>> Okay, topic of our discussion is low-dose radiation risks of these. Your questions?

>> There are [inaudible] low doses [laughter] —

>> Okay, I can --

>> Okay.

>> This one is for Norman, and it's about the cataract. And I was just wondering is there any reason to fit threshold models for the cataract data anymore? And one of the reasons why I'm asking is if you fit that type of model let's say to leukemia data I'm sure you'd find a threshold, okay. And so anyway, that's --

>> The problem is that there's no good experimental data that shows -- and Mark Little alluded to this -- that damage to a single epithelial cell will ultimately result, given sufficient latency, into a sufficient capacity to close a visual decrement. So that's why some of us are saying, well, maybe radiation cataract is not deterministic, but it is -- it's stochastic in terms of the way we think about cancer single-celled clonal population. Maybe, maybe not. I don't know. I don't know the way experimentally to do that, to damage a single epithelial cell and track its progression over time, either an animal model or not. The lens is very strange. As I said, it's the only -- one of the only tissues in the body -- there's never been a primary lens cell tumor. There's something fundamentally odd about this tissue. But it is clear that DNA damage is the initiating insult to lens epithelial cells. And whether it's one, or five, or 10 -- I don't know what that number is -- but a relatively small number of cells is damaged. We know that from looking at micronuclei and other aberrant, fragmented nuclei, and other effects in those cells, or only irradiating a small portion of the lens rather than the entire lens. What the minimum number is I don't know. I don't know if that answers your question, but yeah. I have trouble dealing with the stochastic versus deterministic. It's somewhere in the gray area.

>> And from an occupational protection point of view if in fact it has zero threshold but it takes 70 years to develop at those very low doses does that have any functional consequence in terms of occupational protection?

>> I guess my only point is that I'm not sure what setting threshold models does for you anyway, you know, I mean.

>> Okay, fair enough.

>> Just because you get a -- you fit something, and you get something that's significantly greater than zero it doesn't mean that it's a threshold, you know. But that's --

>> Right, fair enough.

>> So there have been there various low-dose populations described in these talks. Which do we think provides the most compelling evidence for effects at low doses?

>> Shall I have a go?

>> Yes.

>> I think they're all complementary, quite frankly. And I think that -- my feeling is that the -- these studies have been more difficult than I think people have anticipated, certainly I had anticipated [inaudible]. I mean, I always thought that the -- you know, the great -- the great hope for these things -- these studies was the CT scan studies. And these studies [inaudible] large numbers may very well be making a significant contribution. But as John Boyce said, you know, the grand skeptic, you know, that you've got to get round confounded by indication. I mean, you know, there is a -- quite a small French study that shows that when you look at factors that you know predispose certain diseases -- let's just take Down's syndrome and leukemia. Well, Down's syndrome cases do have more CTs, perhaps not surprisingly. And of course they do get more leukemia, so if you're not careful to sort of deal with this -- and I fear that actually means you've got to know the exact reason why children have CTs. You -- and that means you've got to be very careful. I mean, you can imagine a situation whereby a child is involved in a car accident -- that is a passenger in a car and has a CT because of that. It's difficult to see how any confounded by indication could affect that, but you have to know that. Child falls off their bike, falls out of a tree, well, there may be a reason behind that. You can't -- you have to be -- it seems to me that -- and that sort of flows on to other things. I mean, Ethel alluded to something which concerns me about the recent worker studies, for example, and that's not just selection. Now clearly there are selection effects for workers. And you can see this in the so-called healthy worker effect. But it looks like within the workers -- and actually this goes back quite a way if you look at the literature. Within the workforce studies there are additional selection effects --

>> Right.

>> -- and that you have, let's say for want of a better phrase, healthier workers who get selected for internal radiation work. Now I mean, you know, there's lots of complexities going on there in each of these studies, and it's only when you can put the whole thing together, and do a lot of work on each of these studies and put it all together that you see -- you see the whole panorama. But -- so I think I'm still optimistic that you will actually get somewhere. It's just it's a lot more -- it's a lot harder than perhaps we thought it was in the first place.

>> I'll just say that one study that wasn't discussed today -- I think it might have been mentioned earlier -- that I think does provide important information on low-dose -- low-dose rad risk is the Techa River study. In there there's fairly clear indications of a dose response at very low dose rates, and actually quite low doses. So I think that should be kept in mind. And it's also very relevant to things like Fukushima and other accidents because it's cesium and strontium, and so -- and it was an

accident. So I think that should be kept in mind when you think about low-dose risks.

>> I have a question for Dale. You were about to discuss some the issue of indirection between radiation and other risk factors. And I mean, of course smoking is one of the important ones. But for the A-bomb survivors is -- are there any other risk factors other than smoking that are being planned to be analyzed or are more important -- which one is next? When we go away from smoking there's another risk factor?

>> We -- there's information on alcohol consumption. There's information on reproductive risk factors for women. And in these new analyses of the incidence data a lot of that is being used. Often actually there's very little power for looking at interaction. I mean, smoking would be a great example. And you can see, as I showed very, very quickly that you can detect some very complex interaction patterns. But it's much harder with other things. And usually, you know, the -- you can't distinguish between the additive and multiplicative. There's often very little -- enough -- there's not enough data to do that very often. And so you can think of our unadjusted analyses are often sort of like a multiplicative model because there's a sort of implicit these factors are in the background and we're just multiplying it. So unless there's strong departures from a multiplicative model you won't -- I don't think you're going to see too much from this adjustment, but we'll see. And there -- in the A-bomb survivors it's hard to think of things that would be correlated with dose to be confounders. But effect modification is definitely interesting, and we're looking -- not at effect modification, but interaction is being looked at much more now than it had been in the past. And with the new mail survey which is not being used currently but will be used in the next round of analysis there will be a bit more information, especially more current smoking information, which will be very useful.

>> I [inaudible] any comments how experts think about your association between thyroid cancer and are living near nuclear power plants. Previous reports as to generally natural findings, but do you think any -- is there any possibility to increase the risk?

>> [Inaudible] embroil in this?

>> Well, yes. In fact, I'm just involved in this study now of thyroid cancer after the Windscale fire of 1957 which released -- well, it released enough radioactive iodine -- iodine-131 for there to be a local milk ban. But it's nothing compared with the Chernobyl releases, 1000 times, you know, less. But I mean, clearly there is a major excess of thyroid cancer amongst those exposed as children after Chernobyl. Moving away from that it's much less clear. And you know, the Hanford -- I mean, Hanford released a lot of radioactive iodine -- iodine-131 because of the reprocessing of [inaudible] fuel in the early years of operations, or perhaps not-so-early years. So in the first decade or so of operations at Hanford. But you know, it's a big study where a lot of money was spent there, and we didn't find anything in the way of indication of thyroid cancer risk. So I'm -- it's not clear to me, apart from Chernobyl which is no doubt at all.

>> In my [inaudible] there was actually a lot of iodine released.

>> That's true.

>> And there was a study done a few year ago. There are no doses, although there are beginning to be some doses. They're still pretty crude. But in that study a few years ago we looked at people who were born in 1952 and 1953, which were at the time thought to be the years of maximal releases, and compared people who -- children who moved into the city after age 15 to people who were born in the city, so had this exposure. And there -- it was a small group, so thyroid cancer you aren't going to detect, but there was a -- definitely an increase in nodules. And also, it didn't get mentioned, but in the Guangdong high background studies John Boyce did this rather -- was responsible for this rather amazing survey about 25 years ago. And there -- doesn't get commented on very much, but in that paper we noted an increase in thyroid nodules in the high background area. So I don't know about -- these are -- well, the high background areas would be very relevant to that, but this was nodules, not cancer. And also I should say in [inaudible] there is some indications of cancer if you just look at where people live and where the depositions were. And that hopefully will come out soon.

>> So I have a question for [inaudible] talked about the topic the break. I still find the story about the Yangjiang very fascinating not only because I'm personally related to it but also when I think of it -- yeah, I asked [inaudible] in the break he -- I asked [inaudible] whether this background comes from the nuclear plant near that city. That's what I was told. But he answered no, it's actually come from the underground and radiation. So it will be interesting to think of -- it's possible some of the residents who they also are like employees of the nuclear plants, and then they will be double exposed. But yeah, I think there's -- yeah, so well, the short -- [inaudible] my question is just that there could be possible things to follow up in these studies. But you have gave us the reference that I haven't got a chance to check it. So I'm just wondering how much collaborative effort has been shown into this project, and would you mind if gave us more background about this particular project? Thank you.

>> Yes, the Yangjiang, I mean that was the paper by Dow, et al, in Health Physics 2009, I think. Really I don't -- there is a local power plant down there at Daya Bay or something like that. But for sure what they were measuring in the dose meters was the -- I think it's for -- it's certainly [inaudible] monocyte sans its thorium and its decay chains that give the high background. And I'm pretty sure it's the same down in Southern China. But I mean, there are -- was it John Boyce who gave the example of the high rate on house, and the guy who walked into --

>> Yeah.

>> -- work and set off the alarms --

>> Yeah, right.

>> -- because he had so many -- he had the short-lived decay products on his clothing from is house. And you know, so there are these little -- and in fact I also know that there is a mineral water in France, Badoit, who -- that used to have high uranium content. They actually filter out now at the factory. But there was a worker at one of the nuclear plants -- I think it was La Hague -- that they picked up the uranium because he drank this Badoit water all the time, and they were detecting this in his urine samples and couldn't work out what was going on here until they realized that he was drinking all this Badoit. That's all he drank all the time. Now, you know, so there are instances where you get these strange interactions, but I -- truly, I don't think in any of the background studies, and particularly in Southern China, that it is just the background radiation that's doing it rather than anything else.

>> Thank you.

>> My question may be but for the [inaudible] and Dr. [inaudible]. The exposure to high-dose or low-dose [inaudible] radiation in relationship with the risk of [inaudible] leukemia could -- what do you know from the life span study in terms of morphological type of leukemia? I mean, it was b-cell common leukemia or acute myeloid leukemia? And for Dr. [inaudible] maybe is the -- some of the controversial issue could be solved by looking at the specific type of leukemia?

>> Yeah, in the A-bomb survivor studies we do look at least broad groupings, ALL, acute -- AML, CML, and there's virtually no CLL in the A-bomb survivors in the Japanese population. So we look at those, and clearly the acute lymphoid leukemia, the children have these huge risks -- relative risks. And I mean, they're not huge absolute risks, but they're -- you know, they're very much big -- larger than what you expect. But -- and so a child -- in children that's the dominant form of the radiation-associated cancers. And then AML, actually children are probably a little less -- have a lot less than the people exposed as adults. So there are some real differences there. And as I said, CML does not seem to depend a whole lot on age and exposure, but it does have this very different temporal pattern that looks like time since exposure is really the important time scale. It's very consistent with the idea that maybe a single chromosome chain -- you know, aberration type like Philadelphia chromosome or something, could be associated with it. And then you have it, and then it just takes some time to express in the population. So there are very strong differences between the different types.

>> And in terms of these clusters that have been reported, I don't -- I think that the cases are as you would expect for the age group. So the -- it's -- you see the excesses, and they are acute lymphoblastic leukemias, common b-cell, pre-b-cell typically. And this is -- it's not just that the clusters have been reported from near nuclear installations, but I mean, this -- I mean Fallon, down in Nevada, is -- I mean, that's the most extreme charted leukemia cluster that's ever been reported in the literature. And it's nowhere near a nuclear installation. But I mean, again, you look there, and these are just the typical childhood leukemias. I mean, personally I think -- I mean, I know Leo Kinlen quite well in Oxford, and know his ideas about childhood leukemia being a rare

response to a common infection, and that you know, you have mixing of susceptibles and infecteds, and when you have rural -- rural/urban population mixing. I mean, he's shown a very impressive number of studies where you have this extreme urban/rural population mixing, and consequent spikes of childhood leukemia. They're very impressive. I mean, of course what you do need to know is what's the infectious agent. And so, that's down to the biologists rather than the epidemiologists I think. But nothing -- these clusters just look like, you know, groups of what you'd expect for leukemia at that age.

>> I have a question for Richard. One study, which it's not really natural background, but a background study is the Taiwanese --

>> Oh, yeah.

>> -- welders where I would think there's minimal confounding of it, and not too bad a dosimetry, and it's showing a statistically significant increase, at least in leukemia. I was wondering if you had any thoughts on that?

>> Yeah, that's a very -- I don't -- perhaps people are unaware of this, but that in Taiwan -- I -- and it -- I -- it's not natural background, which is why I sort of avoided mentioning it, but it's a very interesting study in that a cobalt-60 source or sources was inadvertently put into a steel reprocessing plant as it were. So it got into building construction steel, tie bars and window frames, you know, anything metal. And in -- mainly in Taipei, in the capital of Taiwan, but in other areas as well. And it was quite a while before this was sort of recognized fully, the extent of this. And before people were taken out of these contaminated buildings. So I -- the people that were living in those buildings have been identified and are being followed up. I think this was a problem in the '80s, and then it was recognized in the '90s. So there is a follow up of this. I think it's Peter Chang who's leading the follow up of this. And there are -- as Jerry says, there are indications from what is, you know, essentially, as Jerry said, elevated background levels for people living in these houses. There are indications of elevated rates of the cancers you might expect, you know, of leukemia. But against that, it's sort of early days yet. But I am certain he's still -- he's still pursuing this. It was not particularly big, the cohort, but an interesting one nonetheless.

>> Rich, if I could follow up on that for a moment. You know that there are three cataract studies in that population as well.

>> That's true.

>> And they showed an age-related increase in what they call focal lens defects in that population, that the longer these young kids lived in those buildings and the younger age at exposure was correlated with an increase in what they called FLD, which they suggest are an early indicator of radiation cataract, of opacity. So most of these children did not have any kind of visual decrement, but they had posterior changes consistent with radiation exposure that correlated with the length of time they spent in those apartments.

>> Do those tend to progress?

>> Yeah, they do. So FLDs tend to coalesce and increase in size.

>> I have a question, we've been studying the A-bomb, the Mayak, the nuclear workers, the miners, Chernobyl, Fukushima, for 60, 70 years now. Have we come anywhere with respect to risk communication and providing objective scientific information on the health effects of radiation that has been effective?

>> No.

>> I would agree with that. I think after Fukushima, I mean, I think, you know, that they have the same problems of communicating risk. People panic. I think you have these long-term psychological effects, which at least they're being looked at in this case, which they've often been ignored. But I think there's a lot more needs to be done, and I think it can be done. I don't -- I think you can explain to the general population what --

>> Do you think that it significantly -- just one second. In Fukushima it's difficult because they are seeing these thyroid cancers and nodules within a year or two of the accident. And when experts try to explain that this is highly unlikely biologically to be radiation-related not only in terms of the latent period, but also given what we've seen about exposure levels, you know, very, very implausible. People just feel that, you know, they're not being told the truth.

>> Right.

>> The reactions --

>> Yeah, I mean, the screening study's a good example. They went in and decided to do this screening study with no comparison really, and then they find a huge percentage of people have very, very small --

>> Teeny, teeny, teeny.

>> -- lesions because they can -- they're very sensitive. And we all know -- or we don't all know, but people know that if you look for thyroid --

>> You'll find it.

>> -- cancer you'll find it. Probably most of us in this room you'll find it. And actually we--

>> Do you think --

>> -- one thing --

>> Do you think that there's a role, though, for epidemiology to be doing a lot more with respect to risk communication?

>> Role for somebody to be doing it, whether it's epidemiologists --

>> Right, yeah.

>> -- or not.

>> I think collaboration with people who are expert in risk communication is the way to go. I don't think epidemiologists are particularly effective. I mean, David Renner [assumed spelling] said he wasn't good when he went with his white coat and his clipboard and said there's no -- and I'm not sure the way in which epidemiologists generally convey information would be sufficiently --

>> We get far too little training.

>> Yes.

>> We get far too little training in communicating to the lay public, I mean, even the educated lay public what real risks are. And we need to do a better job of that, there's no question about it.

>> Or when there isn't risk. I mean, my --

>> Absolutely.

>> -- experience after Three Mile Island was --

>> The mic.

>> -- unbelievable.

>> The contact is very important. There's no doubt about that. I mean, if you -- the problem is if you look at both Chernobyl and Fukushima is the breakdown of trust in authority. I mean, it's quite clear. I mean, some very hard-hitting official Japanese reporting to -- into Fukushima from the Cabinet Office and the Parliament, I mean, highly critical of, you know, the failure of operators -- of operations, you know, and failure of regulation. Now if that happens -- and particularly in Japanese society -- you know, there's a breakdown of trust in authority, and you are seen as another arm of authority. What do you expect? People are going to be mistrustful of you. And you know, and listen to the lunatic fringes, which is indeed what happens. So -- and it's all part of, you know, a very complex mixture. And unfortunately to some extent or another if you are in some way a scientific authority you are tarred with the same brush. It's a very complex problem.

>> Well, I'm sorry, but it seems to me that radiation epidemiology doesn't have a whole lot to say yet about, especially, low-dose risks. And there are great differences of opinion among you who do the work. If you ask me why don't lay people believe us about radiation, we have people who are promoting nuclear power plants that make plutonium that has to be secured from human lungs for 241,000 years. Now that's absurd. There's no building you could ever build that would last that long. There's not enough money put aside to build a new building every 100

years or something. It's beyond reason that we should have done that, but we did. And the people who are for nuclear power say, "Oh, there is no problem. Nuclear power plants are clean." Well, frankly they aren't clean. And so if you ask -- I don't think it's that people are -- very many are listening to the lunatic fringe. I think the nature of what we do with radiation is in some ways incredibly unreasonable. And if you expect people to buy that you're going to be waiting a long time.

>> Now you are conflating two separate things. I mean, it -- why do you say that you need to keep plutonium that long? You say you need to keep plutonium that long because of the sort of studies that Ethel Gilbert's been talking about. It's epidemiology that informs you about risks of things. We know within certain bounds what risks are. What we've been talking about about the risks of low-dose radiation, it's trying to get some precision. We know we're in the right ballpark. I mean, you know, these ideas that -- we're not talking about lunatic fringes here. We're talking about people who seriously suggest that we may be out by factors of 10 to the four, 10 to the five in terms of our risk. You know, people in this -- some of the people in this audience know who I'm talking about. But -- and there are others. It -- we are not looking at that sort of error in risk. Various suggestions have been put forward. I mean, for example, the man-made radionuclides that get into the body are somehow tremendously risky in comparison with risk [inaudible] we get from Japanese atomic bomb survivors. Well, it's not the case. We do -- you know, we know that now. The essential question now is is there a risk at low doses? And there are people who suggest that in fact there isn't a risk at low doses, or at least it's considerably lower than we think it is purely from an LNT model. And bounding the risks there. I mean, I am quite confident that the risk is not out by a factor of 10 to the four and 10 to the five. Of course, we would know about it very easily for radiation -- very easily indeed. And to just sort of alight upon childhood leukemia clusters, for example, without taking any other possibility of their causes -- Fallon's nowhere near a nuclear power plant, for example. And that's frankly nothing to do with nuclear power and all the rest of it. The biggest exposure of the population in developed countries today is through CT scan and nuclear medicine. Now you need to know what the risks are from these procedures. You -- these -- these -- many of these will come out to you and say, "Oh, you know, we need to do these things," and there's no real risk for these exposures.

>> Can I just say, when the bystander effect research first came out there were all sorts of people on both sides of the question who said, "You know, it could be that our risk estimates are 10 times more stringent than they need to be, or it could be that they're only 1/10 as stringent as they need to be." So I don't know anybody who's ever said there's 10 to the fourth uncertainty.

>> I'll give you the paper [laughter].

>> Please do. I'd like to read it. But you know, our -- one order of magnitude would be a lot to worry about if it turned out that it came out one way or the other, too -- much too high or much too low.

>> Well, I'd just like to circle back to this issue of communication and tell you what's happening in the medical community. So the issue with the CT scans has also presented us with an opportunity. You ask who will the public, you know, believe if they don't believe the government or the officials on television, well, research has shown that patients have good relationships with their primary care physicians. And if -- to the extent that we are now improving our -- we believe we are improving our education with our primary care colleagues about radiation and the boundaries on risk, the hope is that that will help with communication about what a particular dose might be should there be an incident similar to Fukushima or an accident. But it will -- it will be a disaster, no question. But these are the kinds of things you can do to mitigate it to some extent.

>> I've found in talking to people that -- I mean, individually to people that if you put it in the context of, okay, there is -- there's almost certainly some risk at low doses, and then explain what that is in terms of the consequences of it's spread over 70 years, that it's proportional to dose, and that it's -- you know, if you get a small dose it's a pretty small risk. And then put it in the context of something like impact of changing smoking habits or something if you want to talk about a population. People understand that, and I think they're sort of reassured that maybe radiation isn't the big thing that they should be concerned about, low-dose radiation exposures.

>> Well, I think that [inaudible] --

>> -- stochastic, I mean, it's like I am the lottery and --

>> Use the microphone, please.

>> Doesn't work here. Okay. I'll repeat myself. I was mentioning about the sensitivity, there may be people that have instead of 1% probability who have tenfold or larger. And then to the low-dose exposure, is kind of stochastic effect, not deterministic. So I mean, how are we going to deal with this?

>> First of all, I think there certainly are people that are much more sensitive --

>> I mean, where there are -- when there is an estimate, it's a number which the IRCP gives. But this is not valid for everybody. I mean, just --

>> Well, I mean, that's obviously true, and one of the things we do in radiation epidemiology is try to look at -- you've probably heard a lot about effect modification, trying to figure out at what ages which people are the most sensitive to radiation. But obviously there is a lot of genetic things that are going on, and we don't know. Maybe someday we'll have some kind of test, and we can say, "Well, this person's really sensitive to radiation, so they should never get any." But we don't have that now, so you just have to assume that it's the -- you know, it's on average. Sure, the one person that actually gets the cancer maybe is super-sensitive. Without knowing that we have to rely on these averages.

>> Okay, any comments? No more panel?