to my knowledge nobody studied the internal -- I mean, there are two questions that you have to ask. One is: where does it get to? Well, I think we have a very good idea of where these things get to now.

The second questions is: does it matter? That's always much more difficult to answer and the basic research into the fate of internalised nanoparticles of uranium has not been fully investigated. Therefore we have to rely on what we know in general about what happens to things that are internalised and some form of biotransformation probably at quite a low level would be expected.

Q. Professor, did you read the protocol for the instruction of expert witnesses?

A. Yes, I did.

Q. Do you not understand that you have a duty to make clear to this Tribunal that things are quite not as unequivocal or as emphatic as you are making them sound?

A. Well, what I said with respect to uranium I stand by because I look at that sort of information every day down the microscope. We know that uranium binds to DNA, because we see it.

Now, whether one can extrapolate in full knowledge from internalised uranium particles to a form where that would happen, I agree, there is -- that is something that's not fully known.

Q. But Professor, you know that this Tribunal is interested in things coming out of the fallout, entering the body and causing illness. You know that that's what this case is about?

A. Absolutely, yes.

Q. So are you not under a duty to point out that the crucial process, the process by which uranium might turn into the acetate which might bind to the DNA has no foundation in research or evidence at all? Are you not under a duty to put that in your report?

A. I think what I've said is reasonable in the current

state of knowledge. I have no doubt that uranium does bind and I have -- again, I would expect internalised metal particles to undergo biotransformation and lead to more bio-available -- that's the way the body deals with external compounds, my Lord. It tries to make them more bio-available so that it can then excrete them so that the whole of the detoxification process involves trying to solubilise internalised metals, particles, other compounds, organic compounds, latch on another compound to make them more water soluble so that they can undergo excretion. That's a general tenet of detoxification of any geno chemical.

Q. Professor --

A. Therefore I would expect that to be the case.

Q. You go on to say in this paragraph:

"These effects are also shown in studies of test veterans."

And you give us reference 8 and reference 9, do you see that, which is Rabbitt Roff and then 9 is Busby and de Messieres? Do you see that?

A. Yes.

Q. By "these effects" do you mean that uranium must be binding to DNA, causing congenital malformations in the offspring and progeny of test veterans?

A. No, uranium does not have to bind to DNA, although that

would make the process more efficient. It does not have to bind to DNA to cause these effects. It just has to be present in the body as nanoparticles.

Q. Well, you told the Tribunal in your report that these effects are also shown. So the "effects" that you are talking about in paragraph 3.5 is uranium's interaction with DNA; is that right?

A. Well, I actually -- I mean I address that there but I didn't say that that was absolutely essential for these effects to be observed. That's not true.

MR JUSTICE BLAKE: What do you mean by "these effects"?

A. Well, radiation is recognised as a carcinogen, so cancer, my Lord, and it's also recognised as a teratogenic, a causation of congenital malformations. So it is a teratogen and those are the two principal areas that I am concerned with.

MR HEPPINSTALL: Over the page, page 8, you deal with the paper again, 4.1, and in your second paragraph you say:

"Taken together, these provide persuasive evidence that the test veterans as a group shared some prior exposure to genotoxic stress which caused transmissible genetic or genomic damage."

A. Yes, I think that's the case.

Q. And then further on at the end your last sentence is:

"One of the veterans in this case, Mr Battersby,

very probably suffered from this effect as his wife gave birth to twins which were badly deformed and did not survive."

A. That's what I understand to be the case, and that would seem to me to be a logical corollary.

Q. That statement is based on the Busby and de Messieres study and the Rabbitt Roff study; yes?

A. And then of course subsequently the second report that I put in. Yes, there's a raised incidence and I can't think of any other -- I mean there were 12,000 vets originally. I can't think of any other shared experience that they might have had where a teratogenic agent would have been administered, which they would have been exposed to.

Q. Before you convey or make such a statement to this Tribunal, or perhaps more importantly to the Battersby family, do you think you have to have a sound evidential basis before doing so?

A. I think we have an evidential basis.

Q. A sound evidential basis?

A. Yes, okay, well, I think that the evidence that we have is adequate to come to that conclusion.

Q. Let's look at SB6/84, please. This is the paper you refer to, Professor.

A. Yes.

Q. Are you experienced in looking at epidemiological studies and assessing their quality?

A. Right. Well, I'm an expert on survey sampling, which is the basis of epidemiology. I have published a book on three-dimensional survey sampling in microscopy and that's sold 10,000 copies. I ran a course on biostatistics when I was at Liverpool University for medical students. And I was appointed by Sir Cyril Clarke, who was the Professor of Medicine at Liverpool, as the chairman of the Liverpool pregnancy and diabetes study which ran for 15 years, and we published a major paper in the BMJ, an epidemiological paper.

I've also published other papers in the field of epidemiology. So I'm used to reading them. I don't describe myself as an epidemiologist but I do understand the topic.

Q. The second page of the paper, the first column under the table, this is the methodology:

"1,000 questionnaires were posted to the last known address of members. The questionnaire asked details of the veteran's service number, branch and occupation in the services. It asked for details of participation in the A bomb tests."

First of all, do you think it's right that the subjects of the study themselves should be asked to give

details of their participation in the A bomb tests?

A. I accept that these studies -- this sort of study is less than ideal. An ideal study would be to do a respective consecutive of all cases, looking at the clinical notes and then recording the outcome that way.

However, the fact that this approach is not ideal doesn't mean to say that it's not useful. It can be used as a pointer. Of course one can always argue about the pros and cons of selection bias, self-reporting. But these are things that even after a long period of time patients or parents are not likely to forget. And so I think it's useful information, while acknowledging that it's not ideal.

Q. They gave details of any miscarriages and birth outcomes, their children and children's early health and late health and also the same details for the grandchildren.

It can't be appropriate, can it, that a subject of an epidemiological survey would provide details as to their own health, the health of their children and the health of their grandchildren? It's not appropriate, is it?

A. What do you mean by "not appropriate"?

Q. Well, it is a very unsafe way of carrying out an epidemiological study?

A. What, for self-reporting?
Q. Yes.
A. It's not ideal, I accept that. But when there is a dearth of information in an area which one can consider to be important then it is -- I wouldn't say it's inappropriate, it's a way of getting at some information and then seeing what it says to you. But obviously with caveats as to the shortcomings of the approach. It's -- I mean clearly I just outlined before what the ideal approach would be and it would be very I think illuminating to be able to go down that route but that takes a lot of time and money and setting up a research project.
Q. The subjects of this study were members of the British Nuclear Test Veterans Association, weren't they?
A. As I understand it, yes.
Q. Do you think it's important to take into account the bias that might be inherent in selecting a group of subjects from a campaigning body?
A. I assume that they have reported what -- you mean the veterans themselves?
Q. Yes. These are veterans who are members of a body who have historically campaigned about the effects of the tests on their health. Is that the right pool of people to use for an epidemiological study?

A. Well, they are the people that are of the interest for this study, so there aren't any others. I mean you can only get the information from them.
Q. Professor, are you aware of the NRPB studies into the nuclear test veterans?
A. Yes, I'm aware of them.
Q. There's a national registry of nuclear test veterans over 20,000 strong.
A. Yes.
Q. That data is available, isn't it, Professor?
A. I haven't availed myself of it.
Q. No, but if you are going to choose a pool for an epidemiological study isn't the worse possible pool you can choose members of a group who consider -- not all of them I accept, but a group that has as one of its aims the obtaining of compensation for nuclear test veterans by reason of their participation in the tests? Isn't that the worse possible pool to go fishing in, Professor?
A. There is a potential source of bias there, yes.
Q. A potential source of bias or an obvious and dangerous source of bias Professor?
A. Well, that's an assumption but, yes, there's a potential source of bias.
Q. We go on:

"Each veteran was asked to recruit a control of approximately the same age to fill out questionnaire which gave the same details."
A. Yes.
Q. It is epidemiological bad practice to ask the subjects of the study to recruit their own controls, isn't it?
A. Normally I would tend to try and take control data from the whole of the background population.
Q. Then we go on --
A. But if they are trying to match here ...
Q. It gets worse, doesn't it, Professor?
"To avoid the element of choice of a control whose children were known to be healthy or to avoid the reverse of choosing a control whose children who were not, we listed a sequence of choice of control as follows: friend, work colleague, neighbour, in-law, other. This introduced an element of randomness to the choice of control."
That really does take the control group outside of any possible good practice in epidemiology, doesn't it, Professor?
A. It's not ideal.
Q. "We permitted questionnaires to be filled in by spouses or children of veterans who had died."
So people who may not have known about the health

situation of people who had died.
A. Erm -- I hear what you are saying, yes.
Q. Well, a child of a veteran may not know the health situation of their father, may they?
A. May not.
Q. No. Professor, if you take all of these flaws in this epidemiological study together, aren't we in a position where you really cannot rely on its results?
A. Well, I note its results and I note the results of -- it's like the previous witness was saying. You look at the whole of the information that's available and not just one paper.
Q. Are you aware that the Rabbitt Roff questionnaires were framed in very similar terms?
A. Yes.
Q. Professor, you do not just note these studies; these studies are the basis of your conclusions, both in 3.5 and in section 4. They are the basis of your statement that:
"One of the veterans, Mr Battersby, very probably suffered from this effect as his wife gave birth to twins which were very badly deformed and did not survive."
Do you think that these studies are a proper basis for making that statement?

A. I think if you take a Bayesian approach to this, the studies point in the same direction. And that's why looking at the whole of the available literature on that is important.

Q. Professor, let's forget the Bayesian approach, let's think of an ethical approach. Don't you think you have a duty, before making a statement which could affect not just the Battersby family but many other families of veterans and the way they think about their health and its causation, that you can only make those statements on a sound scientific basis?

A. Yes, well, let me comment on that.

What we're dealing with here, my Lord, is a situation where people -- I think it is acknowledged -- have been exposed to dusts of uranium, containing uranium, and these have lodged in their body and from what we know they will be distributed throughout the body.

Now, the basis on which the exposure is estimated is illogical in my opinion. That is that for a teratogenic effect to occur -- and we are dealing with teratogenesis here -- the foetus will pass through windows of vulnerability when the DNA in various organs in sequence will be unwound while the cells are dividing. That's when they are very susceptible to damage from radiation.

Now, with a single flash of gamma radiation that will cause some damage but what we're dealing with here is radiation that's present in the body continuously, 24 hours a day, 365 days a week, and therefore it's going to be there as foetuses pass through various windows of vulnerability and therefore the likelihood of exposure is very high.

That really is not, in my opinion, addressed by the ICRP model. I mean if you think that -- I mean the CERRIE committee itself said that, you know, 1 alpha decay gives rise to a dose of 500 microsieverts. Now, if you dilute that into the whole body, which is what the ICRP model does, then you get a negligible dose. But if you think about it in the terms of where that particle is sitting, it is going to deliver an extremely high dose to the region of the particle, and the range of the alpha particle will be maybe four or five cells.

MR JUSTICE BLAKE: I think you are being asked about the positive basis for the conclusions that you reached in your report, and you've just told us about the disagreement you have with the ICRP model.

A. Yes.

MR JUSTICE BLAKE: I am conscious from what I've already read and heard that there are lots of disagreements in this earlier which makes it --

A. The reason I am saying that, sir, is because we shouldn't be surprised if we find a rise in congenital malformations. That would be what I would expect from what I know about the biology.

MR JUSTICE BLAKE: Isn't that about as much as you could say then, unless there is reliable independent evidence to support that conclusion? I think that's the discussion that is being put to you. It's a question of whether you've pitched your conclusions at a higher level of certainty than was scientifically available to you.

MR HEPPINSTALL: Well, let's look at some independent science, shall we? You should have on your table the Mark Little paper, "Evidence relevant to untargeted and transgenerational effects in the offspring of irradiated parents". It's hopefully still loose on your desk, my Lord.

A. Was that given out this morning?

Q. No, it was given out yesterday.

A. Appendix A, was it?

Q. No, it's an NIH public access -- we can provide you with another one (Handed).

If you just flick through the last pages you will see from page 26 onwards, this is a huge compendium of -- a review of a compendium of studies -- well over, I think, 200 studies -- looking at untargeted and

transgenerational effects.

Can we pass you another?

MR JUSTICE BLAKE: No, no. I know exactly where it is. I was just doing some tidying up.

MR HEPPINSTALL: I beg your pardon.

If we look at the abstract of this paper, as I say it's a review of many other papers, we can see in the second paragraph that the conclusion is that studies of disease in offspring of irradiated humans have not identified any effects on health?

A. These are based on external radiation?

Q. Well, you can see they say:

"We reviewed the health effects in offspring of human populations exposed as a result of radiotherapy and some groups exposed to chemotherapy. We also assessed risks in offspring of other radiation-exposed groups ...(Reading to the words)... Experimental findings are also briefly surveyed."

Then if you want to see more detail, if you turn to page 14, please, you might want to read section 3.2 to yourself.

MR JUSTICE BLAKE: Just read that bit to yourself. (Pause).

A. That was precisely what I've just been saying. We're dealing -- these are dealing with external radiation or short-lived isotopes and we're dealing here with chronic

lifelong exposure to internal radiation and therefore the likelihood of damage is very much higher and that's a major problem.

MR HEPPINSTALL: First of all, that may well be your position, Professor, but don't you think you have a duty to this Tribunal to say, "Well, there is this paper by Busby and de Messieres and there's Rabbitt Roff, but also there is a wealth of other evidence about congenital malformations relating to, I accept, mainly external radiation, that I also need to drew to the attention of the Tribunal that goes the other way"? Don't you think you have a duty to do that?

A. Well, in fairness, my Lord, the time available to prepare these reports is very short --

MR JUSTICE BLAKE: Were you aware of this paper when you prepared your report?

A. I'm aware of much of the literature on external radiation, my Lord.

MR JUSTICE BLAKE: I think this is a literature review paper, isn't it?

MR HEPPINSTALL: Yes.

A. Yes.

Q. If you look at the back there's a huge number -- well, there's three tables of papers that were reviewed by these authors to come to their conclusions.

A. I mean, there are a lot of question marks over papers where the choice of the control group is not ideal. For instance in Hiroshima they were chosen within the area where exposure to internal --

Q. We are talking about your duty to mention any of this, Professor. Have you mentioned anywhere in your reports evidence that goes the other way which is contrary to your conclusions?

A. I did not address the literature which is based on external radiation because I think that what is before the Tribunal is a case which involves internal radiation. I mean, if I'd had a few months to write my report I think I would have definitely tried to do that but I didn't have time and I've addressed myself to what I think is relevant, which is internal radiation.

Q. Professor, you didn't have time to put a sentence in your report that said, "Of course there are papers that go the other way" and cite, say, the Little paper? You didn't have time to do that at all?

A. Well, I could have done but I've based my opinion on addressing internal radiation and I have therefore not really taken into account cases based on external radiation because the biology for congenital malformations and for cancer is different if you are being exposed -- you know, we've heard of a lot of the

literature the previous witness put forward where the levels of radiation exposure are much lower than would be predicted as being necessary by the ICRP model.

Q. So your entire thesis is based on the assumption that Mr Battersby and Mr Smith received an internal dose?

A. Well, I mean, I think Mr Smith was estimated by -- I can't remember the name of the author, but it began with an H -- 1 microsievert, Mr Battersby 40 microsieverts.

Q. Millisieverts.

A. Sorry, millisieverts.

Q. There's an order of magnitude difference.

A. Absolutely. Millisieverts. But we've heard of evidence that actually levels of external radiation much lower than that are still being associated with effects and that's because of the biology. It changes completely when you have hot particle emitters internalised in the body, and again it's this fact that it's a localised intense radiation where the particle is lodged that makes it more biologically effective than you would expect from the ICRP model. You know, this dilution of the total effects into the total organ volume or the total body volume actually doesn't bear any resemblance to what's going on in the body biologically.

Q. Professor, I have to tell you that one conclusion that

can be drawn from reading your report is that what you have been asked to do and what you have done is solely to provide supporting evidence to Dr Busby and the ECRR's theories about risks from exposure to radiation and you have not explored any alternative theories or any evidence to the contrary.

A. Well, I'm not a member of the ECRR. I think that's the first thing to say. That is my report, those are my opinions, and I think we have to recall that the CERRIE committee, which in the end turned out to be pretty conservative, had to admit that the ICRP model was out by a factor of 10 probably in trying to assess the effect of internal radiation. So then Mr Battersby's 40 millisieverts would come to 400 millisieverts and, you know, I don't think there's anybody in this room who wouldn't accept that that was something which was going to have an effect.

Q. Professor, the ICRP, UNSCEAR, BEIR VII, IRSN, CERRIE, COMARE and latterly the HPA have all been highly critical of ECRR methods, epidemiology, the basis of their science and their conclusions, because they rely on studies such as the ones we've looked at, Busby and de Messieres.

Do you not accept that you have a duty to this Tribunal, and moreover to the public, to make sure that

those criticisms are set out and explored?
A. What I am bringing to this Tribunal, my Lord, is experience in the fate of particles in the body. I'm recognised as an international expert on that and an expert in teratology, knowing what the mechanisms are for the likelihood of damage to the foetus in windows of vulnerability.
So I've come to my conclusions not because of the ECRR. I've come to my conclusions because of my experience as a pathologist and nanopathology as well.
And to me the current methods of assessing this are not based on the known logical conclusions to known scientific facts. That's why I have come to give evidence.
MR HEPPINSTALL: No further questions, my Lord.
MR TER HAAR: Let me just raise one matter. I didn't want to interrupt my learned friend's flow, but it is a matter of some concern. It was put to this witness that the evidence that he gave that Professor Catovsky should have had regard to the Zablotska paper could not be a fair point because of the date of the publication. It's very unfortunate my learned friend should put this when in the bundle under SB4, tab 39, is the Zablotska paper showing it was published online on 8 November 2012. It would therefore have been available

to a standard online search carried out by any expert --
MR JUSTICE BLAKE: Not in 2011, I don't think.
MR TER HAAR: But Professor Catovsky's second report --
A. The subsequent report was in 2013, my Lord.
MR TER HAAR: So the point made was inaccurate factually and unfair.
MR JUSTICE BLAKE: Thank you.
Re-examination by DR BUSBY
MR JUSTICE BLAKE: Yes.
DR BUSBY: If I might take you back to this contentious Busby and de Messieres paper, where much was said about the choice of controls and all the other possible biases. If we can go to the first page of that paper, which is at --
A. I've got it here.
Q. You've got it. SB/84. Right. Now there's a box at the head of this paper which was peer reviewed, I have to say, nobody's mentioned this, and at the bottom of this box in the abstract would you mind reading or could you just go to the caveat?
A. The one starting "Whilst caution ..."?
Q. "Whilst caution ...", yes.
A. "... must be exercised due to structural problems inherent in the study, we conclude that the veterans' offspring qualitatively exhibit a prevalence of

congenital conditions significantly greater than that of the controls and also that of the general population of England.
"The effect remains highly statistically significant even assuming a high selection of bias in the responses and credibility is strengthened by the high rates of miscarriage reported by the veterans compared with the controls, a result which could hardly have been due to selection effects."
Q. So my question to you then is first of all do you agree that there were not just controls that were selective but there were also controls that represented the general population of England?
A. Yes, if it's compared with the general population of England that would be a normal control.
Q. And those controls were in fact later on, if we go to the "subjects and methods" section on the second page -- no, sorry, just below table 2 on the third page where it says:
"We made two approaches to analysing these data."
A. Yes.
Q. So what were the two approaches? Could you just briefly tell us whether you think those two approaches were reasonable given the constraints there were on the type of study? There was a case control study and also

a comparison with EUROCAT.
A. Yes.
Q. Can you tell us what EUROCAT is?
A. EUROCAT is a database of congenital malformations run across the whole of Europe. It used to be run by my colleague Professor Helen Dolk in the University of Ulster but she has now after many years relinquished that so --
Q. So would you say that EUROCAT is an authoritative source of control data for such a study?
A. Absolutely, yes.
Q. So therefore, by comparing with the EUROCAT national data in a sense it's a backup for the comparison with the selected controls process that Mr Heppinstall was so upset about?
A. That's right. It's a way of checking its validity.
Q. In fact, the paper shows that the results for the controls process and the EUROCAT process were substantially the same?
A. Correct, yes.
Q. Thank you.
Yes, earlier on you mentioned -- you were talking about the dose from a track of an alpha particle to a cell and you said 500 microsieverts, I thought?
A. Did I?

Q. Later on, Mr Heppinstall corrected you.
A. It's millisieverts.
Q. You meant millisieverts.
A. I apologise.
Q. I am sure that you corrected that, that it was 500 millisieverts was the dose to a cell --
A. Yes.
DR BUSBY: -- from a single alpha particle track. No further questions.
MR JUSTICE BLAKE: Thank you.
Questions from the Tribunal
DR RAYNER: Can I just clarify what you were saying about the foetus being exposed, the various windows of vulnerability?
A. Yes.
DR RAYNER: Because as far as I'm concerned "foetus" is a very specific term used in embryological development.
A. Okay, the conceptus.
DR RAYNER: Okay. Thank you.
MR JUSTICE BLAKE: Thank you, Professor. That completes your evidence. Thank you for coming. You can go.
THE WITNESS: Thank you, my Lord.
(The witness withdrew)
MR JUSTICE BLAKE: We'll take a break now for the stenographers to have a rest. 10 past 12.

(12.55 am)
(A short break)
(12.10 pm)
MR JUSTICE BLAKE: Yes. Just before you call your next witness I thought it would be appropriate just to have a check on how we are doing in time. I think that, despite our various problems earlier in the week, we've now caught up and we are about 50 minutes ahead of time, but we will deal with the next witness today. Tomorrow I was proposing to sit at 9.45.
MR HEPPINSTALL: We might be able to do better than that, my Lord, because Professor Thomas is here and ready to start.
MR JUSTICE BLAKE: I see.
MR HEPPINSTALL: I don't think I'm going to be that long with Professor Hooper.
MR JUSTICE BLAKE: Okay.
MR HEPPINSTALL: Subject to his answers.
MR JUSTICE BLAKE: Then I'll keep quiet and review. I have to do a hand down at 9.45 --
MR HEPPINSTALL: We can take stock at 4 o'clock.
MR JUSTICE BLAKE: Would 9.45 be inconvenient?
MR HEPPINSTALL: Not to this side, my Lord.
MR JUSTICE BLAKE: I appreciate you may have to absorb information and papers are floating --

MR TER HAAR: I was concerned about the amount of time available with Professor Thomas just tomorrow, so having a bit of today will be helpful and also a bit extra tomorrow will also be helpful.
MR JUSTICE BLAKE: Provisionally, we can always review it, and see where we get to at the end of today. If we start at 9.45 tomorrow and if we finish a little earlier than 4 o'clock I don't think there will be too many tears shed over that.
MR TER HAAR: That is probably right.
DR BUSBY: We would be content with 9.45, my Lord. If I call Professor Hooper.
MR JUSTICE BLAKE: Yes.
PROFESSOR MALCOLM HOOPER (sworn)
Examination-in-chief by MR BUSBY
MR JUSTICE BLAKE: Now, do you want to give your evidence standing up or sitting down?
A. I think I'm okay standing, thank you very much.
MR JUSTICE BLAKE: Right. If you ever want to change that position please do so just as long as audibility is not lost.
A. Right, thank you.
DR BUSBY: Right. Professor Hooper, you have a copy of your report there, don't you?
A. Yes.

Q. Do you have anything to add to it or any changes you might wish to make?
A. There's one small omission which was the date of the Depleted Uranium Oversight Board, which was 2001 to 2006, which should follow after the assessment panel on the third line from the bottom of the first paragraph. It's just the dates really.
MR JUSTICE BLAKE: The board was 2001 to --
A. 2006. That was the DUOB which followed -- well, it was also in tandem with the other committee, yes.
MR JUSTICE BLAKE: Thank you.
Cross-examination by MR HEPPINSTALL
MR HEPPINSTALL: Do you remain the President of the National Gulf War Veterans and Families Association?
A. Yes.
Q. What's the aims and objectives of that association, please?
A. We represent the interests of the veterans and their families from the first Gulf War.
Q. Does it campaign on the issues of the alleged ill-health effects of depleted uranium?
A. It campaigns on the care of the sick Gulf veterans and it's not just to do with depleted uranium.
Q. But it includes depleted uranium?
A. It includes depleted uranium and other exposures.

Q. Does that association provide representation at War Pension and Armed Forces Compensation Appeals relating to depleted uranium?
A. They have an officer who does that, yes.
Q. Have you represented veterans or provided expert evidence in such appeals?
A. Yes, I have.
Q. Has that always been on the side of the veteran and has the source of your instructions for that come through the association?
A. No, it's always been on the side of veterans that I've been asked to be their scientific adviser.
Q. So you are also the scientific adviser?
A. Yes, indeed.
Q. And has Dr Busby also undertaken that work, provided expert evidence --
A. Not to my knowledge. The expert evidence that Dr Busby has been involved in has been the work with the Depleted Uranium Oversight Board which was a Government committee.
Q. How long have you known Dr Busby?
A. By reputation for some time but I first got involved with him on the Depleted Uranium Oversight Board especially.
Q. And since then? Since 2002?

A. Since 2006, yes, I have been intermittently involved with him with questions for the Gulf War veterans and I have followed his work in Iraq with some considerable interest.
Q. And you describe in the bottom at page 1 of your report:
"Dr Busby is the leading national and international expert on radioactivity and its effects on people and the environment."
A. Yes.
Q. That's a little bit of an exaggeration to say he's the leading national and international expert, Professor.
A. Well, in my reading of the literature he is. I have found him to be reliable and a very good witness and doing some very good science.
Q. Do you only read literature produced by Dr Busby, the ECRR and members thereof?
A. No. My references show that.
Q. So you also read literature by others, do you?
A. Yes, I do.
Q. Mark Little?
A. I haven't seen his particular paper, no.
Q. Professor Brenner of Columbia University?
A. Go on. No.
Q. No?
A. No.

Q. You don't think they might also have a claim on being leading national and international experts on radioactivity and its effects on people and the environment?
A. They may very well be but in my experience my contacts have been mainly through the work that I've done for the DUOB.
Q. You mention at paragraph 6 the ECRR.
A. Yes.
Q. Are you aware of the serious criticisms made of that body and its work by several international and national regulatory and advisory bodies?
A. I'm aware that it is debatable, yes.
Q. Well, are you aware of the criticisms?
A. I'm aware of the criticism that came through the DUOB which is echoing the criticisms of the ECRR.
Q. You say in the last sentence of that paragraph:
"I was one of those who argued this in the DUOB in 2002 and 2006 and scientific developments since have strengthened this position."
Can you assist us with the "this", please?
A. Yes, it has, because the chemical affinity for DNA as a target for radiation and genotoxicity is something that is very important with regard to the concerns of the veterans from the first -- from the atomic veterans

and from the veterans of Gulf War 1.
Q. Do you accept that there's evidence that uranyl acetate has a high chemical affinity for DNA but not uranium?
A. Could you just repeat that question, please, very slowly?
Q. Well, I'll maybe make it simpler. Is it uranyl acetate that has a high chemical affinity for DNA or uranium?
A. My Lord, I'm astonished at such a question. This is third year chemistry in a grammar school.
MR JUSTICE BLAKE: Can we have the answer?
A. The answer is uranium is a metal, uranium acetyl is the ion formed from the metal interacting with acetic acid. The ion is a soluble form of uranium. Uranium the metal is not soluble except in acids and strong acids. We are dealing with two different things. It's the ion that associates with DNA, not the metal, and I would have thought that would have been aware -- some of you should have been aware of that fact.
The metal does not associate with DNA. It's actually quite dangerous stuff to handle. The ions themselves bind at the phosphate groups on the backbone of the DNA of cells and as Professor Howard is telling you this is a fact that is used to visualise DNA in cells in electron microscopy.
Q. Doesn't it have to be in its acetate form in order to

see that effect?
A. No, it doesn't. It can be any salt. The simple chemistry is acid plus base equals salt plus water and if you get uranium with acetic acid you get uranyl acetate, which is the ion. If you do it with nitric acid you get uranyl nitrate and it is the ion that associates with the DNA.
The choice of the pairing -- an ion is in fact a matter of choice for the nature of the experiment and acetate is a very good choice because it's not going to interfere with the medium very much.
Q. Let's forget about the pairing and the salts and the acetates and the nitrates and so forth. Let's just deal with -- well, let's just deal with uranium coming out of fallout.
A. Yes.
Q. Without that metal going through a process to turn it into a salt, let's call it, for that metal there is no evidence that that alone binds the DNA, is there?
A. Yes, but that metal alone does not come out from the fallout. The fallout is generated at a very high temperature in the fireball at something in the region of 5,000 degrees centigrade, I believe, and that generates uranium oxides, mixed oxides. U308 is the atomic composition that is generally agreed, and that is

a composition of two atoms or three atoms, actually, of uranium. Two are in the high vale and hexavelent state and one is in the tetravalent state. So you have uranium oxides that come down in the fallout, not uranium, and they will interact with acids and form uranyl acetate and water.
It's really very, very basic chemistry.
Q. These additional stages to get from the fallout to DNA are not described in your report, are they, Professor?
A. Well, they're not because it is a simple matter of the environment. If you have an acid there present, and you have plenty of acids present in blood and in saliva and juices and in the gastrointestinal tract, the generation will take place very straightforwardly. It's just a very simple basic process.
Q. Have you considered carefully the Wahab paper studying the nuclear test veterans and the associated report by Professor Rowland?
A. I have looked at that paper. I do not have it with me at the moment.
Q. We can supply you with a copy. If you look at page 4 of your report.
A. Yes.
Q. Second paragraph.
A. Right.

Q. In that you say:
"New Zealand nuclear test veterans ..."
Then you say "Wahab et al 2008".
A. Mm.
Q. So you remember considering that paper?
A. Yes.
Q. So we can now look at that paper, SB7/123.
A. Yes.
Q. You recognise that as the Wahab paper?
A. Yes, indeed.
Q. And if you turn back a few pages you'll see that you then find the formal report which was presented to the NZNTVA, the New Zealand nuclear test veterans. Do you see that, 2007?
A. Which tab are we at?
MR JUSTICE BLAKE: You are in the same tab, but if you go on through the article which is --
A. Not before it.
MR JUSTICE BLAKE: -- and you go to the page after 87, then it starts again, I think, at the bottom.
A. (Pause)
MR JUSTICE BLAKE: Is it "Elevated Chromosome Translocation"?
A. That's the title.
MR JUSTICE BLAKE: Page 87, bottom-right.

A. Right. Thank you.
MR HEPPINSTALL: So did you also consider the Rowland paper as well as the Wahab paper?
A. No, I haven't seen this one.
Q. You've not seen this one before. Right.
Well, if you turn to page 34.
A. Yes.
Q. Where you have a table that sets out the doses.
A. Yes.
Q. That have been worked out from the chromosomal aberrations.
A. Mm.
Q. So you have the blinded participants with their codes on the left, we then get the cells scored.
A. Mm-hm.
Q. We know which ring it's in, and the next column, and then we get the dose; do you see that?
A. Yes.
Q. You then get the confidence intervals. Then there's another three columns which deal with the dicentric testing.
A. Yes.
Q. But those results, as you can see, were sparse.
So if we just look at the main conclusions of the main results, can you see that the dose range is all the

way from quite a few nils, through the low 0 point, the low decimals, all the way to 1.4, NZTV-026. You can see that?

A. I can't see the 1.24.

Q. Take a moment to study it, if you wish.

MR JUSTICE BLAKE: The 124, I can tell you, 13 lines down from the top. The participation of the veteran is 026.

A. The veteran is 026. I've got 0s in there, the dose.

MR JUSTICE BLAKE: Take that line. 026, 201, 8, 1.4. Do you have that?

A. No, I haven't. Where is it?

MR JUSTICE BLAKE: Do you have "NZTV-026"?

A. Yes, I have.

MR JUSTICE BLAKE: Right. What is the next entry in the next column along?

A. 203, yes.

MR JUSTICE BLAKE: That is jumping down. That's 33. 201 is 26.

A. 201.

MR JUSTICE BLAKE: Yes.

A. Sorry, yes, you are in the cell scores, I was reading the --

MR JUSTICE BLAKE: Well, I am trying to draw your attention. So if you are sticking on that line, 026, 201, 8, and then I think in the column dose you are being shown 1.4.

Do you have that?

A. Yes.

MR JUSTICE BLAKE: I am just trying to navigate you.

A. Thank you very much, that's very helpful.

MR HEPPINSTALL: Then you can actually see the confidence interval on that 1.4 stretches from 0.5 to 2.1. Do you see that?

A. Yes. Grays, yes.

Q. Now, you're aware that these New Zealand test veterans were on two ships in the south Pacific at the time of the tests?

A. Yes, yes.

Q. So would one not expect them all to have similar doses within a short to medium range?

A. Not necessarily.

Q. Would you really expect the range to be so many at nil and then all the way up to as high as 1,400 millisieverts?

A. The question -- the problem really is how do you handle the randomness of the fallout and the way in which these things have happened in quite discrete areas. And, also, this is the external dosing in grays, the sieverts would be the absorbed dose, we don't know -- it's the same number, almost, as the absorbed dose -- but that's -- one of the questions and one of the big

problems that came out of the DUOB was how do we get such a differential distribution of illnesses amongst people who are, essentially, very much in the same environment? Because there's a big problem of randomness about this, where, exactly what is, who and when and where.

So I'm not surprised by this, I'd expect to see something like this in a highly random --

Q. They are on two vessels.

A. Yes.

Q. I think it's problematic because we don't know who these participants are and the two vessels do different things.

A. Yes.

Q. But we would expect to see, wouldn't we, if you are on a vessel -- and I think the allegation is that they came across fallout whilst steaming through the South Pacific --

A. Mm.

Q. -- if the veterans came across that patch of fallout why would we expect to see different doses?

A. It depends where they were in the ship. If they're inside the ship, down in the bottom of the ship, and not on the surface, on the top, I'd expect them to get very different doses.

Q. I accept there would be a range, but don't you think this range is so extreme that it points to some serious unreliability in the result?

A. Well, the results are the results, unless there's been some very serious mismeasurement. These are the results they've got to live with, and they are difficult results to live with, but there are explanations for them, particularly in the location of the personnel on the ship.

Q. Are you aware of the Pearce epidemiology into the New Zealand nuclear test veterans?

A. I've just received that this morning, I haven't really looked at it, and I'm not a epidemiologist so I'm not really qualified to make any serious comment on that.

Q. You also rely on the Busby and de Messieres paper, we see that from the next paragraph.

A. Yes.

Q. You also rely, we see within those square brackets, on the Rabbitt Roff paper as well?

A. Yes.

Q. You've just told us that you don't have expertise in epidemiology.

A. That is true.

Q. Did you look at those papers before making the statement that chromosome damage in germ cells will have effects

on offspring?
A. Well, the chromosome damage is mentioned in the paper we just looked at.
Q. Well no, let's talk about Busby and de Messieres and Rabbitt Roff.
A. It's not something that's specific to those papers, it's mentioned in several papers.
Q. I agree you also cite Doyle, Areneta, Kang, Alaani, but I want to talk about Busby and de Messieres.
A. Yes.
Q. Have you read that paper?
A. Yes.
Q. You don't have any epidemiological expertise, but on reading that paper did anything cause you any concern?
A. No, I don't think it caused me any special concern. There's lots of questions to be answered, but it's answered some of them.
Q. Were you in court when Professor Howard was cross-examined?
A. Yes, I was.
Q. So you saw me put to him the concerns about the way in which the controls were chosen, selected, the way in which there's self-report, the pool.
Let me ask you this: you're the president of a campaigning group for veterans. Do you think it would

be appropriate to use them as an appropriate pool for an epidemiological study?
A. Yes, it's been done, actually, and -- it's not been done in any depth because the Government wouldn't allow it -- but the paper that I quote from Schroeder is the one on the chromosomal aberrations found in Gulf War veterans. Now, I don't know where those controls came from because Schroeder did that.
Q. Well, all Gulf War veterans, or was the subjects just drawn from the membership of your association?
A. Gulf War veterans who were available through the association, not necessarily members.
Q. Do you think there is an inherent bias in asking those who believe they were damaged by an agent to report about their health?
A. I'm not quite sure I understand the question because the answer is obviously it is important for them to report about their health.
Q. If you are going to collect data from which you are going to do a scientific study do you think it's appropriate to ask people who have a belief, who are campaigning, on the ground that depleted uranium caused their ill-health, is it appropriate to them to report on their own ill-health for a purpose of a scientific study?

A. Well, that was what they believed. What they thought and what they were concerned about was the depleted uranium was widely used in the battlefield, many of them were exposed and it was a potential agent for causing them ill-health. That's why they were looking at it and that's why Schroeder looked at it. It was a German study done in the German laboratories because the English laboratories would not do it. We asked the to repeat it and they would not do it.
So funding was refused to follow up that lead. It seems to me entirely appropriate, when people are ill, to enquire about the environmental concerns of the battlefield. In Iraq they were awful. You can see from the death rates and the damage from radiation and radiation-related effects in the whole of the Iraqi population.
I've got one paper here where there were a 250,000-fold increase in damage to eyes. You know, so if that's gonna happen to their eyes, what about my eyes?
MR JUSTICE BLAKE: We've got quite enough on our plate to deal with.
A. Right, sorry.
MR JUSTICE BLAKE: Fascinating as it would be to extend our activity to look at Gulf War depleted uranium, that's

not what we are doing.
I think let's just drive back to where my understanding of the question is, but if I've got my understanding wrong I'm sure I'll be corrected.
You know very well, that the issue here is about causal link and doubt about causal link between the experiences of the servicemen in 56 to 60, a wide bracket.
A. Yes.
MR JUSTICE BLAKE: One way, it seems, we've been told, and we understand, that evidence can support or undermine a particular claim, is epidemiological studies.
A. Yes.
MR JUSTICE BLAKE: But can you have an epidemiological study which can either support or shed different light, or undermine a claim, if it's based upon the very group of claimants or campaigners for claimants that the whole issue of causation is about?
A. Well, you've got to look at the claimants because that's people you're interested in.
MR JUSTICE BLAKE: I'm sure you've got to look at the claimants, but one does that by looking at their medical reports, doesn't one, and experiences. Is it a form of epidemiological study independent of that narrative?
A. Well, the epidemiology is concerning people who are

showing certain signs and symptoms, clinical signs and symptoms, and if those are present then the answer is yes.
MR JUSTICE BLAKE: But you're not an epidemiologist?
A. That's quite right, but if I was asking a epidemiologist to look at it that's what I would be asking him to do, "These people are ill, please will you look at it", and we've got some reasons for thinking what might cause that illness, then we can proceed from that position.
MR JUSTICE BLAKE: Right.
A. Which is what we did --
MR JUSTICE BLAKE: I have your answer.
MR HEPPINSTALL: You mention a lot of epidemiology, don't you, in your evidence to this Tribunal?
A. Well, it depends what you mean "a lot", I don't think I did mention a lot, I just mentioned enough to show that I was aware of certain epidemiological data and that it was indicative of my concerns about the veterans -- the atomic veterans -- who received a massive assault from depleted -- from uranium, and depleted uranium, as it came down in the black rain, and from these massive bombs that were detonated.
Q. Sorry, Professor, you are making massive assumptions there, aren't you?
A. Well --

Q. Where on earth are you getting your evidence about a massive insult and black rain? Who has told you about that?
A. Well, the black rain was reported over Hiroshima. It was reported over the atomic bomb sites in Christmas Island. So that --
Q. What's your source for massive amounts of black rain in Christmas Island? What have you read?
A. Well, I've read reports from the -- Hiroshima itself.
MR JUSTICE BLAKE: No, black rain, Christmas Island.
MR HEPPINSTALL: What's your source?
A. My source is the evidence from people who were there.
Q. You've read witness statements to that effect?
A. No, I've got a witness statement with me, actually, which I've not had time to read this morning; but that's what I am hoping to find in there.
Q. Haven't you just been told this, Professor?
A. No, I haven't. It's logical, when you send all this stuff up into the air, that it will come down again, and if it's raining it will be washed down in rain.
Q. Do you have any expertise about the physical properties of a nuclear cloud going into the sky, Professor? Do you have any expertise relevant to that question?
A. I don't have any expertise in that field, no.
Q. Why on earth are you telling this Tribunal about it

then, Professor?
A. Because there is expertise that will show it, and my informed judgment, from the release of depleted uranium from rockets and shells, is that there is a whole amount of fallout that comes from them; but it's not going anything like as high or anything like as extensive as the cloud over Christmas Island, which you can look at in photographs.
Q. Professor, do you think it's appropriate to compare apples and oranges? Compare your extensive experience, as president of a campaigning organisation, and draw on that information in these appeals, which are about something else entirely? Do you think it's appropriate?
A. I think it's appropriate because I'm interested in the truth of these matters; I'm not interested in campaigning at the expense of everybody else. My concern is for truth and justice for these people, and it's not for spinning a tale that will somehow persuade other people to take my point of view without evidence. That's my concern: it's truth and justice.
Q. Do you think your position as president of a campaigning organisation for veterans, especially when it's linked to depleted uranium, means you can't give independent evidence to this Tribunal?
A. Only if I lack integrity, and I do not lack integrity.

Q. For example, do you think it would have been a good idea to have carefully thought about whether you should be putting epidemiology in your report when you have no expertise in that area?
A. It wasn't put in there to show I had expertise, it was put in her to show that I have awareness.
Q. But you don't put any awareness of epidemiology that goes the other way in this report, do you?
A. Well, in actual fact I do. One of my references is a DoReMi low dose research towards multi-disciplinary integration, which is a reference there.
Q. Where do you reference that in your actual text?
A. Well, it's in the index.
Q. But it's not in the text.
A. Page 8 of my submission.
Q. That's the references, but where is it in the text?
A. The reason it's in there is because I am part of a multidisciplinary team. You need multidisciplinary teams to look at these sort of big issues, and I'm one part of a team. I don't expect myself to be expert in all aspects. And what they are planning here at a European level is the development of a new project, which will be very expensive to carry out, looking at biology, dosimetry and epidemiology. That's why I am aware of these things. I'm not claiming to be

an expert, but I'm aware of these things.
Q. The DoReMi, to be fair to you, Professor, you do cite it on page 5. You say:
"There does at least seem to be some measure of concern involving in this area DoReMi 2015."
It's then you get into the discussion about MELODI.
A. Well yes, MELODI is part of what lies behind the DoReMi study, yes.
Q. Can you turn to page 6 of your report.
A. Yes.
Q. I just need -- tried to understand what you are saying in this last paragraph on page 6:
"It's my understanding that the law, as related to the pensions appeals, is that the appellant only has to show that there's some reasonable doubt based on evidence which is not fanciful and that their condition could have been caused by their exposures. It seems to me that if the EU could have enough doubt about the radiogenicity of uranium to give several million Euros to a major scientific project to investigate the issue, that must be good enough for the Tribunal to find that there is sufficient doubt about the MoD's assertion that the cancers developed by the test veterans..."
Then you add in the Gulf War veterans:
"... were not caused by their exposures."

You are here, Professor, to give scientific evidence to this Tribunal.
A. Yes.
Q. Where is the science in saying that an EU funding decision supports the raising of a reasonable doubt of causation? Where is the science?
A. Well, do they want to throw money away on something that is specious or fanciful? I don't think so. I think this is a well designed thing, it came out of the CURE study, so that this is a deliberate development from the CURE study which led to the formation of the DoReMi proposals. I don't think it's fanciful, and I don't think it's fanciful and I think the evidence is, from my point of view, as an expert, is in the biology of these systems.
There are lots of things happening from inhaled depleted uranium, especially, which leads to damage to people by effects which are not directly radiation or reduced. So this is how, for example -- to go back to your DNA story -- the DNA story, the DNA opens up and is chemically broken by the addition of a binding of uranium to the DNA backbone, and then that will cause the backbone to open up and fragment the genome, really, so that you've got a broken genome, we've got fragmented genomes, you've got repaired genomes, half-repaired

genomes, all there forming a whole range of possibilities for various cancers being developed. And other conditions.
Q. Professor, you are an emeritus Professor of medicinal chemistry at Sunderland University.
A. That's right.
Q. Have you done any research on any of the matters that you've just talked about?
A. I've not published any. But that's because I have been -- well, I've been busy trying to get the information together --
Q. So what you have --
A. -- except in the DUOB report.
Q. Is what you have just set out information you have learnt in the capacity as president or member of the National Gulf War Veterans and Families Association?
A. No, it's not just in that. I was involved with the Government war veterans since 1997. So before that I was interested and I was concerned, I was seeing veterans, they came to the university to undertake a test which was for a different kind of test altogether from the ones we're talking about, but it was a test that we had at the university which looked at potential damage to the nervous system and to the gut. That's when I first met them.

Q. Are you aware, Professor, that Mr Justice Charles ruled that Dr Busby could not been an expert in proceedings because of his campaigning activities on behalf of veterans and others?
A. Yes, I am.
Q. Is it not also the case, Professor Hooper, that the reason you are here today is to give evidence on behalf of the veterans because you support their cause?
A. I do support their cause, but it's to give evidence about the truth of the case, not their cause.
MR HEPPINSTALL: No further questions, my Lord.
Re-examination by DR BUSBY
DR BUSBY: Professor Hooper, is the source of your expertise on uranium effects partly the research and discussions of the Depleted Uranium Oversight Board which took place over five years?
A. Yes. That's correct, yes.
Q. In that five years were there an enormous or at least certainly a significant number of scientific papers drawing attention to anomalous effects of uranium presented and discussed by the board?
A. That's correct, yes.
Q. So, therefore, your understanding, and what you've been telling the Tribunal about the anomalous effects of uranium, are supported by your discussions and the -- is

that not a fair question, my Lord?
MR HEPPINSTALL: Ever so slightly leading.
DR BUSBY: I'm not very good at this sort of thing. Don't answer it, in that case.
A. I think I already have.
Q. Yes, I think you already have.
MR JUSTICE BLAKE: We may not attach much weight to a leading question, at least in re-examination.
DR BUSBY: Yes, one other question I wanted to ask you about, which perhaps you may have already partly covered. It has to do with these numbers in the chromosome abberation fish testing that was carried out by Rowlands and his team which I wanted to ask you about.
What is your understanding of the range of possibilities for exposure of people who are on ships which have all sorts of compartments in them, as I understand it, there are different things that people do on the ships, you have the captain. What would be your understanding of the range of exposure that might be just a consequence of where they were at the time?
A. My experience of that is the detonation cloud from -- again from the Gulf War, I'm afraid -- where it released chemical agents over the whole battlefield area. Ships offshore were picking up the sign from their NAIAD

detectors of nerve agents. Again, it was people on the deck who were the ones who reported this and were exposed; the people in the bottom, the bowels of the ship, didn't hear it at all, they just didn't know what was going on. But somebody came dashing round and said "Get your NBC suits on because the alarm has gone off".
So that's -- really my experience is drawn from that.
Q. So just to be clear on what you are telling us. There could be people who were not exposed because, for example, they were not in any part of the ship where any exposure could take place?
A. Yes, I think that's -- yes, I would agree with that, yes.
Q. So, therefore, the range that we're talking about, from zero exposure to large exposure, could be explained?
A. Yes, indeed.
DR BUSBY: Thank you. Well, I have no further questions, my Lord.
MR JUSTICE BLAKE: Thank you, that completes your evidence.
THE WITNESS: Thank you very much.
MR JUSTICE BLAKE: And you may go.
(The witness withdrew)
MR JUSTICE BLAKE: Does that mean we've reached the end of the evidence you wish to call, Dr Busby? Hello?

DR BUSBY: Sorry, my Lord.
MR JUSTICE BLAKE: Does that mean we've reached the end of your evidence?
DR BUSBY: Yes, that's end of our evidence, my Lord.
MR JUSTICE BLAKE: Thank you very much. Shall we resume at --
MR HEPPINSTALL: Two o'clock.
MR JUSTICE BLAKE: -- two o'clock.
Someone is having the happy task of preparing the contents of divider 22.
MR HEPPINSTALL: My learned friend Ms Cohen has a list in the papers and we will sort it out, my Lord.
MR JUSTICE BLAKE: I look forward to seeing that in due course.
(12.50 pm)
(The short adjournment)
(2.00 pm)
MR JUSTICE BLAKE:

MR JUSTICE BLAKE: Yes.
MR HEPPINSTALL: I call Professor Thomas, please.
MR JUSTICE BLAKE: Thank you.
PROFESSOR GERALDINE ANNE THOMAS (affirmed)
MR JUSTICE BLAKE: Are you happy standing up?

A. Yes, for the moment. I may sit down a bit later.
MR JUSTICE BLAKE: As you wish.
Examination-in-chief by MR HEPPINSTALL
MR HEPPINSTALL: Professor Thomas, could you turn up bundle SB2, tab 2.18, please.
A. Yes.
Q. Hopefully there you should find your report to this Tribunal dated 17 December 2015.
A. Yes.
Q. Do you remain Professor of Molecular Pathology at Imperial College, London?
A. I do.
Q. And director of the --
MR JUSTICE BLAKE: West London Genomic Medicine Centre?
A. Yes, I do.
MR HEPPINSTALL: Thank you very much.
At the end of this statement at page 11, you gave a statement of truth; is that still the position today?
A. It is.
Q. I think you want to make some minor corrections to your report.
A. Yes.
Q. Could you just take us to those, please?
A. Yes, I noticed -- I haven't got my report here so it might take me a while to find it -- one spelling

mistake. It should be Techa River in 2.12.2, the second to last line, just after the 21 in brackets, the K should be removed.

I can't remember what the other one was now.

MR JUSTICE BLAKE: The spelling of --

A. It's Techa, not "Techka". So just take the K out.

Then I missed out "carcinoma" after the word "pancreatic" and I need to find out where that was.

MR HEPPINSTALL: There is at 2.11.1 the last line is:

"... when the incidence of pancreatic cancer ..."

A. Yes.

Q. Where do you want to add "carcinoma"?

A. "... the incidence of pancreatic ...", I missed the word "cancer" or "carcinoma". Either will do.

MR JUSTICE BLAKE: Which page are we on?

A. We are on page 10.

MR HEPPINSTALL: 2.11.1.

MR JUSTICE BLAKE: Right.

A. Third line from the end of the paragraph:

"The incidence of pancreatic ..."

MR JUSTICE BLAKE: Okay, got it.

MR HEPPINSTALL: At the time when you wrote this report I understand that you had considered Mr Hallard's first report; is that right?

A. I had, yes.

Q. Have you had an opportunity to consider his two subsequent reports?

A. Yes, I have.

Q. Do they cause you to change any of your opinions as expressed in this report?

A. No, not at all.

MR HEPPINSTALL: My Lord, if the report could stand in the evidence as evidence-in-chief, I have no further questions.

MR JUSTICE BLAKE: Thank you.

Cross-examination by MR TER HAAR

MR TER HAAR: Professor Thomas, good afternoon.

A. Good afternoon.

Q. As you may know, I represent one of the two groups of appellants.

A. (Nodded assent)

Q. The larger group.

MR JUSTICE BLAKE: Everyone apart from Mr Battersby and Mr Smith.

MR TER HAAR: That's a simpler way of putting it, yes.

MR JUSTICE BLAKE: She might then know who you represent.

MR TER HAAR: Yes, my Lord.

First of all, have you given expert evidence in the witness box either in court or at a Tribunal before?

A. No, I have not.

Q. Have you prepared reports for that purpose before?

A. Not for the court, no. I have prepared another report but it wasn't included, I don't think, in the court papers. I prepared a report for the previous Tribunal.

Q. To do with this?

A. Yes.

Q. The nuclear veterans?

A. Yes.

Q. I imagine, because it's an unfamiliar process, obviously you had to take your guidance as to what to do with your report very much from the instructing lawyers.

A. Absolutely.

Q. So don't take what I'm about to ask you critically but I just want to explore a little what your understanding was and how you went about it.

A. Well, I was asked to do a very specific job, which was to consider whether there was reasonable doubt raised on reliable evidence that exposure to ionising radiation at certain British nuclear tests was the cause of the appellants' claimed condition and I was asked very specifically to only do that and based on the dose, which was assessed by Rick Hallard, who is our expert on that.

Q. It was actually a slightly more general level of questioning at the moment about the process of writing

a report --

A. Yes.

Q. -- in this case.

Very often an expert witness preparing a report, who may have had the misfortune to come to court more often than you have, will set out a list of the information that was made available to the expert.

A. Mm-hm.

Q. It's quite customary to say, "I was instructed to look at this question and I was given the following material upon which to form my assessment."

Now it's not a criticism of you; you haven't actually done that here.

A. I wasn't aware I was supposed to list that because I thought you were informed of what we were provided with.

Q. It's not a criticism, it's just a fact, it just happened. But those who instruct me, the solicitors who instruct me, wrote a letter to the Government's lawyers this week and asked what you had relied upon. That clearly was a question which was referred to you, I think.

A. Mm-hm.

Q. And you listed out or they listed out in a letter which must have come from you --

A. Which I saw sight of yesterday, yes.
Q. -- that you had had the possibility to look at really all the other experts' reports that had been filed in the previous First Tier Tribunal?
A. Yes.
Q. I take it that you looked at them and took them into account?
A. Yes, I had looked at many of them previous to that for the report that I provided for the previous Tribunal as well.
Q. I quite understand.
One document that does not appear to have been provided to you is the judgment of Mr Justice Charles who was the judge who presided over the Upper Tier Tribunal. Are you aware that there was an appeal?
A. Yes, yes.
Q. It was said by the Upper Tier Tribunal that the legal basis upon which the original Tribunal had reached its conclusion was either wrong or was wrongly reasoned?
A. Yes.
Q. May I take it that you have looked at that judgment as well as the other matters which were listed out?
A. I'm aware of that judgment. I haven't looked at it in detail. It's written in legal language and I understood there had been a query raised about the procedure.

Q. There's a lot else on your plate, I imagine. Not only this but elsewhere.
I want to just try and fix in mind what we say is the correct legal approach -- the Tribunal may disagree with it -- just so you can see where I am coming from.
What we say is that when you are looking to see whether there's a reasonable doubt as to causation -- that is to say in this context -- once you've established that for example somebody has bladder cancer, the question of causation is: was that bladder cancer caused by service on Christmas Island?
A. Yes.
Q. Now in many scientific contexts, and many legal contexts, that is a question answered on the balance of probabilities?
A. Mm-hm.
Q. But here the Tribunal has to deal with a rather different test which is: is there a reasonable doubt based upon reliable evidence as to whether there's that causal link? You understand first of all that's the language of the pension legislation?
A. Yes.
Q. Now what I want to explore with you a bit as I go through the questions is this. My impression is that what you have done is quite clearly set out what your

own opinions are, and possibly you will also say that what you set out are the mainstream opinions?
A. Mm-hm.
Q. But what I think you haven't done is to set out what alternative views there might be, and if you like say whether they are credible, incredible, should be taken into account, should not be taken into account from a scientific point of view. Do you understand the point I'm asking you about?
A. I think I understand the point you're making. I'm not entirely sure I agree with what you're saying but I think I understand the point you're making. I've considered only the point I was asked to address. I could have waxed lyrical about loads of other things but I stuck exactly to what I was asked to do.
Q. But your understanding of what you were asked to do appears not to have included setting out whether there's an alternative school of thought which might lead to a different conclusion. Am I right about that?
A. If you mean have I considered some of the papers that have been discussed earlier in these proceedings, that set out different opinions about how dose should be estimated, I don't think that was within the scope that I was asked to do.
Q. And I'll come in the course of some of the questions to

some statistical material relating to the effects of low doses.
A. Mm-hm.
Q. You refer briefly to the problems of low doses but you don't set out what appears to be at least a credible alternative view to yours that the LNT, the "no threshold", really means no threshold and at low doses you cannot apply a linear --
A. On the contrary. I think I actually state that in this that it is very difficult below 100 millisieverts to be absolutely certain --
Q. You do.
A. -- what that looks like.
Q. You certainly do say that but I don't think you set out the -- there appears to be a contradiction, and I'll come to it in a moment, where you say "but the relationship is linear"?
A. That is assumed for risk purposes as being linear. Perhaps I didn't make that clear.
Q. That's really helpful because that leads me into what may be an important point to keep in mind when looking at the scientific evidence.
First of all, if we look at the evidence there is for whether radiation causes effects we can look at a number of different groups of people who have been

researched, if I can put it that way, a number of cohorts.
A. Yes.
Q. Obviously, right at the forefront on everybody's analysis are the survivors of the two atomic bombs in Japan?
A. Yes.
Q. Which is the LSS study?
A. Yes.
Q. Every bit of literature places that research right at the forefront --
A. Yes.
Q. -- of all the work that's done and you make that point?
A. Yes.
Q. There was I think also -- well, I'll start again.
A second area for research is in respect of those -- I was going to say Western soldiers and sailors who were involved in nuclear testing?
A. Mm-hm.
Q. So that would clearly include the Christmas Island veterans?
A. Yes.
Q. But also those who are involved at Maralinga in Australia?
A. Mm.

Q. And also I assume there are similar studies in relation to Americans.
A. Yes, there are, and Australia and New Zealand as well.
Q. I'm not sure whether the French have divulged any --
A. I'm not sure.
Q. Although they did going for nuclear testing as well.
A. Absolutely they did.
Q. Similarly, perhaps for understandable reasons, the Chinese haven't been entirely forthcoming with any similar research.
A. Yes.
Q. But curiously enough there is actually some research from the former Soviet Union because there is some evidence about testing in Kazakhstan.
A. Yes, I know that literature pretty well.
Q. So that's a second group of cohorts?
A. Yes.
Q. A third group of cohorts -- the third group, whether it is a cohort or not, is research done following the Chernobyl disaster?
A. Yes.
Q. And I imagine there may also be similar research looking at the results of, for example, the nuclear accident in America?
A. Hanford and Three Mile Island.

Q. Three Mile Island I had particularly in mind.
A. Yes.
Q. We can also look at -- there is research about the effects of living near nuclear power stations?
A. Mm-hm.
Q. There's also research in relation to occupational hazards, so people working in power stations, people in nuclear submarines?
A. Yes.
Q. I think I may have missed some others, but a final big group relates to the ongoing research in relation to people who are irradiated, if that's the right expression, as a result of medical procedures?
A. Yes.
Q. So whether they are receiving a radioactive dose as part of radiotherapy --
A. For radiodiagnostics.
Q. CT scans, X-rays, if you need a filling in your teeth, all those sorts of things?
A. Yes.
Q. So there is a considerable body of material.
A. Mm-hm.
Q. There also of course are a very large number of people carrying out research?
A. Mm-hm.

Q. I don't know if you know the expression "quot homines tot sententiae", but it is Latin for meaning "as many men as there are, there are that many opinions".
A. Yes.
Q. But one of the difficulties we have is this: that we need to assess principally what lessons we learn from the LSS cohort?
A. Mm-hm.
Q. That's the primary information we have, isn't it?
A. I mean, that's the largest source of information of a constantly followed population -- whether studies have been designed appropriately although I admit your side of the room may say that's not true.
Q. I will come to some of the perhaps methodological problems with the LSS study but sometimes we have to just do what we can with the material we have?
A. Absolutely.
Q. One of the areas again as to your role which I don't entirely follow is how it interplays with other experts.
A. Yes.
Q. Can I just put it this way. You are not by profession or by specialisation an epidemiologist?
A. No, I'm not but I have worked with many epidemiologists and what I do for a living supports the epidemiologists when they are looking for biological markers.

Q. Of course it does and one of the things that's become apparent during this week is that the interplay between professions in this area of cancer protection, cancer causation, is very much a multidisciplinary area.
A. Absolutely.
Q. But Mr Haylock -- or Dr Haylock, I'm not sure -- who is going to be coming to give evidence next week, he is an epidemiologist?
A. He is a biostatistician.
Q. His report starts by talking about his epidemiological --
A. Biostatisticians are involved in epidemiological studies so whatever he says he is, he is.
Q. This Tribunal also has in front of it, and it's agreed it's part of the material for consideration, epidemiological reports from Professor Parker.
A. Mm-hm.
Q. Who is I think a very well known and distinguished Canadian epidemiologist?
A. Yes.
Q. And Professor Kaldor, who is a very well known and very distinguished UK-based epidemiologist.
A. Yes.
Q. I think that you would accept that both of those epidemiologists are distinguished in their views and

carry weight?
A. Yes, they are well known in their field but there are other epidemiologists who might have a slightly different version on some of the evidence that they might put forward. They are one opinion of different epidemiologists and as you said, there are many and there are many ideas and many, many different responses to things.
Q. Absolutely. At the moment I am trying to establish that sometimes, even with all the respect which one scientist gives to another, a scientist will say "I'm afraid that particular scientist is so far" -- to use the American expression -- "left field that I treat their evidence with enormous caution".
A. Absolutely. There are certain epidemiologists I will put a heavier weight on their opinions because I trust their studies, they have been well defined and the evidence is given in their papers of how they developed their studies.
Q. As I understand it, both Professors Parker and Kaldor are within that group of reliable --
A. Yes, they are within that group. I'm not going to say any more than that because I don't think that's fair.
Q. I understand you may disagree with some of their evidence, but both of them represent views which can

credibly be held by experienced epidemiologists?
A. Yes.
Q. Can I go back to what we started to talk about, the different purposes for which one needs to carry out this research with these cohorts we discussed.
At one level, perhaps the most unpleasant level, a military nation will want to know what the effect of a nuclear explosion is in case it's used in anger?
A. Sure.
Q. For that purpose, what the military are most interested in is immediate effects, the acute effects, both to property and to human beings?
A. Yes.
Q. It's suggested -- I'm not going to go there, but it's suggested that that might be one of the purposes for which the LLS study was started. Leave that aside.
The second concern will be occupational?
A. Mm.
Q. So that you need to try to establish a benchmark below which you can feel: well, there might be some residual risk but the risk is acceptable; I can put this man into a power station, I can put this sailor into a nuclear submarine?
A. Mm.
Q. For that purpose you are looking for a threshold, aren't

you?
A. You are taking all risks into account, so if you want to argue that's a threshold then you can use that term. I think what you are doing is doing a risk/benefit analysis.
Q. Of course you are. You are recognising a certain situation as you cannot eliminate all risks --
A. There is no such thing as no risk to anything. We might as well get that out of the way now. That is absolutely certain. When I walk out of here tonight I could be run over by traffic on the road. You take that risk because you want to get to the other side of the road so I think we have to accept there's a risk to absolutely everything.
Q. It may not be the major purpose but at least one of the major purposes of the ICRP work ongoing is to try to establish the "safe" levels of exposure in an occupational context?
A. Very conservative safe levels. That I think should be acknowledged as well.
Q. But as you rightly pointed out a moment ago, taking into account a risk/benefit ratio?
A. Yes.
Q. A similar exercise, a perhaps sometimes more acute exercise of balancing risk and benefit operates in the

medical field?
A. Mm-hm.
Q. It is one thing what the appropriate risk is if I go to my dentist and have an X-ray of my teeth done. It's altogether another if I'm already suffering from cancer and I need to go through radiotherapy?
A. Absolutely.
Q. Again, what research is trying to do is to try to establish not what an absolutely safe level is but what a reasonable practicable level is?
A. Yes.
Q. For the purpose of, in that case medical treatment?
A. Mm-hm.
Q. Or diagnosis?
A. Mm-hm.
Q. We can then distinguish another area where what you are doing is getting involved in either the pension compensation scheme for example in America --
A. Mm-hm.
Q. -- which is based seemingly on a balance of probabilities -- the NIOSH scheme as it used to be called -- or in civil litigation where the standard is the balance of probabilities?
A. Mm-hm.
Q. In that context somebody who is coming along to give

evidence is being asked: is it more likely than not that causation is established?
A. Yes.
Q. But I think what you are being asked to do in this case is unique, isn't it, in relation to the role of somebody in your position? Because there's no other context in which you are asked about reasonable doubt about causation.
A. It is an unusual phrase that -- you know, I'm not expert in this. You will know whether that's an unusual situation to be in or not from the law's perspective.
Q. From the law's perspective you are quite right -- my Lord knows more than I do -- but so far as from a medical perspective is concerned it's an extremely unusual test to be asked to apply?
A. For a start off I'm not a medic, so I'm never in that position.
Q. From the point of view of dealing with the probability of cause of cancer, reasonable doubt is never a test applied scientifically, is it?
A. You always question whether the agent -- if you are setting up a experiment to decide whether something is carcinogenic, you question whether the agent you are using and the system you have designed to test whether that agent is using is carcinogenic and then you should

also bear in mind all the other things you are doing in that experiment which may have an influence on that.
I would agree you are always looking for doubt. If you are a good scientist you are always looking for doubt, you are always looking for the alternative hypothesis, and finding a way to test that so that you can take a hypothesis way. Like with medicine as you diagnose people you end up subtracting the things you know and are left with something you say: "I can't get any further than that, therefore I can assume it's likely to be the cause".
Q. I entirely follow that. One of the things about the scientific process -- Copernicus and look at Galileo -- somebody can start with a proposition which appears to be sort of received wisdom improbable but it proves to be correct.
A. Yes.
Q. One of the problems with diagnosis of causes of cancers is that it is so immensely multifactorial?
A. Absolutely.
Q. And that is, particularly when we are dealing with low dose radiation --
A. Yes.
Q. -- that is a fantastically difficult problem statistically, isn't it?

A. Yes, because when you get to a point where actually more cancers are going to be caused by other agents that we're all exposed to -- some of you will smoke, I certainly eat too much and my diet will have a role in my cancer risk, your genetics have a role in your cancer risk -- yes, everything else can come to bear and you might end up with, if you take the BEIR VII criteria, for example, 100 Americans given 100 millisieverts each, one will get cancer likely from the causes of radiation, whereas 42 others will get cancer from other causes. So you're looking for the needle in the haystack.
Q. That's very interesting, let's take that. You have established that out of a cohort of 100 people 43 are going to be adversely affected by the same disease?
A. Yes.
Q. As a statistician, epidemiologist, whatever profession you want to call it, you say "I know of those 43 it is probable that one is radiologically affected"?
A. If you believe the LNT, yes. It's all based on the LNT.
Q. 42 probably aren't?
A. Mm-hm.
Q. That causes a problem that faced with an individual human being --
A. How do you decide --
Q. -- John Smith comes into your surgery -- not yours but

a medic's surgery --
A. Yes.
Q. -- how do you decide whether he is the one out of the 43?
A. Yes.
Q. But what you might say, though, is: "I can't tell. I know one of 43 is going to be affected in that way -- or probably -- and it might be this one"?
A. Mm-hm.
Q. That would be a fair conclusion on that particular example, wouldn't it?
A. Mm-hm.
Q. So you may say: "I just can't tell if he is the 43rd".
A. Given the probability is weighted like that you would say: the off-chance it is unlikely I have picked the one out of the 43.
So it depends on how you look at things.
Q. Yes. Equally, if you turn it the other way round you can say: "I don't know but it's quite possible he's the 43rd"?
A. You can't prove and you can't disprove so you're stuck.
Q. That's the problem the Tribunal may have in this case.
A. There's the question of the word "reasonable" I think is the nub here.
Q. Yes. Let's move on a little then to this question of

the LSS study.
A. Mm-hm.
Q. Now, first of all, in terms of pure epidemiology can I take it, for the reasons I asked you earlier, that you would defer to the specialist epidemiologists such as Professor Parker and Professor Kaldor?
A. I would actually choose somebody else. I would choose Elisabeth Cardis, somebody who I know very well and I'm aware of all of her work. So yes, I would defer to somebody like Elisabeth Cardis rather than the two you cited.
Q. Unfortunately I haven't got her here.
A. No.
Q. The Tribunal needs to assess the evidence. Would you agree with me that compared to your speciality, each of them is more expert in epidemiology than you are?
A. I would have to look at their CVs and read their reports again to tell you whether I felt it was an accurate portrayal of what we now consider to be the consensus of scientific opinion. I'm happy to do that if you wish me to.
Q. I may do --
A. It is quite a while since I read them so I can't recall immediately to mind what they say.
Q. What I really want to ask is whether you are the

appropriate person to ask questions about the methodology of the LSS.
A. No, I think I'm an incorrect person to ask about the methodology of the LSS.
Q. Because if we turn to your report --
MR JUSTICE BLAKE: From what you've seen, is Dr Haylock more likely to be an appropriate person for that topic?
A. Yes, I think Dr Haylock would be able to answer questions on that.
MR JUSTICE BLAKE: So you are passing the buck down the line?
A. I am passing the buck to somebody who I consider is more expert than me. That's my job here.
MR JUSTICE BLAKE: I'm just checking.
A. I don't want to mislead anybody.
MR JUSTICE BLAKE: No, no.
MR TER HAAR: I have to say I thought you might say that. As you are here and if you were able to --
A. Yes.
Q. I don't --
A. Epidemiological methodology is not my expert area so I think it would be more appropriate for you to address those comments to Dr Haylock.
Q. That's tremendous, but just to check that I am, so to speak, going to address my questions to the right

person, could you go, please, to page 4 of your report.
A. Yes.
Q. At paragraphs 1.11 first of all 1.11 to 1.13?
A. Mm-hm.
Q. Reading those paragraphs, it seemed to me as a non-scientist that they were really your summary, your understanding of the epidemiology --
A. No, actually they are quotations taken from the paper by Komiya et al which is why the reference is there because if you look at that paper you'll find I quoted directly from that paper which is the most recent review of that.
Q. So as to whether there are any methodological problems with the LSS which might affect that paper, Dr Haylock is the man to ask and not you?
A. Yes, absolutely.
Q. Good. Okay, that's good because this feeds in, doesn't it, to some parts at any rate of the comments you give on individual appellants?
If we go on to page 6, looking for example at Mr Beeton who you deal with in paragraph 2.2, there at the end of that paragraph, the last sentence you say:
"The most recent data from the LSS study indicates that no risk for cardiovascular disease can be determined in those that received doses of less than 500 milligray."

I was about to say "microgrey" but milligray.
Now that appears to me -- correct me if I'm wrong -- to be your reading of an epidemiological conclusion?
A. Yes, I mean the dose that is given in the LSS below which they are not happy at giving any risk associated with cardiovascular disease is 500 milligray. It is direct quotation from the studies.
Q. I follow that. Again it's the same line of questions. If I want to explore whether or not there are any methodological reasons to challenge that, Dr Haylock -- it's his territory?
A. He will certainly know the literature on that. You know, I have taken the best scientific opinion, which is a consensus opinion which is the LSS study is the right model to use.
Q. Professor Thomas, don't get me wrong. It's not critical.
A. No, no, it's fine.
Q. I am just trying to make sure I don't waste the Tribunal's time and ask the person most suited to answer questions.
A. All of that information is based on what is considered to be the scientific consensus of the relationship between dose and effect.
Q. Yes.

A. That doesn't mean there aren't other opinions. It's just that the scientific consensus does not consider them to be valid and there are people better qualified than I am to tell you what those reasons may be.
Q. And to test whether it's a credible alternative view --
A. Yes.
Q. -- over to Dr Haylock?
A. Yes.
Q. Good, thank you very much.
Is the same true in relation for example to the next page, paragraph 2.4, Mr Hatton? It looks as though it is. Where you say in relation to PRV, here you are relying on Professor Catovsky?
A. Yes, I am because I don't think that is covered in the LSS.
Q. There you are deferring to Professor Catovsky's opinion?
A. Yes.
Q. You say you share it but --
A. Based on what I read of his report I shared his conclusions with -- or the references here given. I'm not an expert on haemotological problems so I would defer to his opinion because he is an expert.
Q. So when the Tribunal comes to read your report would this be a fair way of looking at it: you obviously have considerable expertise and I'm not suggesting you've

gone outside your territory when you're looking at these particular individuals.
A. Mm-hm.
Q. But first of all, when it comes to reliance upon epidemiology you defer to those who are more specialised in that field?
A. Yes.
Q. When it comes to specific cancers and other conditions, of which is PRV one example, you defer to those -- I'm not sure if the right word is "clinicians" but those researchers who have more knowledge of those particular conditions?
A. Yes.
Q. If we were dealing with thyroid cancers we would be plumb in your area and there would probably be no one more expert than you in the country?
A. I think others have to argue that but thank you for the compliment, yes.
Q. When it comes to other matters we do have already specialist opinions in the papers which we can refer to?
A. Yes.
Q. Good. Thank you.
The other point, though, on which you haven't given opinions -- again it's a question of what you were asked to do, so again no criticism, but next week we will be

hearing evidence from Mr Hallard.
A. Yes.
Q. You were asked to take his figures and say: assuming those figures are right, what's the consequence?
A. Yes.
Q. We will be suggesting to him next week that actually there are various matters he hasn't taken sufficiently into account and that if you take them into account his figures are too low. That's a matter for him to deal with. We may be successful in persuading him, we may not.
But what you haven't done is to set out for the benefit of the Tribunal what your alternative view would be in relation to a number of these. I think Dr Beeton, for example, you'd say: well, I'd have to get the figure up above 500 milligray?
A. Yes, absolutely.
Q. But you haven't set out for example what would be the consequence if for Mr Abdale it should be 4 millisievert or 10 millisievert or 20 millisievert.
A. I wasn't provided any evidence -- certainly I didn't see from the reports you provided from your side of the argument doses that were individually tailorised for me to make any comments on. The only ones I was provided with were from Mr Hallard and in fact I would not have

written this without dosimetric information because that would have been very stupid.

Q. Why?

A. Because you cannot assign a cause and effect unless you know the dose. The dose is absolutely critical. I think you know that as well as I do.

Q. I wouldn't want to bet on that!

MR JUSTICE BLAKE: Can I ask just ask a question to clarify. You've just been asked about Mr Abdale and the received dosage you got from Dr Hallard.

A. Yes.

MR JUSTICE BLAKE: I think I'm right that you, following him, add up at 2.1, 2 millisieverts with, 2.2, 146 millisieverts, making a total of -- does one combine them to make a --

A. No, what I'm doing is trying to give you some context to say that if you've lived for this number of years on the planet you have an average radiation dose which I've been quite conservative with. 2 is quite low. It's 6, for example, in Cornwall. Don't tell the Cornish authorities that because they'll be really upset about that. But it's just to give you some context that in his lifespan he would have received radiation from natural background sources of 146 which you can't avoid. We all get exposed to that. But the extra that he

received from being involved in those tests was about 2 millisieverts.

MR JUSTICE BLAKE: 2 millisieverts.

A. So if you wanted add his total dose up you could say 148. But then I would urge caution because you don't know what his medical records say about how much diagnostic radiology or if he had a treatment of anything. That is not included in the information we were provided. So you can't give a sum total of dose because you don't have all the information. All I can do is to set a background dose which we can't avoid against an extra dose that was received as a result of being where he was at the time of the explosions.

MR JUSTICE BLAKE: But the entry dose is internal exposure at 2 millisieverts, 2.2, is it? I just want to understand --

A. That's the internal exposure cited on Mr Hallard's report and that's the one I used for the extra exposure he would have had because of him being present at the tests.

MR JUSTICE BLAKE: The question I have, and it may be a very stupid one, is that in 2.1 is any external exposure by reason of presence in Christmas Island accounted for? You dealt with the background exposure that we all have but is there any --

A. No, where it was an internal tissue we are talking about I have used the internal dose because I think that may be of more concern and the internal doses are actually quite low. They are a lot lower than people would expect them to be. If you want I can elaborate on that but I don't want to waste the court's time.

MR JUSTICE BLAKE: I may be wasting yours but I was exploring this.

MR TER HAAR: First of all, my Lord, next week we will be looking with Mr Hallard at how he gets to this.

MR JUSTICE BLAKE: Yes.

MR TER HAAR: But Professor Thomas, can I just on that issue of how low or how high the internal dose is deal with this with you. Because I think this is within very much your speciality.

As I understand it, the way in which this is treated is that you assume that whatever is taken into the body is so speak spread through the whole body mass?

A. No, it depends on the isotopes so you have to understand the isotopes that are present. So, for example, iodine and thyroid is a very good example. We know that the thyroid naturally concentrates iodine because iodine is a very rare element normally. We need iodine to make our metabolism work, so over generations our bodies have developed mechanisms to basically suck up and store

iodine to make those hormones. If you give a dose of radio-iodine most of it will end up in the thyroid because of the biological mechanisms that allow you to concentrate it.

Other things do get spread throughout the body because they don't have a biological mechanism that binds them chemically to structures within individual tissues. So the dose is very different on the isotopes.

You also have to take into account the physical half life of an isotope. So something that does not emit its radiation very often has a long physical half life and you also have to take into account the biological half life of the chemistry of your body and that varies. Iodine, for example, has a half life of about 100 days in terms of its biology. So if you take a dose in it will stay there for about 100 days and then it will get replaced. But the physical half life of iodine-131 is only eight days, whereas caesium has a 30-year half life so most of the time the caesium will sit there and will not emit much radiation while it is in your body and it is lost from the body in about 80 to 100 days.

So the actual dose to the tissue is the combination of the type of radiation, which is the weighting factors used in the ICRP model, so an alpha particle is a lot bigger than a beta electron that has a small energy

ratio.

So it takes into account that. And it also takes into account the biological and physical half life of those isotopes.

It's not as easy is taking a dose of medicine. It's a lot more complicated and you have to bear in mind all of those to really understand the effects of radiation. That's why people find it so difficult.

Q. Some of the evidence which the Tribunal has been hearing this week, I think you have been here whilst it's been going on, is where the significance is of, for example, Professor Howard's evidence -- whether you accept it or not, just so we can set the context of the importance of it --

A. Yes.

Q. -- that if it be right that uranium -- I'm not asking for the answer to the question -- if it be right that uranium bonds with DNA in cells that in itself could be extremely important in some forms of cancer --

A. Can I comment on that? He's quite right, it does bind when you have a thin section --

Q. I will let you have an opportunity to deal with that but first of all, that is the context of the significance of the evidence that was being given. Am I right about that?

A. Yes, but the uranium has to get to your DNA in your body.

Q. I'm sorry, at the moment I'm taking it by stages. The theory which was being put forward by Professor Howard, which I understand you are about to tell me you disagree with, but the reason why it's important is this. If it be right that uranium once it gets into your body in some form can bond with the DNA in cells, it is at least the view of some people that that in itself can be a cause of sometimes quite aggressive cancers, for example pancreatic cancer?

A. Actually there is no evidence for uranium being carcinogenic -- and it's been looked at -- in man, absolutely no evidence. Genotoxic, but not because of its physical properties but because of its chemical properties because it's a heavy metal ion.

Q. As I say, I understand you to disagree with this and it would be impossible for me to stop you expressing your view but I am going to give you the opportunity in a moment. Do I understand first of all rightly the hypothesis which other people are putting forward with which you disagree?

A. You understand the hypothesis being put forward, it's just that I think that hypothesis is not correct.

Q. I'm taking it by stages to make sure we agree with the

hypothesis and then there's the question as to whether you as a scientist agree with that hypothesis?

A. Yes.

Q. I think you go so far as to say that that is not a credible scientific view.

A. No, I don't say it's not a credible scientific view. There's evidence that uranium binds to the phosphate of DNA, because we do use it as a stain for electron microscopy. We could substitute lead instead but actually we do use uranium because it's very good. So I don't have a problem with that. What I have a problem with is then jumping from that to say it's causing defects in people. That's where I take issue. He's quite right that we do use uranium acetate as a dye for electron microscopy.

Q. Would you quarrel with the proposition if it was put in a slightly less firm way, not that it "will cause" but that it "might cause" that transformation?

A. There are several caveats that you have to be aware of from the biology before you can jump to that.

First of all, if you intake uranium you are going to take it into your body in one of two ways. You are going to ingest it. All of us have some uranium in us because it is a constituent part of the earth. It's a very small amount, usually, but you either eat it in

your food or you'll breathe it in in the atmosphere.

Q. Shall we take it as being -- to limit the number of options, can we for the moment assume that it's inhalation?

A. Okay. So first of all it will get into your lungs. Then it has to get out of your lungs into the blood system to be distributed around the body. There is good evidence looking at uranium millers, people who crush uranium in mills, that very small amounts of uranium actually stay within the lungs. Most of it you cough up with the mucus. That's why we produce mucus in our lungs is to transfer particles and things we don't want in our lungs out. So most of it comes straight back out again and does not get deposited. A small amount might get into the lungs. Very little of that will get into the bloodstream because most uranium compounds are insoluble and if they are not soluble in water they can't go through.

I was originally a pharmacologist and spent a lot of time doing toxicology.

Q. I come back to my question. Subject to caveats as to how probable it is, would you at least accept it is a possibility which --

A. But again the dose is critical. The amount that actually gets into the body and stays in the various

tissues is absolutely critical. In fact, what you find with uranium it is so toxic that if you take in too much you have kidney problems as you are trying to excrete it from your kidneys.

Q. Isn't one of the problems --

A. 70 per cent of it gets excreted in the kidneys.

Q. -- that we face in this particular regard that the number of situations in which people inhale uranium happily are very few indeed?

A. I take it you are talking about inhaling radioactive uranium? Because we're all exposed to stable uranium.

Q. I'm talking about the sort of situation that this Tribunal is considering, where you have uranium in the air and possibly resurgent, resuspended from the ground as a result of a nuclear bomb.

A. In certain areas around the nuclear bomb, yes. I think we still have to decide what the distance is over that where it would be deposited because it is quite a heavy atom.

Q. That again we'll be going through to see how Mr Hallard can help us about that and whether he has the expertise to say what he says about that. That's next week's journey. But the point I was putting to you is that one of the problems of deciding what the effect of inhaling uranium in that situation is is that in practical terms

we have a tiny statistical sample?

A. No, we actually have quite a lot. There are uranium miners who when things were less well controlled in the industry would have taken in quite a bit of dust and some of that would have contained small amounts of radioactive uranium. We know certainly they inhaled radon and we know that is a significant health issue with them.

Radon is a much shorter lived isotope and we're all inhaling radon whether we like it or not, that's part of our background dose. There is actually quite a substantial amount of information. If you look at the miners' cohorts that would give you some information about that.

Q. That would give you some information, I'm not denying that, but in terms of a significant statistical survey it's very difficult because --

A. More people were exposed in that situation than have been exposed in this situation so actually I would have thought they were statistically better studies.

Q. They might be better but they are still limited --

A. Every study has its limits.

Q. -- not least because -- I'm putting it bluntly -- many of the countries in which uranium has been mined not being entirely careful about their employees, some have

never divulged their statistics, some you are dealing with matters many, many years later --

A. But there are good cohorts. The Wismet miners' cohort in Germany is a very good one to look at and that has had extensive investigation.

Q. But again -- remind me what's the cohort in that case?

A. Wismet miners. W-I-S-M-E-T.

Q. How many people were involved?

A. I would have to look up the papers to tell you but they may be in bundle.

MR JUSTICE BLAKE: It's not one that is referenced in your materials?

A. It isn't one that is referenced because I wasn't concerned with that.

MR JUSTICE BLAKE: I am just trying --

A. No, no, it might well be in the bundle. We can probably find it.

MR JUSTICE BLAKE: -- to track down the limits of my education.

A. I can certainly find the reference for you overnight if that's what you would like.

MR TER HAAR: Professor, the reason we got into this is you have taken -- I totally understand what you were asked to do -- you have taken the dose levels from Mr Hallard's report?

A. Mm-hm.

Q. So you haven't been involved with, if you like, any input from your point of view into whether those doses are rightly calculated or not?

A. Yes, it wouldn't have been appropriate. I don't have the expertise to do that.

Q. I understand. At the moment we don't even know what levels of uranium there would have been because the Government hasn't even disclosed whether uranium was used at all?

A. Yes, and whether the uranium was deposited in the areas in which the veterans were --

MR JUSTICE BLAKE: I'm not quite sure that's right.

MR TER HAAR: Sorry, I think it would be more accurate to say the levels of uranium --

A. I think you might find that was a bit difficult to get out of the Government as I'm sure that would be a secret.

MR TER HAAR: We haven't tried, but Professor Busby has tried.

A. I'm sure that would not be regarded as something that could be disclosed widely.

Q. For obvious reasons.

It seems to me at the end of the day most of the questions I thought I had for you are either going to be

for Mr Hallard or Dr Haylock, so thank you very much for your time.
A. Thank you.
MR JUSTICE BLAKE: Do you have some questions?
DR BUSBY: I think probably I do. I'm a little bit wrong footed, my Lord.
MR JUSTICE BLAKE: Shall we take a break now?
DR BUSBY: I had hoped to have tonight to get ready to cross-examine Professor Thomas. A break would be beneficial. Yes, thank you.
MR JUSTICE BLAKE: Well, let's have a break. I was going to have until ten past three. I will have to rise tonight at 10 past 4. I would hope, however, that if --
DR BUSBY: Yes, yes, my Lord, that would be very helpful. We could get in the first half of our -- I do have rather a lot of questions for Professor Thomas.
MR JUSTICE BLAKE: Yes.
DR BUSBY: Or I will have, I should say.
MR JUSTICE BLAKE: Well, yes, except I seem to remember that I saw that you didn't actually have any questions to pose on the report and bearing in mind the -- yes, the document at the back of tab 2.22. You need to make quite sure that the questions you do want to pursue you are fruitfully pursuing with the right witness.
DR BUSBY: I think we flagged up our questions -- is this

the one you are talking about?
MR JUSTICE BLAKE: Anyway, I will rise until 10 past 3. Please just think through what you want to explore you are exploring with the right person. There we are.
You are in the middle of giving your evidence. If you haven't given evidence before, please don't talk to anyone about your evidence until it's all over. Thank you.
(2.55 pm)
(A short break)
(3.10 pm)
Cross-examination by DR BUSBY
DR BUSBY: May I start?
MR JUSTICE BLAKE: Yes.
DR BUSBY: I do apologise. I was a minute late, I think my watch --
MR JUSTICE BLAKE: Don't worry.
DR BUSBY: It wasn't keeping the right time.
Professor Thomas, good afternoon.
A. Good afternoon.
DR BUSBY: What I want to start by asking you is if you have -- and I think you've said you have -- considered the CPR rules that outline what an expert report should contain.
A. Yes.

Q. I think you did say that, didn't you?
A. I said that in my statement.
Q. You also told Mr ter Haar that you had read all of the reports that were in the case. That is at least four reports from the Battersby/Smith appellants.
A. I have read them but it was some time ago so I would need to look at them to refresh my mind.
Q. My concern is this. Perhaps you can explain why, since as an expert you are required to, as I understand it, discuss alternative hypotheses or evidence which goes against what it is that you are putting into your report, why your report doesn't appear to contain any discussion whatever of the very large body of information and the papers that were cited and the general presentation of the arguments which we will go through this afternoon and probably tomorrow, relating to this issue. Why did you not --
A. Because I did not regard that as the evidence on which I should be basing my information. I was asked to look at the dose which was to be provided by me and to assess whether it was likely or unlikely that the dose that these appellants were exposed to would have caused the illnesses that they report. That is what I was asked to do from my letter of appointment to this particular Tribunal.

Q. Of course it was, of course it was, but since, as you say, you did read the CPR recommendations for experts --
A. But I would have required the dose from those reports. I did not see any evidence of an individual dose for each of those appellants in these particular reports so I would not be able to do that.
Q. Right, okay. So we've talked a lot about dose and it would be very helpful to me anyway and to the Tribunal if you could just tell us what that means. What is dose?
A. Do you mean in terms of radiogenicity or do you mean in terms of general dose?
Q. How would you calculate or it measure it? What does it mean?
A. If you're talking about radiogenic isotopes, radioisotopes, then it's slightly different from if you are talking about a dose that you would administer to a patient of a drug, okay? The dose is the amount of a substance to which your tissues are exposed. That's what the definition of "dose" is.
Q. The amount of substance to which your tissues are exposed?
A. Yes, and different tissues may be exposed to different doses from the same intake of a substance.
Q. I'm sorry, there seems to be a misunderstanding here.

I am talking about the concept of dose as we are speaking about it in this Tribunal. That would be, to be quite specific, the absorbed dose from a radioactive exposure --

A. Then it's exactly the same. It's the amount of radiation which is the substance to which you are exposed, which your individual tissues are exposed to. So it could be a chemical agent or it can be radiation. The substance that you are in exposed to in this case is the radiation.

Q. That's right. I agree that's a good general definition of dose. I can say I had a dose of 300 milligrams of aspirin. But that's not quite what I'm getting at. What I'm talking about is what is meant scientifically, since you I can see are an expert in this area of radiation risk and cancer, and you would agree with me I hope that where we start out in trying to estimate whether or not the appellants received a sufficient dose to cause a cancer we should start with some understanding of what is meant by dose.

A. That is my understanding of dose: the amount of radiation to which your tissue is exposed. I don't -- I am unaware of any other form of dose. I'm a pharmacologist, I would be expected to understand it.

MR JUSTICE BLAKE: We've got an answer on that question.

Now where do you want to pursue the debate?

DR BUSBY: I'm not really -- I can't really accept the answer, my Lord, because it absolutely --

MR JUSTICE BLAKE: Well, perhaps you had better put the proposition that you think is the correct answer and ask the witness to comment upon what you -- so make the proposition you want her to comment upon.

DR BUSBY: The generally scientifically accepted definition of absorbed dose is energy per unit mass or joules per kilogram. Would you agree with that?

A. Yes.

Q. That's really what I was going for.

A. But radiation is a form of energy so I don't think that we differ.

Q. No, I'm sure we don't differ, it's just that we need to -- because I want to follow this along in a logical fashion to get to the point where I'm hoping to get to with you.

Well, if it's energy per unit mass, then the quantity of dose that is 1 joule per kilogram would be 1 gray, would you agree with that, as a definition of a gray, that's a definition of 1 gray?

A. Yes, but I'm not an expert dosimetrist so when you come into definitions like this that's not my expert field. My expert is the effects of those doses.

Q. Of course. Of course. But we need to get to some idea -- I hope to get to some agreement with you or some discussion with you where we can get to some point where we can try to examine what is meant by "dose" when we get down to the microscopic level. That's where we are going along. So so far --

A. It's the transfer of energy, yes, I would agree with you on that.

Q. So far we agree. Right. Of course, if the dose is from an element or from a type of radiation exposure that involves alpha particles you would agree that the doses calculated are expressed in a quantity known as sieverts?

A. No, that's when you sum all the different types of radiation together, so if you are exposed to both alpha and gamma and beta, the sievert is the sum of the individual components of dose which come from those different types of radiation. That's the definition.

Q. Let me put it differently. If you had an alpha exposure of 1 gray, what would that represent in terms of sieverts?

A. I'm sorry, I can't calculate that. I'm not a dosimetrist.

Q. Well, if I were to suggest to you that all that you do to get an alpha dose in sieverts, or a gamma dose or

a beta dose in grays is you multiply by a factor of 20?

A. Which is the weighting factor that is used by ICRP, yes.

Q. So you would agree with that?

A. Yes.

Q. Right. So do you know --

A. That's more telling you about the effect --

Q. Of course.

A. -- that that dose is going to have.

Q. We'll certainly go to the effects but in order to go to the effects I'm afraid I'll have to sort of go slowly through this rather boring scientific stuff and no doubt I'll have to talk Mr Hallard about that on this level as well. But at the moment, since your report is about the effects of doses, I am hoping to start to try and understand what you mean by "doses".

A. Mm-hm.

Q. Right. Now, if someone is exposed to external radiation at Hiroshima, for example -- and this is the basis of all the risk models that underpin the case of the Secretary of State and the case that you are making in your report here -- we would take all of the energy that impinged on the unfortunate individual at Hiroshima from the gamma radiation from the bomb and the neutrons and all that stuff, the external stuff, and we would divide it by the mass of the individual, so there would be

absorbed energy in joules divided by the mass of the individual and that would give us the dosage rate?

A. Because there is no reason to suppose that you would not be uniformly exposed. There is nothing that would be targeted to a specific area of the body. Unless of course you were shielded, in which case then you would have a difference.

Q. Absolutely, quite so, so if half of you was behind a building and you just happened to stick your arm out then this arm would get a larger dose and that's because it would get more joules per kilogram. So if you could chop your arm off and weigh it and you took the number of joules that were absorbed by that piece of you it would give you the dose in grays?

A. Yes.

Q. The problem arises now -- it's quite important to the discussions here -- what happens when you, for example, inhale a particle of uranium from the bomb, because these bombs were made of uranium -- the Hiroshima bomb was made of uranium?

A. Yes.

Q. And it goes bang and all these particles come down. We heard from Professor Sawada -- I think you were there at the time --

A. Yes, I was here.

Q. -- about the problems with the black rain and then the resuspension of the material and the inhalation and so forth.

What would happen if one of those particles -- and we're not saying at the moment it will but just for the purposes of arguing on this concept of dose -- got through the lung and it ended up in some piece of tissue? How would you calculate the dose for that?

A. You'd have to know what the isotope was, so you would have to know what its physical half life is, and then you'd also have to know what biological half life of that particular substance was in the body and whether it dwelled for longer periods of time in one part of the body than the other.

Q. Quite so.

MR JUSTICE BLAKE: Can I quickly get that answer down? (Pause). Yes. Fire away.

DR BUSBY: Quite so. Now let's say that that particle -- and I think you said that a lot of these particles get into the lung but they don't go any further than that.

A. Yes, you cough them back up.

Q. But I think most people, and certainly there's a lot of evidence and perhaps you can assume that having coughed it up you then swallow it?

A. Yes, that is certainly one way of being exposed.

Q. So this particle then goes right down through the gut, in our thought experiment of course, and it lodges in the colon, in the villi of the colon. You are a pharmacologist, you understand --

A. In the small intestine.

Q. That's right. Well --

A. And the colon.

Q. We are going to go to the colon. We could do the small intestine but we are talking about the -- this particle lodges there, and we have this particle and it sits there and it produces alpha particles for a long time coming out of --

A. In the case of uranium very rarely because of its long physical half life.

Q. Of course. Not many of the particles but some.

Now my question is this, and I hope this is the key issue here of what I want to get to: how would the ICRP deal -- how would the conventional risk model that we have now deal with the dose to the colon?

A. You are asking the wrong person because as I said before I'm not a dosimetrist. But, you know, you have to have the evidence of how much is left in the colon, how long it stays there and all the rest of that. So you'd have to build that into your model. But I'm not an expert on the ICRP model and I think you should address that to somebody who is.

Q. I will certainly go to another expert on it, but I don't think that you need to be an expert on the ICRP model to follow what it is I'm trying to get to.

The ICRP model, as we have just agreed, it dilutes the energy in joules from any exposure into a mass of tissue which I think I forgot we didn't agree this, but I'm sure you will agree represents the organ?

A. Yes.

Q. So this would be the organ dose to the colon.

A. Yes, it's based on an average person.

Q. That's right. So the colon of an average person, and this average person now has a single particle of uranium that's got into his colon and it's just sitting there. And so the ICRP model you would agree with me, I hope, dilutes the decay of energy from that single particle into the whole of the colon and that's the dose to the colon from that single particle?

A. I'm not so sure that they go down to the granularity of the single particle.

Q. That may be the problem, Professor Thomas.

A. So a single particle emitting an alpha is likely to cause cancer in your way of thinking, yes?

Q. I'm not saying what my way of thinking is. I'm trying to ask you what you think.

A. I think the dose you would be exposed to would be very, very tiny from a single particle of uranium and the chances of you getting cancer from that would be very small. You are far more likely to get it from your diet.
Q. That may well be, Professor Thomas, but that's not what we're discussing at the minute. What I am trying to get to at the minute is: what would the ICRP calculate that dose to be, and your answer is it would be very small?
A. Yes, if you're talking about a single particle --
Q. It would be vanishingly small, in fact. I think we can agree vanishingly small, yes.
Now I am going to ask another question about this. Do you know what the track length of an alpha emission is?
A. Not offhand. I'd have to look it up. It's not the sort of thing I keep in my mind.
Q. Sure, but I were to say it's about four cells?
A. It would depend where on the crypt villus it was lodged because of course it has to get to the stem cells --
Q. Of course it would, and in fact this is a thought experiment, we can put it anywhere we like. I leave it to you, you can put it wherever you want to. My concern is what happens in the vicinity of this particle in terms of dose.

Now we've already agreed that dose is energy per unit mass. Since we say that the energy released by this particle is into a mass of cells that consist of not many cells because the range is very small, it doesn't go right the way into the whole colon, so the question is: what is the dose to the cells where the particle is?
A. Well, it would depend, you know, on when where it was lodged but you have to ask a dosimetrist to tell you that, I cannot tell you.
Q. I am just asking you --
A. Presumably, if it's spread over four cells, the dose is deposited at the end of the alpha track, so it would be wherever the track ended which would end up probably in one cell, I would guess, but it's a guess, I'm not a dosimetrist.
Q. Right.
A. Of course the cell that has to be affected for colon cancer -- which I am sure you are aware -- is the stem cell. Stem cells divide very rarely, so actually their DNA is protected most of the time because it's heavily bound up and it's quite difficult to then chat about DNA when it's bound up. And of course we also know about the colon, that you also have to get a stem cell loss from the leash in order to get to propagation of those

mutations before you get cancer.
Si it isn't just as simple as one after(?) particle hitting the DNA and then it gives you cancer, it's not that simple a model.
Q. I am sure that's the case, Professor Thomas, and in fact indeed there's an awful lot of evidence that there are other aspects to cancer apart from the DNA damage aspect. But that was not really the point of this line of inquiry.
All I wanted you to agree with was that the dose to the tissue local to the particle would be enormously higher than that calculated as the dose to the colon by the ICRP model.
A. No -- well, you average a dose across an organ to get an effect, you don't take it as one particle hitting one thing that happens to be a growth control gene. That just doesn't work that way.
Q. Let me ask another question order that is sort of related to this.
A. It's a bit like taking one paracetamol or a taking a box of paracetamol, the effect is totally different.
Q. Well, in the case of one paracetamol and lots of paracetamol you are diluting the paracetamol into the whole body.
A. It depends on whether the tablet gets lodged and it

dissolves near your colon. There are reasons why you get, for example, gastric problems after eating aspirin. And that's because the local area where it dissolves has a higher dose than the rest of the --
Q. I think that's a helpful point of view, I think that really rather supports what I'm saying, does it not?
A. No, because you're talking about a probability after that of getting cancer and the model just isn't that simple.
Q. But in this case you were talking about the probability of getting gastric irritation at the point where --
A. Well, you have quite a high density of material that is being distributed.
Q. Exactly, a high density of material.
A. I'm sorry, I still don't follow where your argument goes that one alpha track will necessarily make cancer.
MR JUSTICE BLAKE: We've got to be a little careful not to have a purely a scientific debate about hypotheses. You'd better just try to track it down to questions and get the best out of this witness to develop the issue.
DR BUSBY: So there's only really one final key -- well not "key" -- one final part to this line of examination. That is does cancer start in an organ, Professor Thomas, or does it start in a cell?
A. It starts in a cell, that is the conventional belief,

but it starts in a cell and then many other things have to happen before you will get a cancer because a cancer is an invasive element, it's not just a tumour.

Q. Okay, I think that's as far as we need to go with that.

A. But also remember your DNA repairs itself too.

Q. Of course, the DNA repairs itself, quite so.

Now, do you agree then that the target for radiation-induced genotoxicity, which would include cancer, is the DNA?

A. When you say that the radiation has a target, it has no target, it happens to bump into DNA. So in that respect it is the target.

Q. I think perhaps maybe I didn't use the right term, I was using "target" in the scientific -- in a scientific sense. I didn't mean --

A. But the radiation does interact with other things in the cell. But we're primarily talking about the interaction with DNA --

Q. But you would agree, would you not, that the scientific consensus now is that cancer, as a consequence, at least in part, or in large part, of lesions that have occurred in the DNA?

A. Yes.

Q. Yes.

So I want to ask you, do you know what the

composition of DNA is? What sort of thing it is?

A. It's a double helix and it has four bases that form it, it has a phosphate back chain.

Q. A phosphate back chain. What else in the body is composed of phosphate?

A. There are lots of things. Many enzymes are phosphorylated. Phosphorylation is an extremely important part of biology, I'm not quite sure --

MR JUSTICE BLAKE: Perhaps narrow it down.

DR BUSBY: Is the skeleton of the body composed of phosphate?

A. It has some phosphate in it, it also has calcium hydroxylapatite in it, which gives it its strength.

Q. And calcium hydroxylapatite is phosphate?

A. No, it's not, it's a different chemical compound. Hydroxylapatite --

Q. Let's get this right. Right.

A. Phosphate is everywhere in your body, you can't avoid it.

Q. So you are saying that calcium hydroxylapatite is not a phosphate?

A. No.

Q. You're not saying that?

A. No, I am saying it's -- I think you are thinking of something slightly different.

Q. No, I am thinking of something different. But anyway, I mean that's your answer. Yes. In fact, calcium hydroxylapatite is a phosphate, but maybe I'm not allowed to say that.

A. Well, you're a chemist, you would understand far better than I would, wouldn't you.

Q. Right. In your responses to Mr ter Haar this morning you made a statement which I found rather confusing which I world like you to explain to me. You mentioned radioactive uranium and stable uranium when he was talking about uranium inhalation from the environment. You seemed to want to distinguish between radioactive uranium, which would be something perhaps that the people at Hiroshima might have inhaled, and stable uranium.

A. I'm not sure I wanted to distinguish them, I wanted to make it clear that uranium is all round us, it's the isotopic amounts that vary in different places.

Q. Of course. But I wondered what you meant by "stable uranium".

A. Stable uranium is the isotope that is not (inaudible words). Don't ask me what its atomic number is.

Q. That's all right, so I understand. It's just that I've not heard it called "stable uranium".

A. Well, every single chemical, entity, that has different

isotopes usually has a stable form as well. So iodine, for example, is 127, and iodine 131 is radioactive.

Q. Of course. But iodine 127 is not radioactive.

A. No. Iodine 129 is.

Q. So are you of the opinion that stable uranium is not radioactive?

A. Stable uranium is not radioactive; it is the non-radioactive isotope of uranium.

Q. I see, okay, okay.

A. Unless I didn't listen properly in my chemistry A level.

Q. Right. Well, the bomb casings -- I am not allowed to ask you, you're not an expert on bomb casings.

A. No.

Q. Right. So can I ask you, as a pharmacologist you are an expert on what happens to substances in the body, or least to some extent, I mean it's your area of --

A. It's my original area.

Q. -- it's your original area of expertise. Yes. So my question is what happens in the body to metals that are inhaled? For instance, uranium oxide particles that might --

A. It depends whether they're in a soluble form. Many of them will, as I said before, will come out on the mucociliary pathway, make it into the gut, but most of them will be excreted by the faeces. A small amount may

get absorbed by the blood. The majority of that is then excreted in the kidney. But it really does depends on the solubility of the compound.

Uranium oxide, for example, is not soluble in water, and things that aren't soluble in water don't get into your body because most of your body is water.

Q. But if I were to eat some iron filings, for example, you would say that none of the --

A. A small amount might undergo some form of chemical change and become a compound which is soluble, but the majority of it will probably pass straight through you.

Q. Are there strong acids in the gut that might --

A. There are strong acids, hydrochloric acid is one of the components of your gut, yes.

Q. That might dissolve the --

A. It would have to make something this it not insoluable, if it made a chloride -- which you would expect it to do because it's hydrogen chloride -- then that -- it would depend on whether that was actually soluble in your gut or a chlorate was soluble in your gut.

Q. So perhaps you might concede that if you were to inhale, for example, a uranium particle, the one that we talked about, and then it was coughed up because it was too large and then it was on its way down to the colon, it happened to go through the stomach where there was 5(?)

normal hydrochloric acid, that some of it might dissolve?

A. Well, it must be able to dissolve otherwise you wouldn't be able to detect it in the blood. But it's only a very small amount of what you take in, between 5 -- 0.5 and 5 per cent based on the data we have from the uranium mill crushers.

So some of it does end up going into your blood, yes, you are quite right. So it must have been organified or made soluble in some respects in order to get into your blood, otherwise it couldn't get there.

Q. So you are agreeing that inhaled uranium, or certainly ingested uranium, a proportion of it will get into the blood and then --

A. A very small proportion of it.

Q. A small proportion of it will get into the blood. And then what will happen? It's a --

A. 70 per cent of that 0.5 to 5 per cent of an individual dose that goes through your gut goes out in your urine in 24 hours, which is why you get the renal toxicity because that's the primary export route of heavy metals. And if you look at most heavy metals you'll see the same profile.

Q. Yes, right.

A. So you're left with a very tiny amount that may be

circulating in your body. About 1 to 2 per cent of that may end up in your bones and that's it. So you're looking at vanishingly small quantities of the uranium you took in actually remaining in your body. Dose is everything. The difference between pharmacology and toxicology is dose.

Q. Yes, I think we've sort of dealt with dose because we have sort of decided, or I thought you'd agreed with me, that the dose to local tissue from particles, certainly, could be significantly high compared to the dose --

A. No, not to a tissue, to an individual cell. You wrapped it right down to the cell. The individual cell, yes, but not a issue.

Q. I think we decided that an individual cell was the origin of cancer, though?

A. Yes. It's not as simple as that, but we'll start there.

Q. Okay. So this very small amount of uranium that gets into the body and has this affinity for the bone because of the phosphate in the bone -- and this is where --

A. But it stays there for one to two years, and then it's excreted, so it isn't there permanently.

Q. I thought you said a few days.

A. No, sorry, the 70 per cent goes in the urine in 24 hours, and 1 to 2 per cent of the remainder will stay in your bones, it stays there for about one to two years

and then is turned over because your bodies are turning over the whole time.

Q. Yes. Have you read the Royal Society report on depleted uranium?

A. I can't recall it. I probably have at some point, but I can't recall it right now.

Q. It's just that that says 13 years. But maybe you disagree with that.

A. I was working off some data I had from the American authorities, but you may be right.

Q. Okay.

A. And I'm sure it varies with different diets, et cetera.

Q. I think this was done from mice, actually.

A. Well, I would caution then. If it's done in mice I would be cautious about transferring that straight to humans because the metabolism is very different.

Q. I think it a paper by Anne Sabolla (?). Anyway, it's not in the bundles, so we can't go to it, and it's not that important.

Because you are saying that a proportion of it goes to the bone. Well, it goes to the bone, I think we agreed, because the bone contains calcium phosphate or, also, calcium hydroxylapatite?

A. Mm.

Q. Right. But of course in the body you have already

agreed that the DNA contains phosphate?
A. Mm-hm.
Q. So if it is in a form that can be stripped to the bone and measured there, then it could be in a form that binds to the DNA phosphate?
A. In theory, yes.
Q. Right. Well, that's all we need because nobody has actually measured it there yet.
A. No.
Q. All I am suggesting is the possibility that the DNA -- the DNA --
A. But of course you have to remember if it's in the bone then the site of origin with the cancer would be an osseous carcinoma. We have absolutely no evidence whatsoever that exposure to uranium, genotoxic in terms of radiogenicity, or natural uranium, causes any problems in the bones.
Q. So you haven't read the papers --
A. In humans. I refuse to accept animal models that have not been validated in humans. In cancer we know that is a total waste of time.
Q. So you would agree then that in animals -- and there have been a lot of studies carried out with uranium, exposure of beadle dogs and mice and a whole range of animals at the Albuquerque -- at the New Mexico sites

were experiments were done with uranium and radium and other things and they do show high levels of bone cancer.
A. I'm not aware of those studies, but I have to say that I would urge caution of taking something straight from an animal and applying it straight to a human. We gave up using animal models in cancer because they don't replicate the human situation.
Q. Absolutely, and I absolutely agree with you, but nevertheless it is some sort of evidence that you --
A. Yes, I mean you have to look at the doses and things like that and to see how it was administered and all the rest of it to make sure that it was applicable to the exposure that would you see in the humans and the doses that you would expect. Many of the toxicology studies really push the dose level right up.
Q. Right. Well, I think we've got to the point now where, although you say that a very very small amount of it is still possible for uranium to bind -- the soluble form of uranium that we eventually derived --
A. Once it's got into your cell and if it's in the right form it may, it may -- and there's no proof, as far as I know nobody has actually looked at the DNA to see if there's uranium bound to it after exposure -- it is possible that it sticks on the phosphate. How long it

dwells there, I don't know.
Q. Yes.
A. That's very important when it comes to the dose in radiation, of course, because if it doesn't stay there very long it's highly unlikely to emit its alpha particle.
Q. But if it were on the DNA in this extremely unlikely possibility that you put forward it would have -- the dose to the DNA would be catastrophic, would it not?
A. Yes, and it may cause the death of that cell, because don't forget, of course, if you get too much DNA damage in the cells you get apoptosis occurring and then you won't get cancer.
Q. Of course. Indeed, I am told that in some people that is all you get is apoptosis and, about 1/5th of the population could never get cancer. I just thought I would say that --
A. Well, I would like to know where you got that one from because I don't think that's true.
Q. I got it from Eric Wright who is the world authority on this issue at Dundee.
A. Yes, I know who Eric Wright is.
Q. So I have come to -- I've almost finished with uranium. So we were talking about particles going into the lung, and then you cough up the particle because it's too big

to get through the lung, as you were saying earlier.
A. Or literally because it happens to get stuck on the mucus that is coming up --
Q. But I want to talk about nanoparticles now. So these are particles that are not too big to get through the lung. Do you happen to know what size of particle can get through the lung?
A. No, that's not my sphere at all, and I'm not gonna answer questions on -- which I don't have the knowledge to answer.
Q. So if I were to say to you that any particle under 100 nanometres can get through the lung, you wouldn't --
A. I wouldn't be able to give you an answer, it's the sort of thing I would have to look up because it's not the thing I'm interested in. So I don't carry those facts around in my head.
Q. Right. I just want you to look at a paper by Alexander Miller which is SB5/101.
I am awfully sorry, my Lord, I did all this outside in a hurry. (Pause)
MR JUSTICE BLAKE: McKeegan and Biggs. Are you in the right bundle?
A. Yes. Miller? The one I have is Miller. SB7? And I only have the abstract, I don't have the full paper.
DR BUSBY: We only provided the abstract.

A. I'm not happy to comment on papers where I only have an abstract, I'm afraid.
Q. Right.
A. You can't read an abstract and be sure that that's actually what the paper says.
Q. Yes. Well, we provided abstracts in order to --
MR JUSTICE BLAKE: I thought --
DR BUSBY: -- to reduce paper, because the Secretary of State was complaining that we are giving them too much paper.
MR HEPPINSTALL: If papers are to be relied upon they are to be provided in full and not in abstract.
MR JUSTICE BLAKE: Wasn't that in my direction last Friday?
MR HEPPINSTALL: Yes.
MR JUSTICE BLAKE: Right. Do you have the full paper somewhere, Dr Busby?
DR BUSBY: Well, not here, my Lord.
MR JUSTICE BLAKE: Are you going to have it for tomorrow morning?
DR BUSBY: I could have it tomorrow morning. Would it be possible to go ahead on the basis that this is what the paper says --
A. No, no, I'm sorry, I will not do that. An abstract can be very misleading, because sometimes people will say things in the abstract which, when you look through,

that is not true in the paper. 30 per cent of my final degree was on this sort of analysis.
MR JUSTICE BLAKE: If we are going to go to tomorrow morning, as I think we are, then we may be able to get the full paper, which will have a better quality of debate. But I think from what I've just heard it's probably important for the witness to have the full paper before you ask her questions about it. So are you going to be able to get to get to --
DR BUSBY: Yes, I'm sure I can get that paper by tomorrow.
A. If somebody could e-mail it to me, I could pick it up at home tonight.
MR JUSTICE BLAKE: I would have thought it's not beyond human possibility. What do I know? But it requires you team Dr Busby, to dig something out so that we can have a useful debate. If we are going to do that for tomorrow can we reserve this topic so we can do it in one go with the full material rather than in two halves?
Generally speaking, if you have papers to put either to this witness or anyone else who is coming tomorrow or next week, can we have the full papers? That's what I spotted that had been asked for. I think I directed you to do that last Friday. I am told I did.
DR BUSBY: Yes, I think you did, my Lord.
MR JUSTICE BLAKE: Okay. That was with the purpose to make

sure that we can have proper preparation. So can you think ahead on that, or someone in your team, please, and make sure all the things that you might or will rely upon are provided.
Is there another topic you can move to?
DR BUSBY: Oh yes. I am sure we can find some other topics. Yes.
I would now like to then move to the region in which you are an expert, which is thyroid cancer.
A. Mm-hm.
Q. Perhaps at first I might ask you about the sensitivity of the -- perhaps you could explain to us about the sensitivity of, you know, roughly in quantitative terms, about the sensitivity of the thyroid organ, what it is and why it's sensitive to ionising radiation.
A. The thyroid is believed to be one of the two most sensitive organs in the body, the other being the breast, and it depends on the --
THE COURT REPORTER: Could you slow down, please?
A. Breast and thyroid are believed to be two of the most radiogenic tissues in the body. The thyroid, we know that radioisotopes of iodine concentrate in the thyroid gland, we use those clinically to actually cure people of thyroid cancer, it's the best targeted treatment we have for any cancer. We're not sure why it is more

sensitive to X-rays, but it is.
Q. Yes. Could you tell us how it is that you are an expert in this particular area? What you have actually studied in the area of the thyroid.
A. My PhD was on the clonal and neoplastic processes in the thyroid, but mainly looking at chemical agents that affect thyroid homogenisis --sorry.
MR JUSTICE BLAKE: Slow down.
A. My PhD was on the clonal and neoplastic proliferative processes in the thyroid --
MR JUSTICE BLAKE: Particularly when it comes to long words.
A. -- and that was mainly concerned with chemical agents that affect thyroid hormone metabolism, which is a lot of pesticides ands things like that.
Subsequent to that, my boss at the time was one of the foremost pathologists and expert in thyroid pathology, and the Chernobyl accident happened, in 1992 he was asked to go to Belarus with a colleague from Italy, who was a thyroid specialist -- in the clinical sense rather than the pathology sense -- to investigate whether the reports that we were hearing about, an increase in thyroid cancer in children, were valid.
I was asked then to run the research after that looking for -- well, everybody hoped they were going to find a molecular fingerprint of radiation in thyroid

tissue that would tell us why these cancers were arising in this population. It hasn't been quite as simple as that as we're still looking for it now 30 years later after the explosion.
MR JUSTICE BLAKE: Pause there.
DR BUSBY: But at the time that there was the increase in thyroid cancer that Professor Williams was interested in, it was generally denied that there was a causal relationship -- in fact, it was denied there was an increase at first and it was Professor Williams that drew attention to it, wasn't it?
A. It was the first two papers in nature in 1992, he was one of the authors of them.
Q. Yes. So how is it that there was such an increase in thyroid cancer?
A. Because there was a large amount of radioiodine released, and a large population of children were exposed. If it had been an adult population we may never have seen the increase.
Q. So --
A. Actually, it wasn't that surprising, if you've been working on the animal models you knew that giving radioiodine to juvenile animals is the only way you make thyroid cancers in animals. In fact, technically they are not cancers because they don't invade the thyroid

lumps, thyroid nodules.
MR JUSTICE BLAKE: Pause there.
DR BUSBY: So just to step back slightly from this and to talk about the sensitivity of the thyroid. The thyroid, as you said, contains iodine?
A. It takes up iodine from the bloodstream. It has an iodine pump mechanism and then it stores it.
Q. So the concentration of iodine in the body is greatest in the thyroid organ?
A. Yes.
Q. Now, you have read the papers that were put in by Professor Howard in which he explains his research at the University of Ulster into the absorption of gamma radiation by different elements. Maybe you don't recall?
A. Yes, I have read them. I would not say that I understood the physics of them, and I would be lying to you if I said that I completely understood --
Q. So if I were to suggest to you that elements in the body absorb gamma radiation in proportion to the fourth power of the atomic number, which is what Professor Howard --
A. Yes, I'm aware of that statement.
Q. -- that would seem quite reasonable. You would accept --
A. I didn't say it seems reasonable, because I don't know

whether it's reasonable.
Q. No, it doesn't seem reasonable, it seems crazy.
A. I think you'd better talk to Professor Hallard about that.
Q. What I meant was the statement, you know, is a statement that you would accept.
MR JUSTICE BLAKE: Let's be sure that when you put a question you put a question. Just so we get the best --
DR BUSBY: Yes. So do you know what the atomic number of iodine is, roughly?
A. Talking about isotopes?
Q. No, just --
A. Again, I don't carry those. I mean, there are various isotopes. I know what the isotope numbers are, but I'd have to --
Q. Well --
A. -- check on that. I don't carry those things around in my head all the time.
Q. No. Well, I was just going to suggest to you that the reason that iodine was -- that the thyroid was sensitive is because it has a very high atomic number.
A. No, I think that's absolute rubbish. I think the concentration of the iodine tenfold against the blood is what gives you the highest dose and nobody disputes

that. That's the major effect.
Q. Are you saying that the thyroid is not sensitive to x-rays?
A. No, I didn't say that. If you remember I said earlier that, yes, we know it's sensitive to X-rays but we don't know why. And I don't know whether the mechanism you are suggesting is the right mechanism because I'm not qualified to answer that.
Q. Very good.
So what you are saying then is that after Chernobyl the dose -- the reason there was a huge increase in thyroid cancer after Chernobyl was exposure to radioactive iodine?
A. Absolutely, irrefutably, because if you plot the graph against date of operation, against age of gestation, you see that all the points are above the line at which the child would have been three months in utero at the time of the exposure.
If you go to -- as the population is ageing, as time is passing, there are fewer and fewer underneath that line, which tells you that it was a short-lived isotope, if it was iodine 131, concentrated in the thyroid, hence the number of thyroid cancers.
Q. So what was the dose that produced that?
A. It's a variable dose. It's not a single dose. The

doses varies from several -- grays in some people to, you know, 50 -- 50 milligrays in others.
Q. So 50 milligrays can cause --
A. You cannot say what caused it, you can say what doses are associated with it, and there is a dose response and it's believed to be linear, of course, because of the LNT. But I can't tell you what dose causes a thyroid cancer, that's impossible to say. There isn't a threshold, we've agreed that.
Q. Well, I don't think I agreed that, and I don't think that the ICRP agrees that either.
A. No, I disagree with that. The ICRP says there's a threshold. There is an intervention level which is different from a threshold --
Q. So you are telling me that the ICRP says that there is a threshold dose --
A. No, I'm not telling you that at all. I am saying there's an interventional level which is the doses to the thyroid are estimated to be that, then you need to take some action to minimise those doses. That's not the same as saying there's a threshold level below which there is no effect.
Q. I'm sorry, I thought that --
A. No, I never said that.
Q. I thought you said that a minute ago.

A. No, I did not say that.
Q. Fine, I must have misunderstood, I apologise. I'm not trying to accuse you of anything or trick you or anything like that.
MR JUSTICE BLAKE: I am just having a look at the time. If you can find a point, a convenient breaking point in this line of questions in the next five minutes, I would be grateful.
DR BUSBY: I think I probably can do that, my Lord, yes. Five minutes?
MR JUSTICE BLAKE: What I want to do is end by ten past, and I may need to just raise some matters for a few moments with each of you. So five minutes being a flexible concept.
DR BUSBY: Right. So the increases in thyroid cancer at Chernobyl were caused by exposure to radioactive iodine from the accident?
A. Yes.
Q. And you can't tell us what the doses were, but --
A. Well, I could tell you a dose range, but I can't tell you individual doses. I don't have that --
Q. No, I don't think I am trying to ask for individual doses, I think I'm trying to get --
MR JUSTICE BLAKE: Would a dose range be helpful to answer your question?

DR BUSBY: Well not really, my Lord, because what I am trying to do is in some way compare this accident at Chernobyl and the exposure to these people, to radio iodine, with the explosion at Hiroshima and the exposure of people there to whatever they were exposed to.
In the case of Hiroshima we needed to know some idea of the dose that caused a particular probability of getting cancer. So all I am really going for, it's not a big deal, it is just sort of approximate doses that you think there was. If you like, a mean dose.
A. I can tell you what the mean dose of evacuees are, if that helps. That was about 500 milligrays. Those were the people who were closest to the reactor and they got about 500 milligray. But the dose range is huge - some people got several --
MR JUSTICE BLAKE: Slow down, please. 500 milligrays.
A. Is the mean dose to the thyroid.
MR JUSTICE BLAKE: Of the evacuees. Mean dose to the thyroid of the evacuees. But the dose range?
A. Is huge. It goes from several grays to the thyroid to --
MR JUSTICE BLAKE: Got that.
DR BUSBY: So, now, do you know how many people were exposed to 500 milligrays? Is that some --
A. Not huge -- no, it isn't -- I can't recall offhand, and

it would be impossible to know that because not everybody had accurate dosimetry done.
Q. Right.
A. But certainly those who were closest to the reactor. I mean, again, it's not simple, because there's the inhalation dose, there's also the dose of ingestion -- sorry, I'm going too fast -- so there's the inhalation dose and there's the dose of ingestion of contaminated foodstuffs, which was largely milk from cows who were grazing on the pasture. The rainfall was different in different areas. The rain brings the iodine onto the grass, the cows eat the grass, the milk has the iodine in it, some of the children were drinking milk, some weren't drinking milk, and some people had a backyard cow and others didn't. So that's why the dose range is huge.
DR BUSBY: I think, my Lord, at this point I have to say that this line of questioning is going to continue for more than five minutes, but this is a convenient place to draw a line under it and we can pick it up again tomorrow morning.
MR JUSTICE BLAKE: Thank you very much. We will continue, if it's convenient to you, at 9.45 tomorrow morning.
THE WITNESS: I will do my upmost to get here, dependent on the tube.

MR JUSTICE BLAKE: Would you prefer ten o'clock?
THE WITNESS: It is unlikely I will be late but I am stuck out on the Metropolitan Line.
DR BUSBY: Ten o'clock?
MR JUSTICE BLAKE: I have been making provisional contingency planning for everyone to have enough time to explore with this witness, but the sense I am getting is that we've moved quite far ahead.
THE WITNESS: I will get here for 9.45.
MR JUSTICE BLAKE: Whenever you can get here we'll start, because obviously the sooner we start --
THE WITNESS: The sooner we finish.
MR JUSTICE BLAKE: That is a scientific concept! To me, at least.
Anyway, you are now in the middle of your evidence. The same warning applies. Thank you, I look forward to seeing you tomorrow morning.
THE WITNESS: Thank you very much.
DR BUSBY: Thank you, Professor.
MR JUSTICE BLAKE: As the Professor is getting out of the witness box can we just have a quick look at what we might be doing tomorrow when at some point, I suspect tomorrow morning, we will complete her evidence.
MR HEPPINSTALL: Indeed. Mr Hallard will be here tomorrow so we can move --

MR JUSTICE BLAKE: So we move --
MR HEPPINSTALL: -- seamlessly to Mr Hallard.
MR JUSTICE BLAKE: Right.
MR HEPPINSTALL: Because we are moving up the days, I think some effort has been made to warn Dr Haylock that it may be earlier than Thursday. It may not, but it may.
MR JUSTICE BLAKE: Right, okay.
MR HEPPINSTALL: Subject to anything that Mr ter Haar wishes to say about when he wants to start cross-examining Mr Hallard.
MR JUSTICE BLAKE: Look, I think it's probably best, since you three will probably know which area do you want to pursue and what sequence you are going to do, but it looks like we are now getting more time, whereas 48 hours ago we looked like we had a bit of a problem.
MR TER HAAR: We've stolen time by passing the buck in some respects to Dr Haylock. So it would be probably helpful to start tomorrow with Mr Hallard because we may need to allow more time. I had anticipated I might well deal with Professor Thomas, but some of the matters I am now going to deal with Dr Haylock.
MR JUSTICE BLAKE: It is just communication. So you can revise, delete, contract there and expand there, just so that everyone has time to know what's going on and it's absolutely helpful to know who is coming the next day.

So one can focus thoughts upon the questions.
MR TER HAAR: It looks as though we will at least start Mr Hallard's evidence at some point tomorrow.
MR JUSTICE BLAKE: It does look like that, yes. I am rather hoping, however, that we do start at 9.45 or thereabouts, that we will complete by four o'clock tomorrow.
MR TER HAAR: Oh, I think we take that as a given.
MR JUSTICE BLAKE: Yes. Simply because there is more to life than ionising radiation.
But I mean we are not going to -- if we start Mr Hallard tomorrow, at, say, 11.30 midday, we're not going to finish him tomorrow.
MR TER HAAR: I would be surprised if we did.
MR JUSTICE BLAKE: It would be a convenient moment towards the end of the afternoon, and so we don't have to burn the candle at both ends.
MR TER HAAR: It's unlikely we complete his evidence tomorrow, and if we finish at 3.30 or four o'clock I don't think it will destroy the timetable for next week.
MR JUSTICE BLAKE: Thank you very much. So I have to hand down judgment. So 9.45, or as soon as the witness is here. If we are all here then we can take advantage of that.

(4.08 pm)
(The court adjourned until Friday, 17 June 2016 at 9.45 am)

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