COMMONWEALTH OF PENNSYLVANIA

PUBLIC UTILITY COMMISSION



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| Letter of Notification of Philadelphia Electric Company relative to reconstructing and rebuilding of the existing 138 kV line to operate as a Woodbourne-Heaton 230 kV line in Montgomery and Bucks Counties. | Docket No. A-110550F055 |
| Further hearing. | |

Pages 963 through 1068

Hearing Room No. 1
State Office Building
Broad and Spring Garden Streets
Philadelphia, Pennsylvania

Tuesday, November 19, 1991



Met, pursuant to notice, at 10:00 a.m.

BEFORE:

HERBERT SMOLEN, Administrative Law Judge

APPEARANCES:

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8th

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C O N T E N T S



E X H I B I T S



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P R O C E E D I N G S

ADMINISTRATIVE LAW JUDGE HERBERT SMOLEN: Good morning, everyone. This is a further hearing in the matter of the Philadelphia Electric Company's Woodbourne-Heaton 230 kV proceeding in Docket A-110550, Folder 055.

This morning's hearing as well as the others scheduled for this week have been reserved for the presentation of the company's rebuttal testimony.

Is the company prepared to proceed?

MR. BONNEY: Yes, Your Honor.

JUDGE SMOLEN: Who is going to handle it this morning?

MR. BONNEY: Mr. Watson will handle the examination. I have one preliminary matter.

JUDGE SMOLEN: What is that?

MR. BONNEY: At the last hearing there were three exhibits that we produced and promised to make copies of. We have distributed to Your Honor, two copies for the court reporter and to the parties copies of PECo Turner-Cross 3 and 4.

JUDGE SMOLEN: Have you marked them yourself?

MR. BONNEY: They were marked at the time of the hearing and they are on the exhibit. Turner Exhibit 3, as well. These are three of the maps that were

introduced the last time.

JUDGE SMOLEN: All right, I see they are marked. Is this large one No. 3?

MR. BONNEY: Yes. I believe that's in the upper right-hand corner.

JUDGE SMOLEN: It says PECo copy of something 3.

MR. BONNEY: Turner 3.

JUDGE SMOLEN: All right. That is fine. That has been distributed to everyone.

MR. BONNEY: Yes, Your Honor.

JUDGE SMOLEN: All right.

MR. BONNEY: That was the only preliminary matter.

JUDGE SMOLEN: Anyone else?

(No audible response.)

JUDGE SMOLEN: Let's go ahead, then.

MR. WATSON: Thank you, Your Honor.

I call Dr. Richard Bockman.

Whereupon,

RICHARD BOCKMAN

having been duly sworn, testified as follows:

JUDGE SMOLEN: Please have a seat. Please state your full name and business address for the record.

THE WITNESS: My name is Richard S. Bockman and my business address is 520 East 72nd Street, New York, New York 10021.

JUDGE SMOLEN: Counsel.

MR. WATSON: Thank you, Your Honor.

DIRECT EXAMINATION

BY MR. WATSON:

Q. Dr. Bockman, do you have before you a document entitled Rebuttal Testimony of Dr. Richard Bockman?

A. Yes, I do.

Q. Do you have any corrections to that document?

A. Yes, I do, Mr. Watson. There are several typos. I would just like to point them out.

Q. Okay.

A. On page two, line nine, that should be professor of medicine. Strike the "y".

On page 11, line 12, it should read deleterious effects of exposure to power frequency. So the word "of" should be in there.

Q. After effects?

A. After effects.

On page 18, line 11, the beginning of the sentence it, the "i" should be capitalized.

JUDGE SMOLEN: Wait a minute that is page -- all right.

THE WITNESS: Page 18, line 11.

JUDGE SMOLEN: All right.

BY MR. WATSON:

Q. Dr. Bockman, if I were to ask you each of the questions set forth in the document entitled Rebuttal Testimony of Dr. Bockman, would your answers be the same as set forth therein?

A. They would.

Q. Subject to the corrections that you have noted?

A. Correct.

Q. The title of your rebuttal testimony, it is also listed at the top, am I correct, as Philadelphia Electric Company Rebuttal Statement No. 1?

A. Correct.

MR. WATSON: Your Honor, I move that the direct testimony of Dr. Bockman on rebuttal be admitted into evidence subject to timely objections.

JUDGE SMOLEN: With that stipulation it is received.

(Whereupon, the document was marked as PECo Rebuttal Statement No. 1 for identification, and was received in evidence.)

MR. WATSON: I pass the witness, Your Honor.

JUDGE SMOLEN: All right. Let's start around here. How about Law Bureau? Questions?

MS. BURKET: No, Your Honor.

JUDGE SMOLEN: PP&L?

MR. DILLON: No questions, Your Honor.

JUDGE SMOLEN: OCA.

MS. McCLOSKEY: Yes, Your Honor. Thank you.

CROSS-EXAMINATION

BY MS. McCLOSKEY:

Q. Good morning, Dr. Bockman. My name is Tanya McCloskey and I represent the Office of Consumer Advocate.

I would like to start with some additional housekeeping matters in your testimony. I believe you cite to some studies that do not seem to be included in your selected references. And unless I am reading this incorrectly, I would like to go through those and make an on the record data request for the full reference to those that did not appear in the selected references. And I may be reading this incorrectly, so...

If you could turn to page 13, line 17, you cite a study by Hojevik, et al., 1991?

A. Correct.

Q. Does that full reference appear in your selected references?

(Witness perusing document.)

A. I don't see it there, not in the proper place. It would be on page 33, but it's not.

That reference comes from the public abstracts from the BEMS meeting.

Q. And what I will be doing for each of these is asking as an on the record data request so that they can be compiled after the hearing and submitted in writing.

JUDGE SMOLEN: Does Counsel understand what the request is?

MR. WATSON: As I understand it, Counsel wants to refer to some studies and wants the full citation to those studies, is that correct?

MS. McCLOSKEY: That's correct. And instead of having him try to recall that by memory, I think it is easier to do that afterwards.

MR. WATSON: That is fine. If it is of any help, if you would simply like to give us a list after you finish your examination of which ones you want, we will give you the full cites for each of them. You don't even have to make the witness go through them. We would be happy to give you the full cites.

MS. McCLOSKEY: There are only four of those. I just wanted to make sure --

JUDGE SMOLEN: Let's put them on the record.

MS. McCLOSKEY: I wanted to be sure he was not referring to a different study that I was not picking up in his references.

MR. WATSON: Sure. Whatever is easiest for you.

BY MS. McCLOSKEY:

Q. If you could turn to page 17, beginning at the last line, 38, and onto the top of 18, you refer to a study by Grota, et al., 1991, and Rogers, et al., 1991.

Were they in your selected references?

(Witness perusing document.)

A. Again, I don't see them. I don't see the one, Grota, where it should be.

And the other reference was Rogers?

Q. Yes. The 1991 study.

A. Right.

(Witness perusing document.)

A. That is not in the proper place either.

I mean, the reference list is alphabetical and if they're not in the right place, they're not there.

Q. I just wanted to be sure there were not additional authors that perhaps I missed reading.

A. No.

Q. Finally at page 21 you do reference a study by Schnorr, et al., and you state that that is in the New England Journal of Medicine. But I was wondering if we could get the full citation for that as well.

A. Certainly. I believe it was July, 1991, but you will need to be provided with that.

Q. Thank you very much.

Now, if I could turn to your conclusions which

appear on pages 26 and 27, and particularly beginning with conclusion number seven, am I correct that it is your opinion that there is no proven adverse health effects from electromagnetic fields on the endocrine and immune systems?

A. That's correct.

Q. Is your testimony in this proceeding limited to a review of those systems, the endocrine and the immune system?

A. Yes. It is meant to be.

Q. And you are not here today to testify as to the the epidemiological studies or the cellular or molecular research, is that correct?

A. That's correct.

Q. Now, if I could flip back to page 20 of your testimony, where you discuss the study by Wertheimer, you provide an evaluation of the study. Do you see that reference?

A. Yes, I do.

Q. And am I correct that the study by Wertheimer that you are referring to is an epidemiological study?

A. These are epidemiologic studies, that's correct.

Q. And the criticisms that you are stating there are drawn from the literature and are not to be

interpretted as your own independent review of that material, is that correct?

A. That is -- I did cite criticisms from the literature, is that correct.

(Pause.)

A. You will note, though, that I do express an opinion because it says I agree with their conclusion. It occurs within the context of reproduction and development.

Q. Are you making an epidemiological evaluation or an evaluation of the epidemiological study at that point when you agree with the criticisms?

A. I'm sorry. Could you restate that?

Q. Certainly. When you state your agreement with the conclusions of the criticisms are you commenting as an epidemiologist at that point?

A. No. I am commenting as a medical person who has read that report and agrees with those conclusions.

Q. Now, if I could turn back again to your conclusions on 26 and 27, is it your opinion that further research is needed in the area of endocrinology and immune systems concerning the effects of E/MFs, or electromagnetic fields?

A. That is a rather broad question. I think -- I mean, it requires a rather long answer.

For example, in the area of reproduction and development, or reproduction in particular, I think very adequate experiments have been done. I am not sure that one can do better experiments than those that have already been done. So it would not be clear to me how one could advocate doing more experiments or that more research would be needed of that kind. I think you will also appreciate from my criticisms of the calcium efflux studies I'm not sure that they addressed any relevant biological issue and I would not say that more research needs to be done of that type of experiment.

I would not -- I mean, this area is dealing with interesting biological issues and I would certainly advocate that we need to do more research in biology. I am not so sure that we have much to learn or that it is a very high priority, since funds are limited, that we need necessarily to do more research with regards to this stimulus of electric and magnetic fields in these areas of biology.

Q. And I take it from your answer that you have touched on two areas -- I recognize that endocrine and immune systems are fairly complex -- but you have touched on two areas that you think there is no further research necessary at this time. However, you seem to indicate that there are areas where research should continue,

other areas involved with endocrine and immune systems. Is that a correct or fair characterization of your testimony?

A. Not quite. I think you are being a little too strong in your emphasis that more research needs to be done. I think, you know, as a research biologist in these areas, not just as a research biologist myself, I think we need to do much more research in biology. I just don't feel that this area of electric and magnetic fields is a very high priority or a very interesting area that is going to help us elucidate what are some of the other more interesting questions in biology.

Therefore, I mean, on my scale of interest it is quite low. And I think some of the research that has been done one need not repeat because it has been done quite well and I think one certainly does not need to repeat bad experiments or poorly done experiments or poorly conceived experiments.

So I don't feel that -- to answer your question perhaps in another way, I don't feel that there is a pressing need to do more research in many of these areas, and I have tried to highlight those areas in particular within this subject where I don't think you could even design new or better experiments.

Q. If you could look at your conclusion number

five on page 27, and that goes to the reproduction, growth and development area, what I would like to ask you is how science or how did you determine that there has been adequate experimental data to reach the conclusion you reached in number five. What type of analysis -- this is more of a theoretical nature -- what type of analysis do you apply to the research to reach that conclusion?

A. I think the methodology that is used is the standard methodology that I use in every area of research that I try to examine, and that is that one goes to the primary literature, that is to say the primary papers, the papers of the scientists who are posing the questions and then trying to answer those questions within the scientific paradigm. And in doing that I have read what I consider to be the best -- I have read -- I try to review all the literature that has been published that is relevant with regards to this particular point, reproduction, growth and development, all the literature that was available. From that I selected out what I thought were the best experiments that were performed and I reviewed each one of those primary publications and upon doing that came to my opinion.

Now, that meant that I started back with the early literature from Dr. Marino of 1976 and 1980 but then

proceeded through all of the studies that were done, for example, by R. D. Phillips, Rommereim, Sikov, culminating in what I think was perhaps the most definitive experiment by Benz and Carsten, a group that were commissioned -- they are at the Brookhaven National Laboratory and they were commissioned to do this study and they studied thousands of animals, and they studied three generations of animals, they studied several levels of electric field exposure and several levels of magnetic field exposure, one and ten gauss. And in doing these studies they were not able to demonstrate any adverse effect on reproduction, growth and development.

Now, the outcomes for those experiments are really quite easy to track in the sense that you look for changes in fecundity and fertility and that the same number of animals basically arrives at the end of the experiment as compared to the controls that were not exposed to the fields, and these were their results. I think they were excellent studies and as I had previously, I don't think you could do that experiment better.

Q. Did you look at or consider whether some of these better experiments can be or have been replicated by other researchers?

A. Yes. Well, you know, the list of names that I

gave you are all separate investigators. For example, Dr. Rommereim continues to publish in this area. He tends to pick larger fields or different strains of animals, but continues to publish. And he has a publication, I think, as late as 1989 repeating the very same experiment that Benz and Carsten did. So, I mean, people continue to do the experiment and continue to get the same result, that is to say, no adverse effect.

And I think this particular experiment on reproduction, growth and development is so important because there is a whole sequence of endocrine functions that must occur for fertilization to be successful and then for the animal to carry the pregnancy and deliver its normal litter. And each step of that is critically dependant on the right hormonal milieu. If you interrupt it at any phase you would clearly alter the outcome, and that does not happen in these experiments. So that is why I come to that conclusion.

Q. I believe in your curriculum vitae you have said that you have reviewed the area of bone healing with strong magnetic fields and in the area of magnetic resonance imaging, is that correct?

A. Well, you have mixed two things there so I have a little trouble with the question. I mean, magnetic resonance imaging is one area --

Q. Yes, they are two areas.

A. -- and bone healing is a separate thing.

Q. Okay. Fine.

And both of these areas, though, involved magnetic fields or the use of magnetic fields, is that correct?

A. Correct.

Q. And with the bone healing and use of magnetic fields, has biological research or research in general determined the process or mechanism by which the magnetic fields aid in the bone healing process?

A. No, they have not. I think that is still an open question. In other words, you are asking me is the mechanism by which the magnetic fields alter bone metabolism or function to result in healing known, and the answer is it is not.

Actually, the question has to be answered half a step back because not everybody believes that these fields do cause bone healing. Dr. Bassett and his collaborators have presented -- and they are adequately cited in the references -- have presented, I think, some very convincing and significant data to suggest that such fields can enhance bone healing.

What we're talking about are non-union fractures. About five or ten percent of people who fracture their bones actually don't heal their bones well. And these

techniques have been applied to try to enhance the rate of healing of these kinds of fractures.

I have to say, though, that a good number of people who are experts within the field of orthopedics, where this fits in medicine, are not convinced that this methodology truly enhances bone healing. So they are kind of split.

Q. Dr. Bockman, have you conducted research into the biological effects of power frequency fields such as those fields associated with transmission lines?

A. I have not.

Q. And have you published any papers such as of a literature review nature about the biological effects of electromagnetic fields associated with transmission lines?

A. I have not.

Q. And when did you first begin to look into the question of electromagnetic fields from powerlines and biological effects from these fields?

A. I guess I began to look into it seriously in 1986.

Q. And are you a member of any of the professional societies that are looking into this question, such as the Bioelectromagnetic Society?

A. I am not a member of that society, no.

Q. Now, if I could turn to page 18 of your testimony --

A. Would you mind if I just made a comment? You asked me if I have worked with power frequency fields. I have not. But I am involved in a study currently, it is a clinical study, looking at the possibility that electric and magnetic fields can enhance bone healing or bone strength.

Q. And that is with a different level of magnetic field, though? That is what has been termed as a strong magnetic field versus the weak magnetic field that --

A. No.

Q. -- is associated with transmission lines?

A. I'm sorry. I didn't mean to interrupt you.

No, the fields are actually quite weak. The issue isn't the strength of the fields but I think the argument is over the characteristic of the waveform and the kind of field that is produced. It is more like a pulsed wave as opposed to the sinusoidal wave that is associated with power frequency fields. And we are using a system of generating such a field to try to enhance the bone strength in the lumbar spine of women who are potentially candidates for such a study because they might be at risk for osteoporosis.

We actually have a clinical study that is underway.

This is a FDA-approved device that we are researching.

You may not be aware of it, but the FDA not only approves a drug after it has been through all of its testing, they actually tell us whether we can do an experiment or cannot do an experiment, and they have given us permission to test this device that creates electric and magnetic fields for enhancing bone strength.

That is a double blinded study. That is to say we don't know who is getting the current and who is not. And the study is still in progress so we don't know the results of the study yet.

Q. Now, looking at page 18, lines eight through 22, where you are discussing reported changes in dark cycle melatonin levels, just to be clear am I correct that you are stating that the changes were limited to exposure to electric fields and not to magnetic fields? They were not exposed to magnetic fields?

A. This work is predominantly -- this research is really predominantly coming out of one person's laboratory, and that the laboratory of Barry Wilson. He has, for the most part, only looked at electric fields. Nevertheless, under certain circumstances I think that there is an associated magnetic field -- first of all, there is an associated magnetic field with these electric fields. And he has quite a few publications and I don't

recall off the top of my head whether he actually has quantified or measured the magnetic component for these. So it probably is not correct to say that these are entirely or strictly electric fields.

Q. Have there been any studies on the effects of magnetic fields on dark cycle melatonin levels, other than the Wilson study you have just discussed?

A. We are stretching my memory. I am not really -- I don't think so, but I am not sure.

Q. If you could refer back to page 17 of your testimony, you reference some work by Lerchl, dated 1990.

A. Wait a minute, I am lost -- oh, there it is. I'm sorry.

Q. Are you aware of whether that research was performed with the effects of pulsed static magnetic fields?

A. I don't recall. I'm sorry.

Q. If you could just keep your place there on page 17 and look at page 34, is the Lerchl study that you are referencing, the first Lerchl study, entitled Marked Rapid Alterations in Nocturnal Pineal Serotonin Metabolism in Mice and Rats Exposed to Weak Intermittent Magnetic Fields?

A. I believe that is correct, the correct citation, 1990.

Q. And do you recall if that study was conducted using pulsed static magnetic fields?

A. You did jog my memory. This did use magnetic fields. I don't remember the characteristic of the field, whether it was pulsed or static.

Q. I have a copy of the study. I don't want to enter it into record, but if you would like to refer to it, it may aid your memory.

(Document handed to witness.)

MR. WATSON: May I see it, please?

MS. McCLOSKEY: Certainly.

(Witness perusing document.)

BY MS. McCLOSKEY:

Q. The question I am trying to get at is whether that used a pulsed static magnetic field in that research.

(Witness perusing document.)

A. It is a pulsed field with a duration of 200 milliseconds that switched on at five minute intervals.

Q. And is serotonin involved in the synthesis of melatonin?

A. It is.

Q. And perhaps for the layman, if you could explain in as easily understandable terms as possible how that happens or what the relationship is?

A. Well, as suggested in the diagram on page 103 of this article that you have given me, it is clear that serotonin is derived from an amino acid, tryptophan. And the serotonin is what is considered a neurotransmitter. It is used by nerve cells in the brain to communicate one with the other.

This particular region of brain which contains very few cells, the pineal, whose function in man is really totally unknown, those few cells in the pineal gland are capable of converting serotonin to melatonin. Basically melatonin is a metabolite of serotonin. The role of melatonin, by the way, and its function in man is totally unknown.

What has been of interest to the researchers in this field has been the fact that melatonin is known to have a circadian rhythm, in other words it goes up and down in a 24 hour cycle. It is one of the biological rhythms. The relevance of that rhythm is not known. Its physiological importance is not known, even in the mice and the rats in which it has been studied.

Furthermore, the rhythm of melatonin is not associated with the rhythm of other hormones whose role we clearly do know and are clearly very important. For example, ACTH, or glucocorticoids, are which are important hormones for regulating body metabolism, they

also slow a circadian rhythm. And there is no evidence that the rhythm of melatonin is in any way coupled to the rhythm of other very important, metabolically important, hormones.

And indeed, when Ehret studied mice or rats under this circumstance or this same paradigm that are used by these investigators that would result in an alteration of melatonin rhythm, one sees no alteration at all in the other more important hormone rhythms and sees no changes in the other physiological rhythms that are seen in animals, for example, feeding behavior, sleep/wake cycles, metabolism cycles. Those things are not changed.

So one has to assume that the changes in melatonin are uncoupled or at least not connected with the changes that are occurring in the other known rhythms of the body.

I'm sorry. I didn't mean to wing off like that.

Q. And after reviewing this article do you recall what the results were of this study?

A. Yes. I mean, I'm pulling this not so much from my memory but from the abstract. I think one of the interesting things was that they did not show that were changes in pineal or serum melatonin levels, which you will recall is the report that comes from the Wilson-Reiter laboratories, that are such changes. So

that using this pulsed magnetic, intermittent magnetic field, they did not see those changes.

We agree that this field that they used is totally different than the ones from power transmission lines?

Q. Yes.

A. Okay.

Q. Did they see a change in the level of serotonin?

A. There is a decrease in the activity of pineal enzymes, serotonin and acetyl transferase, which they say suggests that there is a change in the metabolism. They don't say in the abstract per se that there is a change in the serotonin.

So let's look at the graph figure. Again, they are not measuring serotonin -- well, 5-hydroxytryptophane. It is poorly reproduced, but it would look like part A, in figure 3, part A. It would suggest that whatever the crosshatching bar is, it looks like it is different.

Q. And perhaps if you could focus on the last line of the abstract that is on the front cover?

A. Okay.

Q. And just review that to yourself.

A. Okay.

(Witness perusing document.)

A. Okay. I thought I quoted that.

Q. Oh, I'm sorry.

A. It says that the metabolism of serotonin is quickly affected by exposure of animals to this magnetic field.

Q. Now, if you could turn back to page 18 of your testimony, lines 17 and 18, you state that when humans were studied there was no reported decrease in the pineal melatonin levels. Could you tell us what study you are referring to there?

A. That is actually a study done by Dr. Wilson, Barry Wilson, himself in which he was looking at urinary metabolites of melatonin and showed that in the human subjects that were being exposed to an intermittent field that they did not show changes and effect. There was some suggestion that there might be a slight rise in melatonin level. That would be a response that is completely opposite to what he reports in the rats.

Q. And is that work published by Dr. Wilson?

A. That work is mentioned in a recent book of which he is the editor. And if you want a citation for that look at page 33, the Groh reference. I believe that which Wilson's report of that study is mentioned in his article in this book, of which he is the editor, the book being Extremely Low Frequency Electromagnetic Fields: The Question of Cancer, published in 1990.

Q. Are you familiar with the work of Wilson that was entitled evidence for an effect of ELF Electromagnetic Fields on Human Pineal Gland Function published in 1990 in the Journal of Pineal Research? And maybe to jog your memory, that refers to electric blankets, the use of electric blankets.

A. That's correct. That's actually --

Q. Is that the study?

A. That is the study. You know, I'm pretty sure it is also mentioned in this book, the citation that I just gave you. I may not have read that primary publication.

Q. And I just have a copy of that article, and also again I am using it to refresh your memory and I don't want to have it marked for identification. This is the Wilson article.

A. Thank you.

(Witness perusing document.)

A. Okay. This is not where -- I did not read this article to make that statement, I'm pretty sure, the statement that I made. He has more patients in this study. It is fundamentally the same study so I think in his book we may have given sort of a preliminary report and results. I have to say it is a little different, just quickly eyeballing this, it is a little different

than the report, the result that he's giving here.

Let me just put it in context. What this is is this is not taking human subjects and putting them underneath the power transmission line. What he is doing is he is studying people who are using a specific kind of electric blanket. It's the kind that switches on and off constantly so that they are being exposed to a somewhat dissimilar type of magnetic field, a pulse-type of magnetic field, as was in this experiment here, the first paper that you gave by Lerchl. So this has nothing to do, really, in terms of characteristics or types of electric or magnetic fields that one is exposed to in power transmission lines.

And doing that experiment, what he was hoping to do was to see if there were changes in a urinary metabolite of melatonin, which theoretically is coming from the pineal gland.

Now, I have to say I had some questions about the methodology of doing that, because the pineal gland's production of melatonin is exceedingly small. There is a lot of serotonin that is produced in the body, and is it conceivable that some of this metabolite is coming from places other than the pineal gland? That has never been totally illustrated.

Remember that in the studies that Barry Wilson

does, he measures pineal melatonin levels, which are the levels that theoretically change during a biological cycle. In order to do those experiments he kills the animal at the particular time, takes out the pineal gland and extracts the pineal gland for the melatonin.

In this case we are looking at a very long, distant derivative of theoretically something that the authors have not convincingly demonstrated is or is not produced in the pineal gland, a metabolite. Given that, what I thought he had initially reported in the book, that very short book article, was that the levels he saw actually went up, which is opposite to the response that he reported for the rats. Here, if I am correct in understanding the table 2, there seems to be little or no change, really.

Q. And if you could refer back to that again, to his abstract and the last sentence on that abstract.

(Witness perusing document.)

A. "We hypothesize that periodic exposure to a pulsed DC field, or extremely low frequency electric or magnetic fields, of sufficient intensity and duration can affect pineal gland function in certain individuals."

But he says in certain individuals. I mean, he is obviously showing great selection in the data that he is describing in that sentence because the table, table 2,

does not seem to confirm as a general result that that is the case.

Q. Now, if you could turn to page 17 of your testimony and the research cited on lines 25 to 34, could you tell us which research you are referring to there? Is this the Wilson study?

A. Yes. These are the Wilson studies. In order to see these changes in rats one has to subject them to these artificial laboratory conditions. In other words, the animals have to be totally isolated and entrained in a sense. In other words, they have to be put into this artificial laboratory environment and a very specific light/dark sequence has to be followed religiously for three weeks before you start seeing these changes that he has reported. And then the interesting thing is that if you turn off the fields within three days the animals return to a normal circadian rhythm for melatonin. In other words, these changes that were entrained over three weeks disappear. That would argue that the change is clearly not a permanent change.

Q. Let me just interrupt and you can complete your answer, but when you use the term entrained, essentially what you are saying is they were exposed to 60 hertz electric fields for three weeks?

A. Correct.

Q. And then they were removed from those fields for three days?

A. Three days.

Q. It was just the use of the word entrained that I wanted to get clear on.

A. I'm sorry.

Q. And during the exposure period Dr. Wilson reported an effect on the melatonin level in the brain of the rat, is that correct?

A. That's correct. You should realize he has done the experiments a number of different ways and what he reports are two changes, and that is that there is a diminution in the melatonin, the nocturnal melatonin level, compared to the animals that were not exposed, and that there appears to be a shift for when that peak appears. So the bottom line is that the animals for the most part continue to show a circadian rhythm with regards to melatonin, it is just reduced and there is a slight shift in the time.

Now, I have to say, you know, when you look, he's got maybe five to ten of these papers. When you look at these changes they are not very dramatic. Secondly, the shift is really quite small. And, frankly, these experiments are predominantly being done by Dr. Wilson. Therefore, they haven't really been confirmed on a large

scale. I mean, so we have to accept the data with those provisos.

Q. And when you speak of the shift, that is what you referred to as the time delay?

A. Correct.

Q. Now, are you aware of any studies that have been done where the rats were left in the field for longer than a three week period?

A. As I said, I think Dr. Wilson has done a number of these studies, and I thought that he has done some experiments with longer exposure but I'm not sure.

Q. Now, I believe you stated earlier that science is just not sure what the function of pineal melatonin is in humans.

A. Can I go back a step?

Q. Sure.

A. You remember that I said Ehret reproduced these conditions and then studies the other hormones that show circadian rhythms and showed that they were not affected. I believe that Ehret's experiments were done for a more prolonged duration.

(Pause.)

A. None of these experiments, by the way, show any deleterious effects on these animals associated with these changes. You know, I'm not sure that the rat is an

appropriate model in a sense because the rat is a nocturnal animal. I mean, the animal does its foraging and its eating nocturnally. I mean, it is opposite to man. So I am not so sure how good a model it is to begin with and you certainly can't extrapolate to man. We are talking about circadian rhythms here, which are so clearly determined most often by the strongest effecter of circadian rhythms, which is daylight cycling. We are talking a nocturnal animal and a circadian rhythm and we are trying to extrapolate this data to man. I have never understood that.

Q. You have used the term deleterious effects, and I think you may have used it a number of times. Just so we're clear, when you use that term what are you referring to when you say a deleterious effect?

A. I think what I am trying to say is an adverse health effect.

Q. How would you define as a scientist an adverse health effect?

A. I think in the animal model systems that the animal would be sick in some way, or clearly sick.

Q. Okay.

Now, I believe you had mentioned earlier that you are unsure what the function of pineal melatonin is in the body, or in the human. Do we know what the effect of

a prolonged decrease in melatonin level would have on the body?

A. I would say we do not know that, certainly not for humans and probably not for most of these mammalian species. As I understand it, most of the research with regards to melatonin and the more profound understanding of melatonin's possible relationship to circadian rhythms is done in lower animal forms such as anurans, you know, such as frogs and lizards, snakes.

Q. Are you familiar with a study by Tamarkin published in 1981 that was entitled Melatonin Inhibition and Pinealectomy Enhancement of 7, 12-dimethybenz(a)anthracene-Induced Mammary Tumors in Rats? I think they call it DMBA.

A. No. Not off the top of my head I don't recall that study.

Q. Now, are you aware of whether there have been any animal studies not necessarily related to electromagnetic fields that have shown an association or have looked at the question of melatonin levels and the integrity of the immune system?

A. Yes, I am aware that there are studies suggesting that -- I am trying to think of the context where I most recently saw that. I have not seen the primary reports with regards to that. In other words, a

scientific study done with either isolated lymphocytes or looking at lymphocyte or immune cell function. I think I have only seen references to it in -- oh, yes -- I've seen references to it in articles, sort of summary articles, in particular the one written by Groh in that book that I previously cited in which Dr. Wilson is the editor. He refers to it, but I don't remember whether he had specific citations to really substantiate that.

Q. And are you aware of any studies, again not necessarily related to electromagnetic fields, that report associations between melatonin levels and psychological disorders?

A. There is a huge literature on melatonin affecting a number of systems, including psychological systems, yes. I have not personally reviewed a lot of that literature.

Q. Now, Dr. Bockman, in your review of the question of electromagnetic fields and the biological effects on the endocrine and immune systems, have you become aware of the continuing research in this area that is being conducted?

A. As we discussed at the beginning of this, some of these citations that were not in the back of the report were from abstracts in the BEMS meeting. So, I mean, the answer is yes, I continue to try to track the

literature.

Q. And when you say the BEMS meeting, is that the annual review of research on the biological effects of 50 and 60 hertz electric and magnetic fields?

A. No. I believe that is the society, the Bioelectromagnetic Society, and they study a very wide range of the spectrum of electric and magnetic fields. I mean, they are studying not only 60 hertz effects. I think if you look at the publications, more than 90-plus percent of them are using fields that are not power transmission fields.

It is exceedingly difficult -- from my review of the literature, it seems to be extremely difficult to actually demonstrate biological effects with electric and magnetic fields of the power transmission type.

Q. Now, if you could look at page 21 of your direct testimony where you discuss the study concerning exposure to VDT terminals on pregnant women, did that study that you cite there look at the instance of birth defects as well?

A. I don't remember that portion. You will notice that I make a comment to spontaneous abortion. I think they did look at birth defects but I don't remember the results.

Q. And if you could just refer to page 11 of your

testimony and the research concerning calcium metabolism, we touch on this briefly earlier but by way of background what is the function of calcium metabolism? And I will add the caveat in as layman's terms as possible.

A. Well, that is a very difficult question to answer because there are obviously several levels of calcium metabolism that go on in our bodies. I mean, there is a gross level of calcium shuffling that goes on between our dietary calcium in our bones, and then there is a calcium economy or calcium metabolism that goes on at the level of cells and also within cells.

And it is really -- let me just focus, because these studies to focus on that microscopic level, if you wish, of calcium that is involved in cell and cell function. In that sense, calcium is a very important signal molecule. In other words, the cell is receiving signals from the outside all the time, either electrical signals through nerve transmission or it's receiving chemical signals, some of those being hormones, are chemicals signals. One of calcium's important functions is to transduce that signal when it comes to the surface of the cell -- to the inside of the cell -- to say we just got a message and the message is X. Also calcium becomes what we call a second messenger or a signaling substance.

In order for a substance to be a good signaling substance its level has to be very tightly regulated or controlled because it is basically like a switch. And the way calcium signals as a switch is that the level inside the switch will change, go up or go down. That kind of calcium that changes, the cell has been very clever in terms of partitioning it. Much the way we carry most of the calcium in our body is in our bones, 95-plus -- actually almost 99 percent of the calcium in our body is sort of banked away in our bones.

The cell has much of the calcium within it sequestered away and it is only a very small portion of the calcium that is in biologically active pools, if you want to think of it like that, that is really relevant. And that calcium serves a number of functions, and some of those functions in addition to the switch function or how does it do what it does from a mechanistic point of view, that functioning of calcium we understand in certain circumstances. Sometimes calcium serves in a sense as a glue. You know, that it has two positive charges so basically it can in a sense act on two sides and maybe hold things together, and that is one of its important functions.

It appears, for example, able to bind a particular enzyme to a particular surface of the cell, not the

outside but an inside surface, and that activates that compound, that enzyme, to do its thing. Calcium in that sense serves as, if you want to think, as the necessary fifth partner to accomplish that function.

So the main take-home lessons are that calcium is an important signaling substance for cells, that it isn't every molecule of calcium or all molecules of calcium but selected pools of calcium that are very important. And for the most part you can think that the most important pools or the most biologically relevant kind of calcium is the stuff that is just free or ionized inside the cell, in the cytoplasm of the cell. That is really, from our point of view, the biologically most important type of calcium.

Q. Now, on page 13 of your testimony you speak about the conflicting results in the area of calcium efflux studies. I'm sorry. That is on line 35. How does science resolve these conflicting results in the calcium efflux studies?

A. I think that answer has to be put in context. The experimental studies by Blackman and by Bawin and Adey, those studies measure the leaving or efflux, the leaving, the exiting of calcium from tissues, tissues that have been exposed and not exposed to electric and magnetic fields. And in fact for the most part the

electric and magnetic fields really have no bearing on power transmission fields. We have to realize that those are amplitude modulated fields. They are almost in the microwave range, given out at a frequency that is close to a power frequency field. Those are very different informational content type of waves.

Anyway, what these investigators are really measuring is just this outflow of calcium. They don't really know where the calcium is coming from, and my citations of Parkinson and Hanks and also the reference to Hojevik from the BEMS, those references show that the biologically important forms of calcium are indeed not changing.

So the likelihood is that Blackman, Adey and Bawin are measuring the outflow of calcium from tissues. These are intact tissues, they are actually dying tissues, and Blackman admits these are non-functional tissues. In other words, they were nerve tissue but they no longer perform any nerve function. They died, basically, with regards to their function. So these are dead and dying tissues and you're measuring the outflow of calcium that is probably just loosely attached to the outside of the cell.

So that is why I made my statement that these experiments basically have no biological relevance

because they are not measuring or tracking the biologically relevant pools of calcium within cells. Therefore, frankly, it is no surprise that these investigators cannot report any important changes in biological function when they measure this change this efflux.

If that isn't already confounding, in other words, we are dealing with an experiment that I am telling you has no biological relevance, it is even more confusing the fact that Blackman and his collaborators say that the level goes down, or the efflux goes down, and Bawin and Adey and his collaborators say that the levels go up. In other words, they find their results going in the opposite direction.

So I guess I wasn't very eloquent in my summary, but these are conflicting results. But more importantly, I don't think that these are biologically relevant experiments.

Q. So it would be your opinion -- or would it be your opinion, then, that those conflicting results do not need to be resolved?

A. That's true. We will not learn more biology by trying to resolve their conflicting results.

MS. McCLOSKEY: Thank you, Dr. Bockman.

I have no further questions, Your Honor.

JUDGE SMOLEN: Do we want to go on now? Let's go ahead. Mr. Sugarman.

MR. SUGARMAN: Thank you, Your Honor

CROSS-EXAMINATION

BY MR. SUGARMAN:

Q. Dr. Bockman, what area have you been researching in in the last five years? If any.

A. I have been interested in how to improve bone formation and getting more calcium into bones to make bones stronger. That is sort of at a gross level. I have a --

Q. Go ahead.

A. I have a laboratory. We have three assistant professors. We are doing a lot of molecular biology on some very fundamental questions. But, you know, in the gross terms that is basically what we are trying to do, we are trying to make people have stronger bones.

Q. How have you been attempting to find ways to make people have stronger bones? What research method have you been using? Animals? Tissue? What?

A. I use -- we use individual cells that are models for bone forming cells. We use what are called explant tissues, which are pieces of tissue that come from relevant organs. In our case they are explants of bone tissue. We use intact animals. And in addition to

which you should be aware that I do clinical studies, in other words, I do experiments with and on people.

Q. Have you tried using electromagnetic fields to enhance calcium formation or make stronger bones?

A. As I mentioned earlier, we have a clinical study that is ongoing using electric and magnetic fields that enhance bone formation.

Q. When you say clinical study does that mean that you are using it on your patients that need the help?

A. We are using it on selected patients to see if we can enhance bone density.

Q. Are you telling these patients that you are not persuaded that this treatment is valid?

A. As you know, one is required when doing experimental studies in humans to try to give full disclosure. We explain that we don't know whether they will in fact derive a benefit from this study. In fact, -- yes.

Q. Well, you said study. Did you mean treatment?

A. No. It's a study.

Q. Whether or not they derive a benefit from the study, what do you tell them about what they might derive from the treatment? Obviously they don't derive a benefit from the study.

A. That is the same thing, isn't it? Unless I'm

misunderstanding your question.

Q. I don't think so. If you apply magnetic field in an effort to heal their bone, that might be part of a study as far as you're concerned, but as far as the patient is concerned it is treatment. And what I want to know is if the patient says to you am I wasting my time, what do you tell them? And my money.

A. First of all, they are not paying for this study. They are very generous to give their time and to participate in such experiment studies. These are healthy women who have no known bone lesion. They are healthy intact women who are participating in an elective experimental trial for which there is no statement made as to what the outcome will be.

Q. Oh, I misunderstood you before. When I asked if you were using it for your patients I thought you were using it -- I thought you answered that you were using it on people who need the treatment.

You haven't used -- so to come back to my question, in your practice in terms of treating people who need treatment, have you used any magnetic fields?

A. We have not. I have not.

Q. Has your group?

A. They have not.

Q. Has your hospital?

A. They may have. I don't know.

Q. Is there any -- you are not an orthopedist?

A. That's correct.

Q. What do the -- well, let me phrase it this way. Have you done any research in conjunction with any orthopedic group in your hospital?

A. Yes, I have.

Q. Have you used any magnetic fields for that purpose?

A. I have not.

Q. Has the orthopedic group used any magnetic fields?

A. They may have.

Q. Are they using it to treat patients?

A. Far as I know, they are not.

Q. What is the basis of your knowledge?

A. The basis of my -- the reason I am not being absolutely certain, first of all, I don't know everything that goes on in my hospital. I have only been there three years. I sit on their institutional review boards so I get to see all the proposals for studies that one would like to do and I have not seen such a proposal cross my desk.

Q. Do you know whether the orthopedics department in your hospital is using it to treat patients?

A. To my knowledge, they are not.

Q. What do you base your knowledge on?

A. My contact with my colleagues.

Q. Do you know whether they are recommending patients to others who do use magnetic fields?

A. I do not know that.

Q. You indicated that you use intact animals in your research?

A. That's correct.

Q. What species do you use?

A. For the most part we have been using rats.

Q. And do you feel that rats are extrapolateable to humans?

A. Not always.

Q. Are you interested in rats for rats sake?

A. We do studies in rats because some information may be extrapolateable.

Q. And you indicated that you use explants. I take it that is pieces of dying and dead tissue?

A. We do try to keep them alive.

Q. But they are tying, are they not, once they are removed, once they become an explant?

A. Do you want to define dying for me?

Q. You used the term in answer to one of Ms. McCloskey's questions. And I want you to use it in the

same way you used it in answer to her question, when you challenged Dr. Wilson's work because you said he was using dying tissue.

A. We don't use the same methodologies. We try to keep our tissues viable and we are able to keep them viable, alive and well for the short duration of the study, which actually is longer than their study, but it is about 96 hours at its longest. And we try to maintain those tissues to be alive, as alive as possible.

Q. How do you know that he doesn't?

A. Because he is not using the same types of tissue. Those tissues are -- by the methodology that they are using, it is not possible to maintain the tissue to be viable, and they have so stated. The reason --

Q. Well --

A. Can I finish?

Q. Sure. I thought you were finished.

A. The reason I say that is that the slices of tissue they are using are too thick. Within your body the reason that cells stay alive is that they are no more than two millimeters away from a blood supply of some kind. They are using tissues that are not profused. Therefore, they are just hunks of tissue in a culture dish. They are much thicker than two millimeters. Therefore they cannot possibly get enough essential

nutrients, such as oxygen, to maintain viability.

And Dr. Blackman himself has indicated these are nerve tissues that in their hands at the time they do the experiment those tissues no longer maintain normal neural function. Therefore I would say they are non-functional and most non-viable.

I just would like to finish by saying that the way the experiment is done is that the tissue is removed from the animal, it is then incubated for 20 minutes with radioactive calcium because they are looking at the movement of calcium so they have to be able to track calcium. And the way they do that is to label the tissue, in other words, let all the calcium that's in the tissue equilibrate with a radioactive type of calcium that they can follow.

The trouble is that 20 minutes does not guarantee that they get full exchange of all the calciums and that the calcium they are using to label and that they are going to use to track the experiment, whether that calcium gives you a representative -- a good representation of all the calcium that is in the tissue.

Then they wash the tissue and then they watch the outflow of this radioactive calcium from this tissue. So the tissue by the time they are ready to do the experiment is 40 minutes in a tissue culture dish, no

longer functional with regards to its neural function, and it is releasing calcium from sites that you don't know where that calcium really has gone and whether it has truly equilibrated. I mean, in a sense it's like trying to do pollstering and trying to get a feel for how a vote is going to turn out by taking what is probably an inaccurate sampling of the electorate. It is a poorly conceived experiment and in their hands those tissues are not viable.

Q. Are you talking about Blackman?

A. Yes. And Bawin and Adey also.

The experiments we are doing, the tissues are --

Q. Can I just stay with that for a minute? Blackman, you say you are talking about Blackman, that his experiments are poorly conceived?

A. For the purpose of demonstrating biologically important pools of calcium, those experiments are poorly conceived, correct.

Q. And the studies that you cite as showing no changes -- which are where, on page 17 and 18, all right?

A. No.

Q. I've got the wrong ones?

A. Uh-huh.

Q. Where are the ones that you are talking about in terms of calcium impacts? Is this over on 24 through

25?

A. No.

Q. Okay.

A. I think the references you are trying to find are on page 13.

Q. Page 13? Okay.

A. Yes.

Q. Thank you.

Now, Hojevik, you say?

A. Yes.

Q. How did he handle his tissues?

A. Hojevik is using a methodology that is far more sophisticated. These are live viable tissues that are maintained -- actually, they are cells -- that are maintained in culture. It is possible in those circumstances to maintain cells to be healthy viable functional cells almost forever. He is using a methodology called patch clamp, which is a methodology for which two investigators won the Nobel Prize last year or the year before, Nachman and Sackler I believe.

That methodology basically is able to isolate a very small portion in viable cells, a small portion of the membrane, and using a very sophisticated electrode to monitor the movement of individual calcium ions -- not radioactive but normal healthy calcium that's in healthy

cells -- back and across the membrane.

That, I believe, is the experiment that Hojevik is doing.

Q. Did you say you know where Hojevik is published?

A. Yes. It is in the BEMS abstracts, 1991.

Q. What was that?

A. BEMS abstracts, B-E-M-S.

Q. BEMS abstract?

A. Yes.

Q. That is where it is published, the study?

A. Yes.

Q. Do you have that with you?

A. I do not.

Q. And lastly, you testified that you use single cells in your research?

A. We use cell culture. Often it is more than one cell.

Q. I thought you said single cell culture?

A. Well, single type of cell.

Q. Okay. Do you agree that this single type of cell as an experimental or research methodology is a highly artificial condition?

A. In that it is not in a living intact organ or organism, I guess it is certainly different. But for

studying certain issues of molecular biology those are more easily accomplished. I mean, the reason one goes to different model systems in biology is that one asks questions of each of those model systems that are relevant to the biological issue being examined. It would be inappropriate, obviously, to study things that are appropriate for an intact interrelating system in a single cell system, sure. I agree with that.

Q. So do you maintain your rats in their normal environment in all cases in your research?

A. Well, I don't know what you mean by a normal environment.

Q. Well, on page 17 of your testimony it appears to be a criticism -- I'm not sure, maybe it's not. Page 17, line 25. You attempt to dismiss the positive results of the E/MF research on melatonin by stating, quote, under highly artificial laboratory conditions where experimental rats are deprived of normal environmental cues, end of quote.

So my question is do you in all your research maintain the rats in their normal environment?

A. You will remember that when I was describing circadian rhythms I told you that one of the most important influences on circadian rhythms is light/dark cycles.

Q. May I please have a direct answer to my question instead of an argument?

MR. WATSON: With all due respect, he is trying to answer the question.

THE WITNESS: I am working to it.

JUDGE SMOLEN: Wait. One voice at a time.

Let's have the question again. Or we can have the reporter read it back if you don't recall, Mr. Sugarman.

MR. SUGARMAN: I'm sorry?

JUDGE SMOLEN: Can you restate the question?

MR. SUGARMAN: Yes.

BY MR. SUGARMAN:

Q. The question was do you in all cases maintain your experimental rats in their normal environment, in all your research?

A. I mean, the answer would have to be no. I mean, these are specially raised animals that are brought into a laboratory system where they are put in cages.

Exactly my point with regards to this study. We have no idea what circadian rhythms in free living animals, where it would seem to be relevant since light and day and night are very important for entraining circadian rhythms in normal animals.

Q. Isn't it true that the extrapolation of any experimental results to living human systems is

stochastic?

A. It is difficult sometimes to make extrapolations and ultimately we need to do these experiments in humans. I mean, man can only be the test subject for results that we want to see in man.

Q. So your criticisms of the laboratory conditions of these experiments are relative and not absolute? You think they are less extrapolateable because of the conditions that existed?

MR. WATSON: Your Honor, objection. He has two questions there. Can we just get one and then the other?

MR. SUGARMAN: It's fair cross-examination.

JUDGE SMOLEN: Yes, but one question at a time is fair.

MR. SUGARMAN: All right.

BY MR. SUGARMAN:

Q. Isn't it true that your criticism is one of relative validity of extrapolation?

A. I'm not sure I know how to answer relative extrapolation. I'm not sure what those terms mean. I mean, you will have to clarify the question because I don't know how to answer it the way you are asking.

Q. Never mind.

Now, you testified in response to Ms. McCloskey's questions that Wilson's work -- and she showed you the

Journal of Pineal Research, his article of 1990, with Wright, Morris, Bushbom, Brown, Miller, Sommers-Flannigan and Anderson, sponsored by Batelle Pacific Northwestern Laboratory, or I should say that that is where they are, I thought you had first said that it concludes that the results on melatonin from electromagnetic field exposure are the opposite of what that group or Wilson usually reports. And then when you were shown the study you testified that it seems to go both ways. Did I understand your testimony correctly?

A. It's close. I would make the comment that which Wilson's experiments showing a decrease in melatonin levels is with 60 hertz fields in rats.

Q. I understand that you are not persuaded that it is relevant or extrapolateable relatively speaking --

MR. WATSON: Your Honor.

JUDGE SMOLEN: Let him finish.

BY MR. SUGARMAN:

Q. I'm sorry. I thought you were finished.

A. This experiment for this reference handed to me by Ms. McCloskey by Wilson is in human subjects being exposed to some form of intermittent field from electric blankets in which some very distant surrogate measurement of melatonin, some metabolite that is measured in the urine, is being evaluated. And, yes, the results that

appear to occur in the rats in one type of experiment with different conditions appears to be quite different than the results that he is reporting here.

Q. Are they similar in one respect, and that is in both cases there is an effect?

A. I am not convinced there is an effect in this electric blanket experiment.

Q. That the statistics show an effect?

A. At one exposure period in one group -- I'm sorry -- two groups.

Q. And are you aware of the melatonin work having been documented by Dr. Russell Reiter of the University of Texas?

A. Dr. Reiter and Dr. Wilson publish together.

Q. I don't see Dr. Reiter on this paper. That is why I listed all the authors: Wilson, Wright, Morris, Bunchbaum, Brown, Miller, Somers-Flanagan and Anderson?

A. Dr. Reiter may not appear on every publication of Dr. Wilson, but most of the publications of Dr. Reiter have Dr. Wilson's name on the paper, particularly when they are in this experiment.

Q. Are you familiar with Stevens?

A. Yes.

Q. Richard Stevens?

A. Yes.

Q. Are you familiar with Richard Stevens' chapter called The Question of Cancer in the book that you mentioned, in the 1990 publication?

A. I think that I have read it. I don't cite it here.

(Pause.)

Q. I'm sorry. I thought you were looking.

Do you discount Dr. Stevens' work?

MR. WATSON: Your Honor, objection. It is beyond the scope. Stevens is an epidemiologist.

MR. SUGARMAN: I am testing him by other authors. It is a standard question.

JUDGE SMOLEN: I am going to permit the question.

THE WITNESS: Could I have the question again?

BY MR. SUGARMAN:

Q. Do you discount Stevens' work?

A. The work I'm most familiar with by Stevens is really a hypothesis, not an experiment. And his hypothesis was that melatonin may or could possibly be linked. It is a hypothesis. That is what he published, I believe, in the American Journal of Epidemiology.

That is a hypothesis. I mean, if you would like to discuss his experimental work, I would like to see it and then we could discuss it.

Q. Stevens, Wilson and Anderson say in the

reference that you referenced in your direct testimony, quote, First, melatonin itself --

MR. WATSON: Could we have an identification?

MR. SUGARMAN: Page 367.

MR. WATSON: Of what?

MR. SUGARMAN: Of the article or the chapter -- I'm sorry -- chapter 15 in the book edited by whomever that the witness cited in his direct examination, the 1990 text that he cited.

MR. WATSON: Okay.

BY MR. SUGARMAN:

Q. And the statement is, "First, melatonin itself is oncostatic and can inhibit the growth of several cancer cell lines in vitro." Do you agree with that?

A. I only know of one cell line where that has really been clearly demonstrated. That is the MCF-7 cell line.

Q. Second, "Melatonin affects the function of the hypothalamic-pituitary-gonadal axis and may thereby affect the availability of hormones required for the growth of hormone dependent breast, ovarian and prostate cancers." Do you agree with that statement?

A. That is a hypothesis. Much of the experimental basis for making that hypothesis is research that has been done on low animal forms.

Q. Like rats?

A. Excuse me?

Q. Like rats?

A. No. More like lizards, salamanders, toads.

Q. Is it your statement that the first half of the sentence is hypothesis or the second? Let me read you the first half. "Melatonin affects the function of the hypothalamic-pituitary-gonadal axis." That is the first half of the sentence.

MR. WATSON: Your Honor, I am going to object to that. I think he is at least required to show him the document and the text.

MR. SUGARMAN: No problem.

JUDGE SMOLEN: Let him take a look at it.

(Document handed to witness.)

BY MR. SUGARMAN:

Q. Do you agree with that statement?

A. Do you want to show me where you are?

Q. Yes, sure.

(Witness perusing document.)

A. There is -- I think there is a very good basis of experiments in low animal forms to suggest that melatonin may actually -- may effect the function described here. So that is really a qualified yes because many of the experiments show an association and

not a causative effect, in other words, the changes in melatonin are associated with. And these are in low animal forms that we have characterized already. So that is my qualified answer.

Q. And I take it that the second half of the sentence, where it says it may thereby affect the availability of hormones required for the growth of hormone dependent breast, ovarian and prostate cancers, that is the half that you are saying is hypothesis?

A. I think that is a real hypothesis, particularly since many of those animal forms don't have prostates, for example.

Q. Then in the next sentence, "Changes in melatonin secretion may affect the production of other hormones such as estrogen and prolactin and alter the proliferation of normal, intermediate or malignant cells."

A. That is largely hypothesis also.

Q. If you accept that two of those, the two observations that contain the word "is" or "do", in other words, that are not qualified in the text by "may", then do you agree that pineal function might be linked to the etiology of cancer in several ways?

MR. WATSON: Objection, Your Honor. It is compound. He has a first, if you accept X and then do

you agree with Y --

MR. SUGARMAN: I will strike the first half.

MR. WATSON: If he would split it out and ask one at a time.

MR. SUGARMAN: I will strike the first half.

BY MR. SUGARMAN:

Q. Based on the prior answers do you agree that pineal function might be linked to the etiology in cancer in several ways?

A. I think there is very little basis for coming to that conclusion, very little scientific basis for coming to such a conclusion.

Q. Do you agree that it might be?

A. Anything is possible, Mr. Sugarman.

Q. Is it possible that my sitting here in this room is a function that is linked to the etiology of cancer?

A. The answer is yes.

Q. And in your view is the statement that pineal function might be limited to the etiology of cancer in several ways, in your view is that possibility equal to the possibly that our sitting here in this room might induce cancer?

A. Well, first of all, you substituted the word limited instead of linked.

Q. Did I say limited?

A. Yes, you said limited.

Q. I'm sorry. Let me rephrase my question. I didn't mean to use the word limited.

Are you saying that the possibility of our sitting here in this room has the same degree of probability or possibility as the statement pineal function might be linked to the etiology of cancer in several ways?

A. I don't know how to quantify that, but I think they are both highly conjectural statements.

Q. Are they equally highly conjectural?

A. I can't say. I just said that I couldn't quantify either statement but I would characterize both as being highly conjectural made by people who you would have to agree as well are not oncologists or specialists in the field of cancer and cancer promotion, et cetera.

Q. What enables you to say that they are not specialists in the field of cancer promotion?

A. Does Dr. Wilson have qualifications as being an expert in cancer or human disease?

Q. I thought we were talking the promotion of cancer.

A. We were talking about the statements that you were referring to by Dr. Reiter and Dr. Wilson. And I am asking you the question. I don't know, but it strikes me

that you're asking -- they have come to a highly conjectural position in an area where one would have to argue whether or not they have the credentials to be knowledgeable.

Q. Why would one have to argue? Aren't they dealing -- a minute ago you said they are not specialists in the promotion of cancer. Don't you agree with me that they are specialists in the promotion of cancer and your real disagreement is with their work and with their conclusions and not their credentials?

A. That's not what I said, Mr. Sugarman. What I said was that they are not experts in this area and their conclusion is highly conjectural within that area.

Q. It seems to me you are playing games with the words in this area.

MR. WATSON: Objection, Your Honor.

BY MR. SUGARMAN:

Q. What do you mean by this area? You said promotion of cancer before. You said they are not specialists in the promotion of cancer.

JUDGE SMOLEN: Let's have one question, now. Go ahead. You are arguing with the witness.

MR. SUGARMAN: I'm sorry. I will withdraw it. I thought we are engaged in dialogue. I will withdraw it.

BY MR. SUGARMAN:

Q. You said before that they are not specialists in the field of promotion of cancer. Now your terminology is they are not specialists in this area. What area are you talking about now?

A. My original statement had to do with oncologists, people experienced with clinical cancer. I also don't think that they have publications -- we are talking about Dr. Wilson -- Dr. Wilson does not have publications in the specialty of oncology. He does not have publications as far as I know in the field of cancer promotion or initiation.

Q. What do you call his work, then, if it is not in the field of cancer initiation and promotion?

A. Dr. Wilson's studies that we have been describing and discussing all morning have to do with circadian rhythms of a hormone, melatonin, which has measured in rats. That is not cancer promotion.

Q. Why not? If he says that it is cancer promotion, as much as you might disagree with it is it not in the field of cancer promotion?

A. There are touchstones with regards to people who do cancer promotion studies. I don't think that Dr. Wilson has really achieved any of those nor would help necessarily claim to be an expert.

Q. What touchstones are you talking about?

A. Normally people who do studies with cancer promotion and oncology are using agents that are known carcinogens and use model systems in which these processes have been described. I don't believe that Dr. Wilson has done those studies.

Q. I don't understand your answer because perhaps you could explain to us how a person looking for a cancer agent whose certainty is not established could do work in cancer promotion by your definition.

MR. WATSON: Your Honor, I would object. This is argumentative and it is way beyond the scope.

JUDGE SMOLEN: Well, I am going to permit the question. I will overrule the question. You've got a question and the witness apparently has an answer.

A. I would respond to your question by pointing out Dr. Wilson's own quotation in his response to the draft EPA report in which he says, and this is -- I am paraphrasing this, I don't have it necessarily exact -- in which he says that these changes in melatonin that he has measured should not be used as a basis for arguing that E/MF is potentially a carcinogen.

BY MR. SUGARMAN:

Q. Let's assume your paraphrase is accurate --

A. Excuse me. I didn't finish.

Q. Oh, I'm sorry. Go ahead.

A. I would assume by that statement that Dr. Wilson does not himself see his work on circadian rhythms of melatonin as related or relevant to the area of carcinogenesis and oncology.

Q. Are you really saying that if somebody does not express an absolute conclusion about a subject that he is studying that therefore he is not in that subject?

MR. WATSON: Objection, Your Honor. It's argumentative.

JUDGE SMOLEN: I know it has been asked and answered but --

MR. WATSON: And it is asked and answered in addition.

BY MR. SUGARMAN:

Q. Are you really saying that if a person --

JUDGE SMOLEN: Wait a minute. We have an objection.

MR. WATSON: I object at this point, Your Honor. This is far afield, it is argumentative and it has been asked and answered a couple of times.

JUDGE SMOLEN: What I am going to do, in all fairness, since it only requires a one word answer, I am going to allow him to answer that question. Because he is really restating the same question and asking the witness does he mean what he really said before.

Do you mean what you really said before in your previous answer?

THE WITNESS: I meant everything I said before.

JUDGE SMOLEN: All right. Next question.

BY MR. SUGARMAN:

Q. Then do you agree that you are not an expert in the field of cancer causation or promotion because you don't -- as related to E/MF -- because in your opinion there is no evidence that it is related? Or no persuasive evidence, to quote you.

A. That is a very complex question. It's got several parts. One part has to do whether or not I am an expert in cancer promotion. And then there is a question that has to do with whether or not I am saying that as my answer or non-answer because I think there is a link or not a link. To me, those two questions are, first, are totally unrelated.

Q. That is what I thought until you said that Dr. Wilson was not in this field because he does not say that you can definitely conclude --

JUDGE SMOLEN: We don't want to go over that again. Why don't you ask a question.

BY MR. SUGARMAN:

Q. Isn't sauce for the goose sauce for the gander? If Dr. Wilson is not in this field because he does not

draw definite conclusions from his work so far, isn't it true that you are not in the field because you don't draw definite conclusion from your work or non-work?

MR. WATSON: Objection, Your Honor. It is argumentative. It has been asked and answered.

MR. SUGARMAN: It is cross-examination.

JUDGE SMOLEN: Well, it is cross-examination but I am going to sustain the objection. Let's go on to the next one.

BY MR. SUGARMAN:

Q. Now, you recognized, as I remember your testimony -- well, maybe not. Let me ask you, since you are from New York do you recognize Dr. David O. Carpenter as an expert on a potential relationship between electromagnetic fields and public health?

MR. WATSON: Objection, Your Honor. Irrelevant. This doctor and this witness is not in a position to bless or not bless a particular individual as an expert in a particular field. It is a determination to be made if Dr. Carpenter appears, shows that he is qualified. Then the Judge may determine whether he is an expert and admit his testimony as expert testimony or not. It's irrelevant to hear Dr. Bockman's position on this issue one way or the other.

JUDGE SMOLEN: Go ahead, Mr. Sugarman.

MR. SUGARMAN: It's the most elementary form of cross-examination of an expert, to ask him if he recognizes an authority.

MR. WATSON: No, Your Honor, it is not. It is elementary to ask an expert if he recognize a learned treatise as being authoritative in a field, not to ask someone if he recognizes an individual who is doing research, whether he is an expert. That is done by the Court.

JUDGE SMOLEN: We are getting bogged down by semantics here. Perhaps Mr. Sugarman will rephrase the question.

BY MR. SUGARMAN:

Q. Do you recognize Carpenter in publications in the Forum for Applied Research and Public Policy as an authoritative source?

MR. WATSON: Objection, Your Honor. He has not cited an authority here.

MR. SUGARMAN: I cited Carpenter.

MR. WATSON: Cite the document.

MR. SUGARMAN: I don't have to -- that is outrageous. He can't tell me what to do, first of all. And secondly, his statement of the law is totally inaccurate.

JUDGE SMOLEN: You are asking a question and you

obviously have a reference.

MR. SUGARMAN: I do have a reference.

JUDGE SMOLEN: Well, cite the reference.

MR. SUGARMAN: Well, Your Honor, I want to -- if he does not recognize the article I still want to ask other questions.

JUDGE SMOLEN: You don't want to?

MR. SUGARMAN: I do. If he does not recognize this article. Maybe he hasn't read it.

JUDGE SMOLEN: Well, you haven't given him the title of the article.

MR. SUGARMAN: I just want to make it clear I am not agreeing with the objection.

JUDGE SMOLEN: I know, but I have sustained the objection.

MR. SUGARMAN: You have?

JUDGE SMOLEN: Yes, and I asked you to cite the article?

MR. SUGARMAN: Your Honor is not ruling, I hope, that I cannot ask him about the expert.

JUDGE SMOLEN: I didn't rule anything more than cite the article.

MR. SUGARMAN: Thank you. That is what I thought. Thank you.

BY MR. SUGARMAN:

Q. Are you familiar with an article entitled Powerlines and Cancer, Public Health and Policy Implications, by Carpenter and Ahlbom, in the Forum for Applied Research and Public Policy?

A. When was that published?

Q. 1988.

A. I don't recall it, no.

Q. Are you familiar with Dr. Carpenter?

A. I have come across his name. I believe he had some association with the New York panel report.

Q. Are you aware that Philadelphia Electric Company has cited him as an authority?

A. No, I am not aware of that.

MR. WATSON: On, Your Honor, just for the record, Philadelphia Electric Company has not necessarily blessed Dr. Carpenter as an authority or not. I think the record will speak for itself on that.

JUDGE SMOLEN: Let's go to the next question.

BY MR. SUGARMAN:

Q. Let me ask if you agree or disagree with this statement by Dr. Carpenter: "Magnetic fields may not be related to cancer but this possibility appears less likely with each additional study. Whether there is a relation, the problem requires a clear answer. There must be funds provided to mount additional research in

this area. The research should be conducted by the best available scientists and administered and interpreted by cancer and health authorities who have no relation to the financial interests of the utilities." Do you agree with that statement?

MR. WATSON: Objection, Your Honor. It is way beyond the copy of this witness' testimony.

JUDGE SMOLEN: Well, it was raised with other witnesses. There is some reference to it.

MR. WATSON: There may be some pieces in there but a lot of this is way beyond the scope. He is testifying as a --

MR. SUGARMAN: The witness testified there is no need for any additional studies in this area --

MR. WATSON: -- endocrinologist --

JUDGE SMOLEN: Wait. One voice.

MR. WATSON: In the area of endocrinology and immunology and has given his opinions. A number of those statements go way beyond it.

JUDGE SMOLEN: Let's take each sentence by itself and then we can make individual objections to the particular portions.

MR. WATSON: Could we have a reference and see the reference and show it to the witness?

MR. SUGARMAN: Yes. Forum for Applied Research and

Public Policy, Winter, 1988, pages 96 to 100.

JUDGE SMOLEN: Is there a copy available for the witness?

MR. SUGARMAN: I don't think I have more than one copy but I will be happy to give it to the witness. What I read was the last paragraph in full.

(Witness perusing document.)

MR. SUGARMAN: And, Your Honor, the PECo document that I was referring to...

JUDGE SMOLEN: Is there a question on the table?

MR. SUGARMAN: The question is does he agree or disagree with the statement.

JUDGE SMOLEN: Well, you were going to break it down into individual sentences. I think you read more than one sentence.

MR. SUGARMAN: Okay. The document I am referring to is a document entitled March, 1990, Update by the Electrical and Magnetic Field Briefing Committee of Philadelphia Electric Company, which states that, "A candid evaluation was made in a published report at the conclusion of the New York powerlines project in July, 1987, by Dr. David Carpenter, M.D., executive secretary of the project, which consisted of 16 research studies on electric and magnetic fields."

JUDGE SMOLEN: That is a document in which you

state that PECo refers to the document which is now before the witness?

MR. SUGARMAN: No, not to the document, Your Honor, but to the --

MR. WATSON: Then I object to that, Your Honor, and move that it be stricken.

JUDGE SMOLEN: To the what?

MR. SUGARMAN: To the authority itself. As I stated before, that PECo endorsed Dr. Carpenter. That is what I said before.

JUDGE SMOLEN: You are arguing a point, Mr. Sugarman. Why don't you ask the witness a question and let's see. If we have an objection I will rule. Let's not make argument at this time.

MR. SUGARMAN: Okay. I am asking the witness if he agrees with the statement.

JUDGE SMOLEN: Break it down.

BY MR. SUGARMAN:

Q. "Magnetic fields may not be related to cancer but this possibility appears less likely with each additional study." That is the first sentence.

JUDGE SMOLEN: And the question is do you agree with it.

A. I don't have an opinion on this. I mean, this is public policy. This is often going to be based on

epidemiology. I am not a specialist or an expert in those areas.

JUDGE SMOLEN: All right.

BY MR. SUGARMAN:

Q. Next sentence, "Whether there is a relation, the problem requires a clear answer."

A. The same answer.

Q. The next sentence, "There must be funds provided to mount additional research in this area."

A. The same answer.

Q. "The research should be conducted by the best available scientists and administered and interpreted by cancer and health authorities who have no relation to the financial interests of the utilities."

A. I cannot say. That is a public policy statement and it is not my area of expertise.

Q. Now, do I understand that your testimony is confined to the pathways of melatonin and calcium?

(Pause.)

A. Is that your question?

Q. Yes.

A. I am trying to address the issues with regards to endocrine and immune.

Q. Right. But do I understand that the pathways that you are dealing with are melatonin and calcium and

no others?

A. No. I thought I tried to discuss several pertinent areas of interest or issues that have been raised in this area.

Q. What other pathways did you discuss other than melatonin and calcium?

A. I didn't discuss pathways so much as systems. I tried to cover in the endocrine area. I tried to cover -- first, I tried to explain why I thought it was relevant to discuss the endocrine area, and then I tried to discuss four general categories, neuroendocrine function, research on endocrine gland function, research on biological rhythms, and research on reproduction and growth.

Q. You didn't discuss any particular pathways? Or do you agree that you did discuss melatonin and --

A. I think we are having --

MR. WATSON: Objection, Your Honor. Repetitious. The record speaks for itself. This is the witness' direct testimony and --

MR. SUGARMAN: I didn't understand the witness' answer.

MR. WATSON: -- it is limited to what it is limited to and it includes what it includes. And that can't change.

MR. SUGARMAN: I agree. I'm just trying to find out --

JUDGE SMOLEN: Wait a moment. I think there is a difficulty in language. You keep referring to pathways and the witness talks about something other than pathways.

MR. SUGARMAN: I agree. So I want to keep asking -- he keeps not answering my question.

JUDGE SMOLEN: Well, ask a question, then. We are sustaining the objection at this point. Ask the next question.

MR. SUGARMAN: Thank you.

BY MR. SUGARMAN:

Q. What pathways did you study?

A. What do you mean by pathways?

Q. The biological or chemical or physical functions whose alteration might contribute or not to the electromagnetic fields having an effect on the body.

A. Where such pathways had been examined, I examined such pathways in those categories of neuroendocrine function, endocrine gland function, biological rhythms, and reproduction and development.

Q. And what pathways were those?

MR. WATSON: Objection, Your Honor. Repetitious. He's already said --

MR. SUGARMAN: He still hasn't identified the pathways.

JUDGE SMOLEN: I am going to overrule the objection.

MR. WATSON: It is written right here.

JUDGE SMOLEN: That's all right. He can answer the question.

A. I believe there were -- by your definition of function, we looked at functional areas within each one of those broader categories.

BY MR. SUGARMAN:

Q. Right. And what pathways did you identify and consider?

A. We were here when we discussed calcium and calcium metabolism, both at macroscopic and microscopic level.

Q. Right. And I said calcium and I also said melatonin. And I asked if there were any others.

MR. WATSON: Objection, Your Honor. It's not a question. It's a statement.

MR. SUGARMAN: It's still a question. I' sorry. I'm just trying to move this along.

JUDGE SMOLEN: Are there any others. All right. Go ahead.

BY MR. SUGARMAN:

Q. I just want to know what were the other pathways if any besides those two?

A. I talked about reproduction.

Q. What pathway?

A. In those pathways I gave an indication that a sequence -- there was a necessary sequence of events which had to occur for successful fertilization and maintenance of the pregnancy as well as termination of the pregnancy to occur to result in a normal outcome.

In my report I also discussed feedback systems and pathways that are responsible for regulating endocrine gland and endocrine gland function. If that's what you're asking.

Q. Right. Thank you. That's what I wanted to know.

Did you discuss ion cyclotron resonance as a physical part of the interaction?

MR. WATSON: Objection, Your Honor. This has already been asked and answered.

JUDGE SMOLEN: It may have been asked by Ms. McCloskey.

MR. WATSON: No, no. He is asking him what did he include in his direct testimony and his direct testimony is already in the record and what he included is what he included. It is repetitious. Whatever is there is

there. If he has a question about it then that would be different.

JUDGE SMOLEN: Go ahead, Mr. Sugarman.

MR. SUGARMAN: One of the functions of cross-examination is to clarify what the witness has not covered. Very standard cross-examination of an expert.

MR. WATSON: Then ask whether he --

JUDGE SMOLEN: Overruled. You may answer.

THE WITNESS: Could I have the question again?

BY MR. SUGARMAN:

Q. Did you deal with either, implicitly or explicitly, ion cyclotron resonance as a physical part of the interaction?

A. I don't believe in this report I discuss cyclotron resonance.

Q. Now, are you familiar with the work of Grahm and Cohen?

A. Which work?

Q. Evidence of Changes in Heartbeat in Men Exposed to 60 Hertz Magnetic Fields for Short Periods of Time.

A. Where did that work appear?

Q. I don't believe it has been published. Are you familiar with it?

A. I don't know what you are talking about.

Q. You don't. Okay. You don't know what I am

talking about?

A. If it is an unpublished report how could I have seen it?

Q. Well, I didn't ask if you have seen it.

A. If you would like to show me the report.

JUDGE SMOLEN: We're just wasting time. If it is unpublished, I think the witness said he doesn't know.

BY MR. SUGARMAN:

Q. Well, I want to make sure. You don't know about it?

A. I'm not sure what the question is. I mean, I am familiar with the fact that Grahm -- and who is the other person?

Q. Cohen.

A. Cohen. Have done preliminary studies, but they are unpublished, unsubstantiated. I have, I think, in my review, because this question came up in prior sessions before Public Service Commissions in which I was given, you know, sort of an abstract of work in progress, I am vaguely familiar with the work. But it is unpublished, incomplete, nonsubstantiated work suggesting that there are changes in heart rate.

Q. And do you have any knowledge of who Grahm and Cohen are? That is, whether they are authorities in the field.

MR. WATSON: Your Honor, objection. It is beyond the scope.

JUDGE SMOLEN: Yes, this is beyond the scope.

MR. WATSON: This witness is not a cardiologist.

JUDGE SMOLEN: Sustained.

BY MR. SUGARMAN:

Q. Did you consider their work in formulating your opinion?

A. Their work I don't think really bears on the area in which I have provided my report or testimony.

Q. Very good.

Did you consider Liboff's work in formulating your opinion?

A. What do you mean by consider? What do you mean by consider Liboff's work?

Q. Well, are you familiar with Liboff's work?

MR. WATSON: Can we have a reference, Your Honor, to a particular study?

MR. SUGARMAN: Let's try Resonance Transport in Membranes, by Liboff, McCloud and Smith.

MR. WATSON: Date and journal?

MR. SUGARMAN: Electromagnetics in Biology and Medicine, edited by C. T. Brighton and S. R. Pollack in 1991.

A. Actually, I just got a copy of that book and I

have not read that particular article. Brighton, I believe, is head of orthopedics at the University of Pennsylvania. And there are a number of articles with regards to the possible role of certain electric and magnetic fields, pulse fields, in enhancing bone repair. So I have the book on my desk but I have not read that article.

BY MR. SUGARMAN:

Q. And how about an abstract entitled Human Lymphoma In Vitro Proliferation Increases Following K-Plus Cyclotron Resonance Magnetic Exposure?

A. I'm not familiar with that abstract.

Q. And how about -- we'll come back to Grahm and Cohen, an abstract entitled D-2-1 Human Cardiac Activity in 60 Hertz Magnetic Fields, by Grahm and Cohen, in a book entitled, quote, the Bioelectricmagnetic Society 13th Annual Meeting Abstract Book, 1991. Are you familiar with that?

A. I think I may have purused that article.

Q. So you are familiar with the published abstract by Grahm and Cohen?

A. I believe that I reviewed that in going through the BEMS abstract book, but I could not recall that study.

Q. And you have also seen some of Liboff's work

dealing with ion cyclotron resonance?

A. That is similar to your first question in which I asked for a reference.

Q. Well, at that time I was asked to identify which work. So I have identified two or three of his publications on that subject. And I am asking the question again now, are you familiar with his work in that area?

A. I have read some of that work.

Q. And have you considered any of those publications in formulating your opinion?

MR. WATSON: Your Honor, objection. This goes beyond the scope. The witness has cited the studies, he has testified in the field of endocrinology and immunology. We are off into ion cyclotron resonance. He has not come on as an expert in that field. He didn't testify to it in his direct examination. The cross here is way beyond the scope. It's not material to the issues here.

MR. SUGARMAN: He testified --

JUDGE SMOLEN: Let him finish.

MR. SUGARMAN: I'm sorry. I thought you were finished.

MR. WATSON: Therefore, for all those reasons I think the objection should be sustained on this.

MR. SUGARMAN: He testified, among other things, there is no -- page 27, line nine through 12 -- "my overall conclusion is that there is no basis to conclude that power frequency electric and/or magnetic fields have adverse effects on the health and function of the endocrine or immune systems." And my question is whether he is -- and before that he says that it does not have any cancer effect in terms of those systems. And so my question is in formulating that opinion did he consider data which other authorities have considered to be relevant to whether cancer in humans is formed, including in the endocrine and immune systems.

MR. WATSON: In the first place, Counsel is testifying.

JUDGE SMOLEN: Counsel is testifying. I understand that.

MR. WATSON: He has a number of statements that are not supported by any evidence in this record.

Secondly, there is --

MR. SUGARMAN: That's not true.

MR. WATSON: -- there is no reference in here, in these conclusions, to cancer. I think it is, as I stated it, on page 27, and I think Counsel just read it, it is limited to the health and function of the endocrine or immune systems. That is the scope of his direct

examination and that ought to be within some bounds at least the scope of the cross.

MR. SUGARMAN: But, you see, that depends on Mr. Watson's testimony that you can bind these subjects and that you don't consider if E/MF has having --

JUDGE SMOLEN: Here is what I'm going to do. For the moment I am going to overrule the objection but I am going to direct Counsel to confine this particular question as to whether or not this witness considered X, Y or Z study in reaching his conclusion number seven, number six, number five, et cetera, so that the question falls within the framework of this witness' expertise and within this witness' conclusions.

BY MR. SUGARMAN:

Q. In that case I will ask you did you consider Grahm and Cohen or Liboff in forming your conclusions one through seven or any of them?

A. Grahm and Cohen's work, as I understand it, from what I have been able to see of their work, which is limited, has to do with changes in heart rate, and I don't think that their experiments are relevant to the fields or pathways that I have discussed in my report or in my statements today.

I have read several of Dr. Liboff's publications and I think also that Dr. Liboff's theoretical work on

cyclotron resonance is not relevant to what I have discussed today or to my conclusions.

Q. Now, turning to page 20 of your testimony, you evaluate the work of Wertheimer, et al., and in answer to Ms. McCloskey you indicated that you did have an opinion as to the validity of the epidemiological study that they reported. Am I correctly --

MR. WATSON: Objection, Your Honor. That does not state the record correctly.

MR. SUGARMAN: What?

JUDGE SMOLEN: I didn't hear the basis for the objection.

MR. WATSON: I said I object, it does not state the record correctly. The record reflects, I think, that the witness referred on lines 24 through 32 to somebody else's criticism and then on lines 34 through 37 he did not make a criticism of the epidemiological design or conduct of the experiment but pointed he out that the statements were not persuasive in light of the animal research previously discussed in his testimony. That is what the record accurately reflects.

JUDGE SMOLEN: Now, each one has their own view of the record. What is the question?

BY MR. SUGARMAN:

Q. The question is do you have an opinion as to

the validity of the Wertheimer-Leeper conclusion that there is a significant association between exposure to electrical magnetic fields and reproductive success?

A. Yes, I have an opinion.

Q. And is your opinion based on criticism of their epidemiological quality, or is it based on comparing the epidemiology to the animal research or something else?

A. All of the above.

Q. So you do have an opinion and do express an opinion and do intend to express an opinion about their epidemiology?

A. I have an opinion, yes.

Q. And do you feel qualified to have an opinion in that area?

A. I do not feel qualified to express an opinion as an expert in epidemiological.

Q. Then on what do you base your opinion?

A. I base my opinion on my own personal scientific evaluation as a person who often has to read epidemiologic studies and often come to some opinion about those studies.

Q. Do you use epidemiology to interact with your animal research and clinical research? When I say use it, I don't mean do it, but use epidemiological studies as part of forming an overall conclusion along with the

other work?

A. With regards to animal studies?

Q. No. I mean with regard to overall conclusions.

A. But you had the word animal in there.

Q. I will take the word animal out. I was saying with everything else that you do, whether it is clinical, whether it is animal or whatever. Do you include epidemiology in forming overall conclusions? And if the answer is partly yes and partly no, please free feel to say so.

A. The answer is partly yes and partly no.

Q. Okay. Could you describe the extent to which you use epidemiology and the extent to which you don't? Or the areas that you use it and the areas that you don't.

A. The reason I corrected you when you had the word animal in there is that epidemiology clearly is about epidemics and the field in general as I understood it, as I learned it in medical school, had to do with usually epidemics in man.

We use many of the methodologies that are used in epidemiology all the time. That is to say the statistical methods of analyses are used all the time, as was evidenced in the studies that I have quoted, but also the ones that Ms. McCloskey cited. We always use

statistical analysis to support or given some validity measurement to the experiments that we are doing and the results. So we use some of the same methodologies that are being used by epidemiology.

We are influenced, I am influenced, as a practicing clinician in endocrinology by epidemiological studies. One of the big controversies in medicine today is whether or not there is a cancer risk from the use of estrogen in women who are post-menopause, and that is really one of the most interesting debates that is going on currently in the medical literature, as to whether there is a significant risk of breast cancer. And there are several epidemiological studies, very well conducted, that come down in absolutely on opposite sides of the issue. So I as a practicing clinician must read and evaluate such epidemiological studies and it certainly influences the way I practice.

Q. All right.

A. It also influences the kinds of research that I do because it impacts on what I am trying to do. I am trying to make bones stronger in menopausal women. Therefore, to design my studies I need to take into account the fact that this is a major issue and it impacts on what I am clinically ultimately trying to achieve.

Q. Thank you.

Have you formed an opinion as to whether the epidemiological literature as a whole supports, refutes or is unclear relating to the relationship between electromagnetic fields and the subjects on which you testified, namely, the endocrine system and the immune system?

A. I have trouble answering that kind of question because it just covered everything and I just don't know what it is that you really are asking. I wonder if you could sort of --

Q. Well, are you familiar with the epidemiological studies that conclude that there is a statistically significant association or increased mortality in various health areas associated with exposure to electromagnetic fields?

MR. WATSON: Objection, Your Honor. It assumes facts not in evidence and not established.

MR. SUGARMAN: They are in evidence.

JUDGE SMOLEN: Well, you believe they are in evidence. He believes they are not in evidence.

MR. SUGARMAN: Your Honor, I refer to the testimony of Janes and I refer to the testimony of Liboff. They are in evidence. He may not agree with them, but they are in evidence.

MR. WATSON: Then he can ask him if he agrees with the statements.

JUDGE SMOLEN: I'm not sure he agrees with -- let's have the question again.

BY MR. SUGARMAN:

Q. Are you familiar with any studies -- I will take any assumption out of the question here -- are you familiar with any studies that show positive, that is, statistically significant increased mortality in the broadest sense of the word, effect associated with exposure to electromagnetic fields?

A. I am familiar with epidemiological studies that purport to show such changes. In other words, and I would qualify that, because the Wertheimer studies you have to appreciate do not make the association with electric and magnetic fields because they do not measure electric and magnetic fields, but, rather, a surrogate measurement: the size of a wire coming in to the household. This is, again, not a transmission line and it isn't a measurement of field.

There is another study -- yes, I am familiar with another study that purports to show an increased incidence of a different kind of cancer presumably associated with higher morbidity and morality, in which field measurements were made, and that is the study by

Tomenius. Now, in that study there is actually a decreased risk, if you wish in your terms, a negative effect, for persons that are closer to the line than at a specific distance from the line.

So, yes, I have read --

Q. Do you --

A. Can I finish?

Q. I'm sorry. Go ahead. I keep thinking you are finished.

A. Yes, I have read -- that time I was in mid-sentence. Give me a break.

I have read these studies and I have formed an opinion about those specific studies. But, again, you know, it is not my area of expertise but you can't read these studies without having an opinion.

Q. Are you familiar with the 1989 study entitled Cancer Incidence in New York Telephone Workers by Matanoski, Elliot and Breysse of Johns Hopkins School of Hygiene and Public Health?

MR. WATSON: Objection, Your Honor, beyond the scope. This witness has said clearly, yes, he has read some epidemiology studies because they are available in the literature. But he is not an expert in epidemiology and he didn't testify to epidemiology.

JUDGE SMOLEN: I understand. And he has not been

asked whether he agrees with it, but are you familiar with it. I'm going to allow him to answer yes or no whether he's familiar with that study.

A. I don't know if I have seen the report that you are referring to, but I have seen abstracts and heard reports of Matanoski's work, yes.

BY MR. SUGARMAN:

Q. Do you have any opinion about it?

MR. WATSON: Objection, Your Honor.

JUDGE SMOLEN: Now I am going to sustain that.

BY MR. SUGARMAN:

Q. Let me ask you this -- let me rephrase the question, then. In reaching any of your conclusions numbered one to seven on pages 26 and 27 of your testimony did you rely on your conclusions relating to epidemiological studies in whole or in part?

A. I would say that I did not. As I indicated in my initial answers to Ms. McCloskey, I based my opinion in the endocrine and immunological fields on the primary literature in those fields.

Q. But didn't you just testify a few minutes ago that in your work you consider epidemiology too?

MR. WATSON: Objection, Your Honor, it is argumentative. And secondly, he testified that in his work. He was talking about the work he does in his lab,

not his testimony.

JUDGE SMOLEN: Sustained.

BY MR. SUGARMAN:

Q. Are you saying this testimony that you gave here is somehow different than your normal work in forming conclusions?

A. No. That is not what I am saying.

Q. I didn't think so. So therefore why didn't you consider epidemiology in your conclusions on pages 26 and 27?

A. Because in this report I am testifying specifically with regards to the literature in endocrinology and immunology. And I think that the literature supports -- the literature that I have reviewed and have cited here sufficiently supports -- is sufficient and all that is necessary to support my conclusions one through seven.

Now, in the larger scale of life, I have read these other reports.

Q. Well, let me ask it this way: if there were epidemiological studies that you regarded as high quality which concluded that there is a statistically significant association between E/MF exposure and effects on the endocrine system or the immune system would you feel obliged to consider them in reaching your conclusions?

MR. WATSON: Objection, Your Honor, it is speculation.

MR. SUGARMAN: It's a hypothetical to an expert.

MR. WATSON: It calls for the witness to speculate that if there were something that existed and it had certain findings what would the circumstances be and what would his reaction be in the future.

JUDGE SMOLEN: Sustained. I'm going to sustain the objection.

BY MR. SUGARMAN:

Q. Are you aware of any epidemiological studies other than Wertheimer purporting to find effects on reproduction and/or the endocrine system, neuroendocrine system -- I'm sorry -- the endocrine system associated with exposure to E/MF?

A. If I understand the question, am I familiar with epidemiologic studies that purport to show effects of E/MF on the endocrine and immune system?

Q. Right, other than the Wertheimer study and Tomenius study. Any others?

A. Again, you are mixing things. The bulk of Wertheimer's studies and Tomenius' publications deal only, as I understand them, with the issue of cancer and cancer incidence. Dr. Wertheimer has published studies with regards to fetal loss. If you want, that is

potentially within the area of reproduction. And Mr. Schnorr, as was cited, has published a study with regard to abortion, spontaneous abortion. Those, I believe, are the only two studies that I am familiar with.

Q. Now, do you feel that, or in your opinion, epidemiological studies purporting to show other types of effects other than on the endocrine and immune systems from E/MF, would they be something that you would have to consider in forming your opinion relating to the effect of E/MF on endocrine and immune, or could you safely disregard them?

A. I would broaden your statement. I mean, I would consider any study in any field that might impact on the endocrine and immune system. The answer would be yes, I should try to consider every study.

I will point out that epidemiologic studies can at their best -- at their best -- show an association but never truly show a cause. And that is why -- but epidemiological studies very often serve a very valuable function of helping us direct our effort, which I guess in some way is something you are implying, to look at a particular area. But when we go to look at that area we basically need to take the problem and dissect it much more closely to look at the mechanism. Epidemiology cannot do that.

Q. I don't quarrel with that. It wouldn't matter if I did, because you are the witness. But my question to you is do you have an opinion as to whether the epidemiological literature on the effects of E/MF on any of the bodily symptoms needs to be factored in to your conclusions as expressed on pages 26 and 27 of your testimony?

MR. WATSON: Objection, Your Honor, asked and answered. We have already done this three times.

MR. SUGARMAN: What does Mr. Watson think the answer was?

JUDGE SMOLEN: No, no. He says it was asked and answered before.

MR. SUGARMAN: I'm saying it wasn't there. I didn't hear any answer.

JUDGE SMOLEN: I am going to let the witness answer. I will overrule. You can answer.

A. As I understand the question, I think where epidemiological studies may have given some relevant information or indication or a signal that an area needed attention, I thought I quoted those epidemiologic studies. So clearly in a sense I considered them. In other words, in here I discussed both -- I didn't discuss, but I mentioned both the Wertheimer and the Schnor study. So clearly, I think I considered them.

Q. Even though they didn't relate to the endocrine or immune systems?

A. You are shifting the ground.

Q. See, what I was trying to find out was whether you have an opinion as to whether epidemiological studies that don't themselves deal with the immune or endocrine systems need to be considered.

MR. WATSON: Your Honor --

JUDGE SMOLEN: The witness has answered that and I think his answer said that even in a broader sense -- I think he did answer that.

MR. SUGARMAN: Well, I think his answer -- the reason I asked the question was I thought his answer had implicit in it that somebody, himself or whoever, had to decide in each case whether the studies were relevant to the specific issue. So I am asking if he has made such a decision with respect to epidemiological studies, not about the endocrine or immune system, whether they are in fact relevant to forming his opinion on pages 26 and 27.

JUDGE SMOLEN: Well, that may be the second or third time you asked the same question. We are just wasting a lot of time.

MR. SUGARMAN: I don't think so.

MR. WATSON: I think it has been asked and answered. Secondly, it is clear that part of his

testimony about the endocrine system, subpart D, deals with reproduction and development. He has pointed out that in that area where there was an epidemiology study relevant to reproduction and development, which he is discussing in the context of the immune system and endocrine system, that he referred to those. So he has answered it and done it and it is set forth on page 20.

JUDGE SMOLEN: I am going to sustain the objection. Go to the next question.

BY MR. SUGARMAN:

Q. Just so it is clear, are you saying that reproduction is part of the endocrine system considerations?

A. I think much of reproduction is dependent on the endocrine system.

Q. Now, you testified as to the Wilson study that he exposed the rats for three weeks and then the change dropped off after the three weeks and you said that, quote -- and I quoted your testimony as best I could in cross-examination -- that would argue that the effects are clearly not permanent, that is, the effects of the exposure to the electromagnetic fields.

A. Correct.

Q. Now, in looking at the transmission line that is at issue here, or the type of exposure that is

involved in that, do you understand that the exposure here would not be short-term but would be chronic?

A. Chronic exposure to whom?

Q. To the individuals living near the transmission line?

A. Well, I am not an expert on knowing how much exposure individuals near the line would have, but I could virtually guarantee that the exposure would be far below the levels that were used in Dr. Wilson's experiments.

Q. Without quarreling with that, or without questioning you about that, do you agree, however, that it would be chronic?

A. The exposure would be chronic?

MR. SUGARMAN: Right. Thank you. I don't have any further questions.

JUDGE SMOLEN: Well, I think -- I don't know that that last response was an answer or if it was --

THE WITNESS: That was a question.

JUDGE SMOLEN: -- a question.

MR. SUGARMAN: I'm sorry.

JUDGE SMOLEN: He was repeating your question.

MR. SUGARMAN: I'm sorry.

BY MR. SUGARMAN:

Q. Do you agree that the exposure would be

chronic?

A. I have no way of knowing. I mean, it strikes me that people come and go near the line.

MR. SUGARMAN: I have no further questions anyway. Thank you.

JUDGE SMOLEN: Do you want to break at this time before redirect? If there is any redirect.

MR. WATSON: We have no redirect, Your Honor.

JUDGE SMOLEN: Anything further of the witness?

MR. SUGARMAN: Nothing further of the witness.

JUDGE SMOLEN: Then the witness is excused. Thank you very much, sir, for appearing and testifying today.

(Witness excused.)

MR. WATSON: Your Honor, we do not have Dr. Cole at the moment but we will have him first thing tomorrow morning.

MR. SUGARMAN: How about the other one?

JUDGE SMOLEN: That is for Friday.

MR. WATSON: We are following the schedule we gave you exactly.

MR. SUGARMAN: Which is?

JUDGE SMOLEN: It's in the letter of the 15th.

MR. SUGARMAN: I have not seen the letter of the 15th. .

MR. SMITH: Your office called us and told us your

fax machine was broken but I gave the information orally to Mrs. Turner on last Thursday.

JUDGE SMOLEN: There is an error in the letter, as you know.

MR. SMITH: And I followed up in the letter on Friday.

JUDGE SMOLEN: The letter refers to Tuesday, November 20th. The next to the last line. That should have been the 19th, obviously.

MR. WATSON: The listing up above is right. November 19th. We made a mistake in the next part.

JUDGE SMOLEN: So we are scheduled, then, for tomorrow at 10:00 a.m. for Dr. Cole.

MR. WATSON: Yes, Your Honor. And then Friday --

JUDGE SMOLEN: And Friday for Dr. Gelmann.

MR. WATSON: -- for Dr. Gelmann.

MR. SUGARMAN: Your Honor, I have one other thing on the record I guess I ought to say. The Commonwealth Court rescheduled an argument that I have to take place tomorrow sometime. What I am planning to do is to be here and follow the list, unless it is first thing in the morning. Then I'll go there and then I'll come here. I would not think it necessary to suspend this hearing or to request that you suspend, because Ms. McCloskey has questions and whatever works out I will work around.

JUDGE SMOLEN: Let me ask, where is Dr. Cole, his location?

MR. WATSON: He's from Alabama.

JUDGE SMOLEN: All right. Then we will just --

MR. SUGARMAN: I don't know where I am on the list, Your Honor, but I will try to track it and work around it.

JUDGE SMOLEN: In your preparation do you have any idea as to how long your cross-examination would be?

MR. SUGARMAN: Well, it partly depends on Ms. McCloskey.

JUDGE SMOLEN: Well, we may want to go out of order and let you go before Ms. McCloskey.

MR. SUGARMAN: I would say between an hour and two hours.

JUDGE SMOLEN: Maybe we ought to start that way --

MR. SUGARMAN: Unless I am first on the list.

JUDGE SMOLEN: Then you can come back in the afternoon.

MS. McCLOSKEY: Ms. Dusman will be doing the cross of Dr. Cole, and I think we are anticipating about 45 minutes, which means we probably won't use the whole day and we can be flexible.

JUDGE SMOLEN: Let's play it by ear, then, and we'll see what happens. If you're first on the list then

we will have no alternative but to let the OCA go.

MR. SUGARMAN: Again, Your Honor, I think I can proceed independently of them and if I get into any repetition I will bear that burden.

JUDGE SMOLEN: Very good. Today's hearing is adjourned until tomorrow morning. Thank you very much.

(Whereupon, at 12:20 p.m., the hearing was adjourned, to be reconvened at 10:00 a.m. on Wednesday, November 20, 1991, in Philadelphia, Pennsylvania.)

C E R T I F I C A T E

I hereby certify, as the stenographic reporter, that the foregoing proceedings were taken stenographically by me and thereafter reduced to typewriting by me or under my direction; and that this transcript is a true and accurate record to the best of my ability.

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By: Robert J. Stonaker

Robert J. Stonaker

Philadelphia Electric Company Rebuttal Statement No. 1

11/13/91 Phila. PD.
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**BEFORE THE**
**PENNSYLVANIA PUBLIC UTILITY COMMISSION**



**REBUTTAL TESTIMONY**
**OF**
**DR. RICHARD BOCKMAN**

**ON BEHALF OF**
**PHILADELPHIA ELECTRIC COMPANY**



**November 1991**

# REBUTTAL TESTIMONY OF RICHARD S. BOCKMAN

## I. Background and Qualifications

Q Please state your name and business address.

A. Richard S. Bockman, 520 East 72nd Street, Apartment Lobby S, New York, New York, 10021.

Q What is your occupation?

A. I am a medical doctor, a researcher and a teacher in the fields of endocrinology and immunology.

Q What is endocrinology?

A. Endocrinology is a subspecialty of Internal Medicine and involves the study and treatment of hormonal and metabolic disorders. Such disorders are associated with abnormalities in body chemistry and with disordered physiological function. A few examples of the types of disorders that I study and treat as an endocrinologist are thyroid diseases (e.g., goiters and certain forms of cancer), neuroendocrine-pituitary dysfunction (e.g., growth disorders), metabolic disorders (e.g., diabetes, osteoporosis) and certain disorders of sexual development and function.

Q What is immunology?

A. Immunology is a medical subspecialty which involves the study and treatment of disorders to the body's defense system against infection and disease.

Q Where are you employed?

A. At the Hospital for Special Surgery, which is a part of the Cornell University Medical College.

Q What positions do you hold at the Hospital for Special Surgery?

A. I am the Head of the Endocrine Service and the Endocrine Bone Service at the Hospital for Special Surgery, where I am also an Attending Physician with patient care responsibilities. I currently spend the majority of my time engaged in clinical and laboratory studies to determine the mechanisms by which the endocrine system regulates calcium metabolism. I also hold an academic title as Professor of Mediciney at Cornell University Medical College, where I teach the practice of Internal Medicine and Endocrinology to interns, residents and medical fellows. In addition, I hold an Adjunct appointment at the Memorial Sloan-Kettering Cancer Center.

Q Please describe your educational background.

A. I received my undergraduate degree in biology from Johns Hopkins University. I then attended Yale University Medical School, where I received my M.D. degree in 1967. After completing my M.D., I earned a Ph.D. in biochemistry from Rockefeller University in 1971.

Q Were you awarded any research fellowships while at Rockefeller University?

A. Yes, I was awarded a research fellowship by the National Institutes of Health for graduate research in biological chemistry.

Q What did that research involve?

A. The use of magnetic resonance spectroscopy to study the effects of very high intensity magnetic fields (10,000,000 - 15,000,000 mG) on molecules in solution.

Q Could you explain what is meant by magnetic resonance?

A. Magnetic resonance is a research tool that uses very high intensity magnetic fields and pulsed radio fields to study how molecules interact with one another. The technique has now been widely adopted as a medical diagnostic tool.

Q Did you receive any fellowships as part of your medical training at Yale University Medical School?

A. Yes, I received a fellowship to study immunology for a year in Paris at the Centre de Recherches Allergiques et Immunologiques. I studied with Dr. Bernard Halpern, one of the world's leading immunologists.

Q Did you continue your medical training after completing this research and receiving your Ph.D. degree?

A. Yes. I undertook my internship and residency in Internal Medicine at New York University Medical College. I then was awarded a fellowship in Internal Medicine at the New York Hospital and Cornell Medical College. At the same time, I began working at Memorial Sloan Kettering Cancer Research Institute as an Associate Attending Physician and an Assistant Professor of Biochemistry.

Q What is Memorial Sloan Kettering Institute for Cancer Research?

A. Memorial Sloan Kettering is one of the leading cancer research centers in the United States.

Q Are you licensed to practice medicine?

A. Yes, in the state of New York.

Q Do you have a medical specialty?

A. I am a Board-certified specialist in Internal Medicine.

Q Do you have a subspecialty as well?

A. Yes, I am also Board-eligible in the subspecialty of Endocrinology.

Q Are you a member of any medical societies?

A. Yes, I am a member of the Endocrine Society, the American Society for Clinical Investigation, the American Federation for Clinical Research, and the American Society for Bone and Mineral Research.

Q In the course of your career, have you published the results of your own research?

A. Yes. I have published over 70 scientific articles reporting the results of my own research in the fields of endocrinology and immunology.

Q What are some of the journals in which your articles have been published?

A. The journals in which my research has appeared include the *Journal of Immunology, Clinical Immunology and Immunopathology, Cancer,* the *Annals of Internal Medicine*, the *Journal of Clinical Investigation*, the *Journal of Experimental Biology*, the *Journal of Cancer Research*, and the *Journal of Clinical Oncology.*

Q Have you acted as a peer-reviewer for any scientific or medical journals?

A. Yes. For example, I have acted as a peer-reviewer for *Endocrinology*, the *Proceedings of the National Academy of Sciences*, the *Annals of*

*Internal Medicine*, *Cancer Research*, and the *Journal of Clinical Investigation*, among others.

Q What were you asked to do in this proceeding?

A. I was asked to conduct an independepent review of the literature related to extremely-low frequency ("ELF") electric and magnetic fields as they relate to endocrinology and immunology, particularly focusing on power frequency (60 Hertz) electric and magnetic fields ("EMF"), and to state my opinions and conclusions about whether power frequency electric and/or magnetic fields cause adverse effects on human endocrine or immune system function. I was also asked to state my opinion as to whether the fields associated with the Woodbourne-Heaton 230 kv line would cause any adverse effects on human endocrine or immune system function. To conduct this research over 200 primary research papers and many reviews, summaries and reports on the topic were examined.

## II. Background on the Endocrine System

Q What is the endocrine system?

A. The endocrine system refers to the tissues and organs in the body that produce or respond to hormones.

Q What can research on the endocrine system tell us about human health?

A. Endocrine-regulated systems are exquisitely balanced. When complex biologic processes like conception or fetal growth occur, they are regulated by an elaborate temporal sequence of hormone secretions under control of the endocrine system. A biologically significant disturbance to any component of the endocrine system would have deleterious biological consequences that would be obvious and measurable. Hence, endocrine function is a very

sensitive measure of the possible biologic effects of an external stimulus, such as electric and magnetic fields.

## III. EMF Research on the Endocrine System

Q Has research been conducted on EMF and the endocrine system?

A. An enormous amount of research has been conducted that is relevant to evaluating whether there are endocrine system effects from exposure to electric and magnetic fields. I have divided this research into four general categories: research relevant to the neuroendocrine function; research on endocrine gland functions; research on biological rhythms; and research on reproduction and growth.

### A. EMF Research on the Neuroendocrine System

Q What is the neuroendocrine system?

A. Precise coordination of biologic activities is essential to a living organism. Regulation of its internal environment requires a highly controlled system of signals. These signals frequently are given in the form of protein molecules, known as hormones. Certain hormones are released from within the brain, which then regulate the production of other hormones from the pituitary gland, a small gland at the base of the brain. The hormone-producing tissues of the brain and pituitary gland comprise the neuroendocrine component of the endocrine system.

Q What is the role of the pituitary gland in the neuroendocrine system?

A. The pituitary gland has been called the "master gland," because it produces a variety of hormones that regulate many different organs in the body. Since the pituitary is itself regulated by hormones from higher brain centers, it is the neuroendocrine system as a whole that affects control of the peripheral endocrine tissues. Many of the

hormones produced in the peripheral tissues circulate in the body and in turn regulate certain functions of the neuroendocrine system. This complex feedback loop is a common feature of the endocrine system. Endocrine feedback systems often function very much the way a thermostat regulates a furnace to keep household temperature constant.

Q What occurs in the neuroendocrine system when a human is exposed to an external stimulus?

A. With any external stimulus, such as sound or light or heat, the human body responds to the stimulus by activating thousands of nerve cells which, in turn, can trigger neurochemical releases affecting the body's endocrine system. This is a normal physiologic response and does not imply that injury to the responding neurons is occurring or that other potentially adverse effects will result.

Q What kinds of research have been conducted on EMF and neuroendocrine function?

A. With respect to power frequency fields, the neuroendocrine research has been conducted at several levels. First, there have been a number of in vivo (i.e., whole animal) studies to assess whether and under what conditions electric and/or magnetic fields are the sort of stimuli that can be perceived by the human body. This is important because, without perception, an external stimulus will not cause neuroendocrine system responses. Second, a number of studies have examined animal behavioral response (i.e., "arousal" response) to electric fields of sufficient strength to be perceived by the animals. A third area of research has investigated whether animals exposed to electric and/or magnetic fields experience neurochemical changes that might be associated with adverse health effects. In addition, there is a fourth area of related research dealing with calcium metabolism that warrants consideration and should be addressed separately.

## Research on Perception

Q Please describe the research on perception of EMF.

A. The research results show that people and animals first become aware of EMF through external cues. For example, they can hear the mechanical switching as the experimental field is turned on or they may receive an auditory cue to the field's presence because of the snapping sound a high voltage line may make. Another external cue to the presence of EMF may be the slight movement of body hair and tickling sensation that is associated with hair vibration. In an alternating electric field of adequate magnitude, body hair will vibrate slightly as the field and surface charges on the hair interact.

The force and frequency of hair vibration -- and hence the person or animal's ability to perceive the field -- correlates directly with the strength and frequency of the AC electric field. Studies show that by means of body-hair vibration, most rats are able to perceive 60 Hz fields of 4-10 kV/m (Stern et al. 1983, Sagan et al. 1987), while the threshold appears to be higher for mice and other animals such as swine (Graves 1979, Rosenberg et al. 1981 & 1983, Kaune 1978). In man, fields of 7 kV/m will cause some hand and arm hair to vibrate, while approximately 23 kV/M is needed to activate head hair (Deno & Zafanella 1982). Humidity can raise these thresholds such that the field levels required for perceiving hair movement can be as high as 30 - 65 kV/m (Kato et al. 1989).

At the present time, there is no data to support the concept that people can perceive electric or magnetic fields from electric transmission lines when no external physical cue such as sound or hair movement is present (Hauf 1982). With respect to magnetic fields, there is no evidence to date to indicate that humans can perceive power frequency magnetic fields at levels that far exceed the levels associated with transmission lines.

Q What are the implications of perceiving an electric or magnetic field?

A. One effect that can occur as a result of perception is the arousal response that I mentioned earlier in my testimony.

**Research on the Arousal Response**

Q What is the "arousal response"?

A. In most animals, initial exposure to any new stimulus, including EMF at levels significantly above the threshold for perception, results in "arousal." This arousal results in transient, measurable changes in the levels of certain hormone. Arousal is a normal response to a newly perceived stimulus. This arousal response is usually a short term response that lasts only seconds or minutes and, if the stimulus is not noxious, it has no adverse effects.

Q What are the results of the EMF studies that are relevant to the arousal response?

A. In most EMF studies with fields at levels significantly above the threshold for perception, there is an arousal response. After this initial response, the test animals quickly grow used (i.e., habituate) to the fields and all endocrine parameters that were being measured rapidly return to their basal state even though the field is maintained.

Q Could you give some specific examples of research results in this area?

A. Rosenberg et al. (1981) and Hackman & Graves (1981) have shown that animals rapidly habituate to field strengths that are significantly above their threshold for perception. In the Rosenberg study, mice exposed to a 75 kV/m field initially displayed greater activity during what was normally their diurnal period of rest or

sleep. However, this response soon disappeared. Subsequent reapplication of the field produced no discernible reaction at all. Even the initial arousal response could not be elicited reliably below a field strength of 50 kV/m.

When field strength increases, test animals demonstrate a variety of responses. For example, rats were reported to show an aversion to electric fields of 75 kV/m. Closer study has revealed that they avoided these higher fields during their inactive (sleep) periods, but continued to freely explore the high field area when they were active (Hjeresen 1980). Even with fields strengths of 160 kV/m, mice did not appear markedly disturbed. At 200 kV/m, mice clearly were highly aroused. It should be noted at electric fields greater than 100 kV/m, the animals will frequently experience microshocks (similar to carpet shocks) as they move about their cages. This situation was often the case in early EMF studies in which stringent grounding conditions were seldom maintained. Microshocks are very strong stimuli and they are artifacts of the test situation. Humans near transmission lines are not subjected to fields of this magnitude and do not experience microshocks as a consequence.

## Research on Neurochemicals

Q You stated that there is a third area of research related to the neuroendocrine system that has investigated whether animals exposed to electric and/or magnetic fields experience neurochemical changes that might be associated with adverse health effects. Please describe that research.

A. To date, there is little to suggest that field strengths well above an animal's perception threshold cause any abnormality in neurological function or behavior. Subtle changes in blood or brain levels of neurotransmitter substances or of enzymes regulating neurotransmitter levels have been observed in some studies (Carmaciu, et al. 1977, Fisher, Underman & Knapp 1978, Seegal et al. 1989). These changes in neurotransmitter levels probably reflect the fact that the animals perceive the field and are demonstrating a normal recognition response to a newly perceived external stimulus.

Moreover, in these studies no abnormal neurological or behavioral correlates were observed. In addition, the reported responses are within the normal range of experience for the test animals and cannot be considered a health risk.

This same conclusion was reached following a major independent review of the EMF research conducted by the National Academy of Sciences. Indeed, even with 50 Hz magnetic field exposures as high as 50,000 mG, no changes in cerebral blood flow or brain wave activity (EEG) were observed in humans (Bartko et al. 1988). In sum, the studies of neurotransmitter levels have not demonstrated any deleterious effects exposure to power frequency electric or magnetic fields.

**Research on Calcium Metabolism**

Q You also stated that there is a fourth area of research, related to the neuroendocrine research, that deals with calcium metabolism. Please describe what you mean by "calcium metabolism."

A. Calcium acts as a signal molecule between external stimuli and the inner functioning (metabolism) of cells. As such, calcium has an important role in the function of the endocrine system.

Q Do you have experience evaluating research on calcium metabolism?

A. Yes. As I stated earlier in my testimony, I currently spend the majority of my time engaged in clinical and laboratory studies to determine the mechanisms by which the endocrine system regulates calcium metabolism. In addition, before my current position I was head of the Laboratory of Calcium Metabolism at Memorial Sloan-Kettering Institute for 14 years.

Q What kinds of research have been conducted on EMF and calcium metabolism?

A. The EMF research on calcium metabolism typically has involved naked cells and/or tissue in culture in petri dishes. (E.g., Adey and Bawin, 1982, Albert, 1980, 1985, Bawin and Adey, 1975, 1976, 1978, Blackman, 1979, 1980, 1981, 1982, 1985, 1989, 1990). The principal objective of this research has been to investigate whether EMF exposure induces significant changes in calcium metabolism in isolated cells and tissues. To the extent that such changes occur in vitro, the next inquiry would be whether these changes are observed in whole animals and whether such changes affect endocrine system function or result in potentially adverse effects.

Q. Please describe the in vitro research on EMF and calcium metabolism.

A. One of the categories of in vitro calcium research is known as the "calcium efflux" research. Many of the calcium efflux studies that have been conducted to date used amplitude-modulated radiofrequency fields (i.e., 147,000,000 - 150,000,000 Hz, with the field modulated at 6 - 16 Hz). These fields differ significantly from the 60 Hz fields generated by transmission lines and other sources of 60 Hz electricity. In addition, the results of these radiofrequency field studies are inconsistent in that they report conflicting changes in calcium efflux (i.e., movement into or out of tissues) from study to study. With respect to 60 Hz fields, the available data indicate that such fields do not affect calcium metabolism in living organisms.

Q What is the significance of the calcium efflux studies?

A. In assessing the potential significance of the calcium efflux studies, one needs to consider the parameter of calcium movement that was considered in the studies. Calcium is found within cells, within cell membranes, and attached to cell membranes. Not all of this calcium is biologically active or significant. The question, therefore, is whether the calcium efflux studies have identified any

changes in biologically active calcium (e.g., calcium in the cytoplasm of cells).

Viewed from this perspective, it should be noted that the calcium efflux studies have examined calcium movement in non-functional, dying tissue, which in and of itself raises questions about the biological significance of the conflicting results because we can expect to see changes in calcium movement in dying tissue. More importantly, however, there is no evidence in the calcium efflux studies that EMF exposure has an effect on any of the cell's calcium-dependent processes. In fact, a study by Parkinson and Hanks (1989), showed that when key calcium parameters are considered (i.e, cytoplasmic calcium levels), EMF had no measurable effect on the biologically active calcium in cells. Other investigators using techniques capable of measuring the movement of individual calcium ions across the cell membrane recently reported that they found no EMF-induced changes in calcium movement (Hojevik et al., 1991).

Q Does EMF cause changes in biologically important calcium in whole animals?

A. No. If biologically important calcium were being disturbed, one would expect to see functional changes in animals exposed to EMF. The findings by Parkinson and Hanks are consistent with the previous research results of several primary investigators in this area who have found no functional changes in cells or in intact animals during exposure to EMF.

Q What do you conclude with regard to the research on EMF and calcium metabolism?

A. While the conflicting results of the calcium efflux studies are of scientific interest, there is no indication that 60 Hertz electric and/or magnetic fields modulate cell function or endocrine system function by altering calcium metabolism.

### Conclusion Regarding the Neuroendocrine System

Q What do you conclude with regard to the research on EMF and the neuroendocrine system?

A. The experimental data show that animals, including humans, can perceive EMF through external cues such as auditory noise or, at sufficiently high electric field levels, through hair movement. Perception can result in a measurable arousal response similar to the arousal response found in response to everyday stimuli. This response is transient, normal, and does not indicate adverse health consequences. Some neurotransmitter levels can show subtle change after EMF exposure. These changes also are consistent with a normal recognition response to the perceived stimulus. The research on calcium metabolism does not indicate change in biologically important calcium. In sum, the research indicates that exposure to EMF can cause subtle, transient biological changes in the neuroendocrine system. These biological changes are consistent with a normal perception or recognition response and do not indicate that exposure to EMF is harmful.

## B. EMF Research Regarding Endocrine Gland Function

Q The second major area of research you identified is research on endocrine gland function. Please describe the importance of endocrine gland function.

A. Many powerful hormones are produced by the endocrine glands, including glucocorticoids (such as corticosterone, a hormone produced by the adrenal glands and essential for life), epinephrine, norepinephrine, and growth hormone. These hormones are released when an animal is stressed and can significantly alter body metabolism. Examining the levels of these hormones provides a very strong indicator of whether there is any effect on endocrine gland function, and provides a direct measurement of whether these important hormones are altered.

Q What are the results of the research on EMF and endocrine gland function?

A. Even with prolonged exposure to significant electric and magnetic fields, these hormones are not elevated in the blood and the data indicate that animals are not stressed by these fields.

In an early set of studies, Marino et al. (1977) claimed that prolonged exposure of mice to EMF caused a decrease in corticosterone levels. Subsequent research has failed to corroborate this finding (Graves & Poznaniak 1981, Free, et al. 1981, Hackman & Graves 1981, Portet 1983, Quinlan et al. 1985). Careful and detailed research has shown a transient increase in corticosterone levels on first exposure to EMF that is consistent with the arousal response described above. This increase lasts only minutes and the response rapidly disappears as the animals accommodate to the field. Reapplication of the field produces no effect, indicating that the animals have habituated to the field. (Hackman & Graves 1981).

## C. EMF Research on Biological Rhythms

Q The third major area of research you identified is research on biological rhythms. Is biological rhythm the same as "circadian rhythm"?

A. Circadian rhythms are a type of biological rhythm that have a cycle equal to one day.

Q What are biological rhythms?

A. Biological rhythms are cycles of biologic processes that are generally coordinated by external stimuli such as the daylight/ darkness sequence. These rhythms include the sleep/wake cycle, the body temperature cycle, and the cyclical release of several neurologic hormones. Researchers examine biological rhythms and

changes in those rhythms because they are a possible indicator of the body's responsiveness to external stimuli.

Q What are the research results on EMF and biological rhythms?

A. Substantial research has been conducted regarding EMF and major biological rhythms, such as the rhythm in body temperature, eating patterns, sleep/wake cycle, (Ehret et al. 1980) and hormones such as prolactin and growth hormone. (Quinlan et al. 1985) None of these major biologic rhythms was shown to be altered by exposure to EMF.

Q Are you familiar with the research by Vasquez, et. al. (1988) on changes in the circadian rhythm in certain neurotransmitters that was discussed in Mr. Janes' testimony?

A. Yes. The Vasquez research reported that the circadian rhythm of certain neurotransmitters, as measured in the rat hippocamus, was altered after exposure to EMF.

Q What is your evaluation of the Vasquez research results?

A. Several comments on the Vasquez work are appropriate. First, the role of neurotransmitters as chemical bridges for light, heat, and pain, which were noted by Mr. Janes in his testimony, do not occur in the hippocamus. In the portion of the brain where those important functions occur, there are no known circadian rhythms in neurotransmitters. Second, the Vasquez research must be evaluated in the context of the body of research on neurotransmitters, which I discussed previously in my testimony, and which shows that there is no adverse effect on neurotransmitters. Finally, the Vasquez research also must be evaluated in the context of the research which shows that biologically important rhythms are not disturbed by exposure to EMF. When evaluated with those comments in mind, the Vasquez results do not indicate a harmful effect on biological rhythms.

Q Are you familiar with the research by Wilson, Reiter, and others on the circadian rhythm of the hormone "melatonin"?

A. Yes. In the EMF research, the principal interest in biological rythms has focused on melatonin, and the reported changes in melatonin (e.g., Lerchl, 1990, 1991, Reiter, 1988, 1990, Wilson, 1981, 1983, 1986, 1989, 1990) are the primary basis for the reported conclusion that EMF can affect circadian rhythms.

Q What is melatonin?

A. Melatonin is a hormone that is produced by the pineal gland. The pineal gland has no known function in human beings: one theory holds that it is a vestigial gland that no longer serves a biologically significant function in humans. Melatonin produced by the pineal gland is one of several neurologic hormones that is known to have a distinct rhythm that is tied to the daylight/darkness cycle. Specifically, it has been shown that melatonin levels in rats are suppressed by light and increase with darkness.

Q What are the results of the EMF research on melatonin?

A. Under highly artificial laboratory conditions where experimental rats are deprived of normal environmental cues, electric field exposure has been reported to produce a small decrease and time delay in the expected nightly rise in pineal gland melatonin levels. At least 3 weeks of fixed, artificial laboratory conditions were needed to elicit this response and within 3 days of removing the rats from these artificial conditions, normal melatonin rhythms were reestablished. No deleterious effects on the health of the animals were observed in the study, and no study has demonstrated any such biological effect of magnetic field exposure.

In a more recent study, the investigators reported that they failed to find any differences in pineal melatonin or melatonin metabolic levels in animals exposed to field strengths of 10 to 65 kV/m (Grota

et al., 1991). Similarly, an investigator recently reported that baboons exposed to 60 Hz, 6 kV/m and 500 mG fields showed no changes in nocturnal melatonin levels (Rogers et al., 1991).

Q What are the implications of the reported change in rat melatonin?

A. There are no known or reported biologic consequences of the reported change in dark cycle melatonin levels, either in rats or humans. Nor is there evidence of any effect of EMF on any other major biologic rhythm or any other hormone. it is important to reiterate that these effects on the melatonin rhythms are not associated with changes in other major biologic rhythms such as sleep/wake cycles, body temperature, eating patterns, or the circadian release of other hormones. Also, it should be noted that the reported changes in dark cycle melatonin levels are limited to rats exposed to electric fields, not magnetic fields. In addition, when human subjects were studied, there was no reported decrease in pineal melatonin levels. Consequently, it cannot be said that the rat melatonin study provides a basis for concluding that power frequency electric or magnetic fields leads to adverse effects on human biologic rhythms.

## D. EMF Research on Reproduction and Development

Q The fourth major area of research that you mentioned is research on reproduction and development. What does research on reproduction and development tell us about human health?

A. In mammals, successful completion of such functions as fertilization, implantation, fetal development and birth are dependent on a precise temporal sequence of hormone production at three levels (hypothalamic, pituitary, and gonads). This system is very susceptible to perturbation from any extrinsic stimulus that causes internal imbalances in hormone function. Disruption of any of the important steps will cause the process to fail and this will be readily detectable through decreased fertility or increased fetal death. For these reasons, successful reproduction and development

reflect in a most sensitive manner the status of integrated endocrine organ function.

Q What research has been conducted on EMF and reproduction and development?

A. To date, a number of studies have been carried out looking specifically at the effects of power frequency electric and magnetic fields on mammalian and non-mammalian reproduction and development. Early studies by Marino et al. (1976, 1980) reported effects on reproductive parameters. These studies were confounded by electric shocks that the animals suffered because the experimental cages were improperly grounded.

Subsequent studies which controlled for these confounders found no effects of EMF on fertility (Cerretelli et al., 1979), mating performance or fertility (Sikov 1984), fertility or fecundity (Sikov et al. 1982, 1984, Phillips et al. 1981, Mahmoud et al. 1989) or numerous other reproductive endpoints (Benz & Carsten 1987). In a recent study by Rommermeim et al. (1989), the researchers examined whether exposure to 60 Hertz fields had adverse effects on reproduction and development in laboratory rats. In this study, several hundred animals were exposed to fields of 10, 65, or 130 kV/m for 19 hours a day, both before pregnancy and during gestation. Rommermeim reported no differences between exposed and unexposed animals for a broad range of reproductive and developmental parameters, including impregnation, maternal mortality, fetal weight, sex ratio, fetal malformations, and fetal growth.

Q Are you familiar with the research on chick embryos by Delgado and the similar research known as the Henhouse Project?

A. Yes. This research (e.g., Delgado, 1982, Berman, 1990) used pulsed fields that are produced by specialized laboratory equipment. Transmission lines do not create pulsed fields.

Q Has any research on chick embryos been conducted using power frequency fields?

A. Yes. For example, Graves (1985) conducted extensive research on chick embryos using power frequency fields and examining a variety of reproductive endpoints. They found that exposure to power frequency fields did not affect any of the reproduction and development endpoints studied.

Q Are you familiar with a study on reproductive effects by Wertheimer, et. al.?

A. Yes, Wertheimer (1986, 1989) has conducted two epidemiological studies on reproductive effects, one examining the question of whether use of water beds is associated with fetal loss, the other examining the use of electric heat in the home. Wertheimer reported that both of these activities are associated with adverse reproductive outcomes.

Q What is your evaluation of the reproductive work by Wertheimer?

A. This work has been subject to severe criticism on many grounds, including that the researchers selected a biased sample, that they selected arbitrary, non-scientific comparison periods, that the data collection methods were crude, and that the fetal loss rates could not be and were not actually determined in this study. These criticisms are set out by Ahlbom, et. al. (1987) in the Final Report of the Scientific Advisory Committee of the New York State Power Lines Project. I agree with their conclusion that "the claims of Wertheimer and Leeper . . . do not appear justified."

In addition, these reports are not persuasive in light of the extensive, well-done animal research, discussed previously in my testimony, which reported no effect on reproduction and development.

Q Has there been any recent research on EMF and reproduction and development?

A. Yes, recent animal studies by Rommermeim et al., Mahmoud et al., Berman, and Chacon et al. showed no effects of EMF on numerous reproductive endpoints.

Another study involving reproductive measures was recently published in the New England Journal of Medicine (Schnorr et al., 1991). This study was conducted by personnel from the National Institute of Occupational Safety and Health (NIOSH) and the American Cancer Society who examined whether women working with video display terminals (VDTs) during pregnancy had an increased risk of spontaneous abortion. Approximately 800 pregnancies were studied. The exposed group involved pregnant women who typically worked an eight hour day with VDTs. The study found "no increase in the risk of spontaneous abortion associated with the occupational use of VDTs."

Q What do you conclude with regard to the research on EMF and reproduction and development?

A. The issue of EMF effects on reproduction and development has been examined extensively and there is no persuasive scientific evidence that exposure to power frequency fields has any adverse effects on reproduction, development, or related endocrine function.

## IV. Background on the Immune System

Q Dr. Bockman, previously you discussed immunology and the immune system. What is the immune system?

A. The immune system is the network of cells and tissues that protect the body from disease. The cells that form this network originate in the bone marrow and fetal tissues and often end up circulating in the peripheral blood or in and amongst the cells of the body. Immune cells have the unique capacity to recognize substances that are

foreign to the body, including bacteria, viruses and foreign tissues (as from transplanted tissue or non-compatible blood transfusion). Once an object has been recognized as foreign and thus harmful to the organism, immune cells are capable of inactivating and removing the offending object. If, however, the immune system fails to function properly, then an invading disease invariably overwhelms the body defenses.

Q Can changes in the endocrine system affect immune system function?

A. Yes. Immune cells can be regulated by a variety of hormones and, as a result, immune system function can be affected by altered endocrine function. Cortisone and corticosterone, products of the adrenal gland, are prime examples of hormones that regulate immune cell function. When present in excessive amounts and for prolonged periods of time, cortisone can reduce the ability of immune cells to fight invading bacteria and viruses.

## V. EMF Research on the Immune System

### A. Research on Endocrine Regulated Immune Functions

Q Has any research examined whether exposure to EMF affects hormone levels that are important to immune function?

A. Several excellent studies have examined the levels of cortisone and corticosterone in animals exposed to EMF. In only one study could a transient and minimal rise in blood corticosterone levels be measured and this occurred only when the field was switched on the first time. This response is a normal physiologic response when test animals first perceive the field. Within fifteen minutes, blood hormone levels return to normal levels and show no further rise whether the field is maintained or switched on and off.

At the present time there is no evidence to suggest that the fields associated with AC power lines are a sufficient stimulus to cause an abnormal rise in corticosterone or cortisone levels. Thus, there

is no scientific basis to conclude that power frequency fields can affect the immune system through the pathway of altered endocrine function.

## B. Research on Immune System Function

Q What other kinds of research are useful in evaluating the effect of an agent on the immune system?

A. Many tests have been developed that attempt to assess the integrity of the immune system. Some tests examine the function of specific immune cells taken from the body (in vitro tests). Other tests examine the reactions of the whole organism to various challenges to the immune networks (in vivo tests). The in vivo tests, while more difficult and time consuming, provide a much more accurate reflection of the functional integrity of the immune system since they involve whole organisms rather than isolated cells deprived of the body's defense mechanisms.

### In Vitro Immune Research

Q Please describe the in vitro research on EMF and the immune system.

A. One study (Conti et al. 1983) used a standard in vitro test for evaluating cell function. Human peripheral blood lymphocytes were isolated and placed into short-term culture. Blastogenic (immune-cell/lymphocyte proliferative) responses of these lymphocytes to mitogens (concanavalin A,-Con A, phytohemagglutinin - PHA and pokeweed mitogen - PWM) were measured in the presence and absence of EMF. In vitro exposure over the frequency range 1-200 Hz inhibited PHA-induced blastogenesis. Very low amplitude fields with suboptimal doses of PHA had a small effect in increasing cell proliferation (Cadossi et al. 1988).

The biologic relevance of these studies using unusual plant lectins as the stimulating factors (agents to which people are not typically exposed) remains unclear. In a more recent and detailed set of experiments, Winters (1986) examined immune cells from dogs and

humans that were exposed to factors that elicit an immune response. These studies were performed in and out of various combinations of electric and magnetic fields. No significant effect of immune cell function was observed.

Other in vitro experiments studied a unique mouse cell-line (groups of cells that are unlike normal immune cells in that they can grow continuously outside the body). This particular cell-line known as CTLL-1 resembles a class of immune cells that have a strict requirement for particular growth factors and have the capacity to kill certain tumor cells. When 60 Hz fields were applied to these special immune cells in the naked culture dish, the ability of these cells to kill the tumor target cells was reduced (Lyle et al. 1983, 1988). The effect was not dose-dependent. The mechanism of this unique effect in culture dishes is not known, nor has this effect been observed in intact animals exposed to power-frequency fields.

**In Vivo Immune Research**

Q Please describe the in vivo research on EMF and the immune system.

A. Standard toxicity protocols have been used to study the effects of EMF on animals exposed to various pathogenic micro-organisms. In an early study Odinstov (1965) injected mice with various concentrations of the bacteria Listeria monocytogenes and then exposed the animals to a 50 Hz electromagnetic fields. No differences in acutely exposed animals and controls were observed. With chronic exposure, however, more of the exposed animals died when a semi-lethal dose of the bacteria was injected as compared to the control group.

In separate experiments, Cerretelli et al. (1979) injected mice with Staphylococcus pyogenes after exposing them to 25 kV/m fields for up to 42 days. No differences in mortality were noted for the exposed and unexposed groups. Earlier, Krueger and Reed (1975) used a similar protocol. After 212 days of exposure to a 75 Hz, 100 V/m field, mice were given an intranasal challenge with influenza virus. Again, no difference in mortality was measured when the

field-exposed and controls were compared. In the last two experiments, more commonly found organisms were tested. The early studies of Odinstov with Listeria monocytogenes have not been replicated.

Several groups of investigators have examined a variety of immune parameters in animals exposed to power frequency fields. Ragan et al. (1983) and Quinlan et al. (1985) examined the immune responses in rats exposed to strong electric and magnetic fields. They observed no significant changes in immune cell parameters. Wolpaw et al. (1987) saw no changes in immune cell numbers in monkeys exposed to EMF.

Perhaps the most complete studies of immune function in animals exposed to EMF were those of Morris et al. (1979, 1981, 1982, 1983). Their assays in mice exposed to 60 Hz fields 21 hours per day for 30 or 60 days assessed immunoglobulin synthesis, serum complement levels, immune cell number and distribution. No differences in any of the parameters were noted when the treated and control groups were compared. In subsequent studies, animals were exposed for up to 150 days to EMF (60 Hz, 200 v/m), and the blastogenic response of peripheral blood lymphocytes to Con A, PHA and PWM was assayed. In contrast to the single study of Conti et al. (1983), EMF exposure caused no observable changes in either T or B lymphocyte responses to mitogens.

### C. Conclusion Regarding EMF and the Immune System

Q What conclusion do you reach with regard to the research on EMF and the immune system?

A. The comprehensive animal studies indicate that exposure of intact animals to EMF similar to those experienced under AC power lines produces no obvious deficit in immune cell function. With the exception of Odinstov's early unconfirmed study using L. monocytogenes, there is no evidence that exposure to moderate or even strong power frequency electric and magnetic fields adversely affects the host's immune system.

## VI. Conclusions Regarding EMF and Human Health

Q Dr. Bockman, based on your experience, training, and review of the research literature, have you reached any conclusions regarding EMF and human health?

A. Yes.

Q What are those conclusions?

A. My conclusions are:

1. Electric fields experienced directly under AC power transmission lines are below or just at the threshold of perception for most animals and man. There is no evidence that humans can perceive 60 Hertz magnetic fields at levels that far exceed the levels associated with transmission line absent external cues.

2. Electric field strengths several times greater than the threshold for perception may cause an initial arousal response. However, this response fades rapidly and the animals habituate to such fields. Chronic exposure to such fields causes no obvious abnormality in neurologic function or behavior. There is no evidence that such fields elicit a stress response.

3. There is no evidence that power frequency electric or magnetic fields alter intracellular calcium levels or that calcium acts as a transducer of EMF effects on nerve, endocrine or immune cells.

4. There is no scientific basis to conclude that power frequency electric or magnetic fields have any significant effects on circadian rhythms involving body functions or critical pituitary hormones.

5. There is adequate experimental data to show that EMF do not adversely affect complex endocrine system function needed for successful reproduction, growth or development.

6. Immune cell viability and function is not significantly affected by exposure to EMF and no adverse effects have consistently been demonstrated in intact animals.

7. My overall conclusion is that there is no basis to conclude that power frequency electric and/or magnetic fields have adverse effects on the health and function of the endocrine or immune systems.

Q Does this conclude your testimony?

A. Yes.

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BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION

EXHIBIT RB-1
OF
DR. RICHARD BOCKMAN

ON BEHALF OF
PHILADELPHIA ELECTRIC COMPANY

November 1991

# CURRICULUM VITAE

Richard S. Bockman, M.D., Ph.D.

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|---|---|
| Present Appointments: | Head, Endocrine Service<br>Associate Senior Scientist,<br>The Hospital for Special Surgery |
| | Professor, Department of Medicine,<br>Endocrine Division, and of Biochemistry<br>Cornell University Medical College |
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| Place and Date of Birth: | New York, New York, September 14, 1941 |
| Education and Degrees: | |
| | Johns Hopkins University, B.A., 1962<br>Yale University, M.D., 1967<br>Rockefeller University, Ph.D., 1971 |

Research and Professional Experience:

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| 1990 - Present | Professor of Medicine, Cornell University Medical College |
| 1988 - Present | Head, Endocrine Service and Associate Senior Scientist, The Hospital for Special Surgery |
| 1982 - 1990 | Associate Professor of Medicine, Cornell University Medical College |
| 1982 - 1988 | Associate Attending Physician, Memorial Hospital |
| 1979 - 1988 | Laboratory Head, Laboratory of Calcium Metabolism |
| 1978 - Present | Endocrine Research Training Grant Faculty Member |
| 1975 - 1981 | Associate, Sloan-Kettering Institute<br>Assistant Attending Physician, Memorial Hospital<br>Assistant Professor of Medicine, Cornell University |
| 1973 - 1975 | Residency in Medicine, New York University-Bellevue<br>Teaching Assistant in Medicine-Bellevue Program |
| 1971 - 1973 | Fellow in Medicine, Cornell University Medical College<br>Associate, Sloan-Kettering Institute<br>Assistant Professor, Biochemistry, Cornell University |
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| 1967 - 1971 | Graduate student in Biological Chemistry at Rockefeller University, Laboratory of Dr. Lyman C. Craig, Thesis: High Resolution NMR Spectroscopy, Conformational Studies on Polymixin B |
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Professional Societies and Organizations:

American College of Physicians, 1975 (Fellow, 1980) (Board Certification in Internal Medicine, 1974)
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Honors and Awards:

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| 1965 - 1966 | Yale University Medical School Fellowship for Study Abroad spent at: Centre de Recherches Allergiques et Immunologiques with Dr. B. Halpern |
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Extramural Activities:

Co-organizer, First International Conference: Prostaglandins and Cancer, Washington, DC.
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Co-organizer, 1986 International Conference on Prostaglandins and Cancer, Rome, Italy
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