

DeCOTIIS, FITZPATRICK, COLE & WISLER, LLP

NEW YORK, NY
TRENTON, NJ

GLENPOINTE CENTRE WEST
500 FRANK W. BURR BOULEVARD, SUITE 31
TEANECK, NEW JERSEY 07666
TELEPHONE: (201) 928-1100
TELEFAX: (201) 928-0588
www.decotiislaw.com

Catherine E. Tamasik, Esq.
Direct Dial: 201-907-5265
Email: ctamasik@decotiislaw.com

July 9, 2009

VIA OVERNIGHT MAIL

Ken Sheehan, DAG
Division of Law
Dept. of Law and Public Safety
124 Halsey Street
Newark, New Jersey 07102

Kristi Izzo, Secretary of the Board
New Jersey Board of Public Utilities
2 Gateway Center
Newark, New Jersey 07102

**Re: I/M/O THE PETITION OF PUBLIC SERVICE ELECTRIC
AND GAS COMPANY FOR A DETERMINATION PURSUANT
TO THE PROVISIONS OF N.J.S.A. 40:55D-19
(SUSQUEHANNA-ROSELAND)
BPU DOCKET NO. EM 09010035**

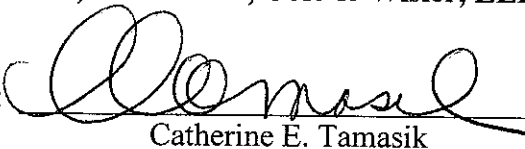
Dear Mr. Sheehan, and Ms. Izzo:

On behalf of our clients, the Fredon Township School District and the Willow Lake Day Camp, and in accordance with the Schedule as amended by the Board of Public Utilities on May 13, 2009, we submit herewith the Testimony of Martin Blank, Ph.D. which is in reply to Public Service Electric & Gas Company's Petition and supporting testimony.

Thank you for your attention.

DeCotiis, FitzPatrick, Cole & Wisler, LLP

By:



Catherine E. Tamasik

cc: Tamara L. Linde, Esq., V.P. Regulatory, PSEG Services Corporation
All Parties Designated on the Attached Service List
(all copies by e-mail only)

**STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES**

**IN THE MATTER OF THE PETITION OF
PUBLIC SERVICE ELECTRIC AND GAS
COMPANY FOR A DETERMINATION
PURSUANT TO THE PROVISIONS OF
N.J.S.A. 40:55D-19
(SUSQUEHANNA-ROSELAND)**

BPU DOCKET No. : EM09010035

**TESTIMONY OF MARTIN BLANK, Ph.D.
ON BEHALF OF MUNICIPAL INTERVENORS IN OPPOSITION TO THE
SUSQUEHANNA-ROSELAND
TRANSMISSION LINE PROJECT**

I. Summary of Testimony

Along with the growing need for electric power in modern society, there are growing concerns about the health risks arising from exposure to the electromagnetic fields (EMF) associated with transmission and use of electric power. Scientific research has continued the study of biological processes affected by EMF and the consequences to human health. The present level of understanding of biological mechanisms underscores the need for greater protection of populations exposed to EMF, especially young children. Recent research has even provided a plausible biological explanation for the link between EMF and leukemia at the 3-4 milligauss (mG) level found in epidemiology studies. I shall present evidence regarding EMF and leukemia showing that:

- EMF affects many fundamental biological processes at field strengths in the range of observed epidemiology thresholds
- Low levels of EMF stimulate stress protein synthesis (**the stress response**), a protective cellular mechanism in reaction to such harmful stimuli as high temperature and acidity.

Activation of the stress response indicates that cells react to low levels of EMF as potentially harmful.

- It is clear that EMF leads to DNA chain separation, since initiation of stress protein synthesis requires the two strands of DNA to come apart. EMF interacts with DNA in the stress response at very low intensities, and can cause damage to DNA at higher intensities. EMF stimulation of DNA is important, because cancer is associated with changes in DNA called mutations.
- The relevance of DNA damage is seen in a study where children missing DNA repair genes have a much greater incidence of leukemia.
- EMF has also been associated with harmful biological effects in adults. EMF inhibits the secretion of melatonin which normally inhibits the growth of breast cancer cells, and breast cancer cells have been shown to grow faster in EMF. EMF also increases the incidence of Alzheimer's disease and senile dementia, the incidence increasing with the duration of EMF exposure.
- There are plausible molecular mechanisms to account for the observed biological effects of EMF. Biochemical studies have shown that EMF can accelerate electron transfer reactions and that electrons can be displaced in DNA. The physical properties (electron affinity, fluorescence depolarization) of the CTCT groups in DNA activated by EMF could contribute to these interactions.

In the past, EMF safety issues only dealt with the need to protect against acute large EMF effects, such as electric shock or the firing of nerves, and not against chronic low level effects. Recent research, showing potentially harmful biological effects associated with chronic low level EMF, indicates the need for greater protection. We now know that even weak magnetic fields

are biologically active. They easily pass into cells and are unlike electric fields that are attenuated at the cell membrane by a factor of over a million. For this reason, even weak EMF constitute a significant risk, especially to children who spend many hours a day in schools and summer camps located near power lines. The magnetic fields exceed biologically active levels at the edge of the right of way (ROW), and for some distance beyond ROW.

II. Testimony of Martin Blank, Ph.D.

Q.1. Please state your name and address.

A.1. My name is Martin Blank. I reside at 157 Columbus Drive, Tenafly, NJ 07670.

Q.2. Please state your profession and describe your academic responsibilities.

A.2. I am Associate Professor of Physiology and Cellular Biophysics at the College of Physicians and Surgeons, Columbia University in New York City. My primary responsibility has been to conduct research, and I have specialized in the study of electromagnetic fields (EMF) and their effects on cell biochemistry and cell membrane function. I have recently specialized in the study of stress proteins and charge transport enzymes (protein catalysts). I have also taught Medical Physiology to first year medical, dental and graduate students, including a year as Course Director in charge of 250 students. My Curriculum Vitae is provided as **Exhibit A**.

Q.3. Please describe your formal education.

A.3. I have a Ph.D. degree from Columbia University (1957) in physical chemistry, as well as a Ph.D. from Cambridge University (1959), England, in colloid science. Colloid science was an interdisciplinary department that included biology, physics and chemistry that would be called biophysics in the United States.

Q.4. Please state related academic and industrial research experience.

A.4. In addition to Columbia University and Cambridge University, I have worked in other academic settings: Polymer Department, Weizmann Institute (Israel); Bioengineering Department, University of California-Berkeley; Pharmacology Department, Hebrew University (Israel); Biochemistry Department, Monash University (Australia); Frumkin Institute of Electrochemistry (Moscow, USSR); Biophysics Department, University of Warsaw (Poland); Chemical Physics Department, Tata Institute for Fundamental Research (India); Chemistry Department, University of the Negev (Israel); Biology Department, University of Victoria (Canada); Department of Theoretical Physics, Kyoto University (Japan).

I have also done research in industrial laboratories: California Research Corp, Richmond, CA; Esso Research and Engineering Corp, Linden, NJ; 3 Unilever Research Labs (Port Sunlight and Welwyn in England, and Vlaardingen in the Netherlands).

Q.5. Please describe your scientific publications

A.5. I am author of over 200 peer-reviewed papers and reviews, and 12 edited books on electrical properties of biological systems. The books include Proceedings of the First World Congress on "Electricity and Magnetism in Biology and Medicine"; "Biomembrane Electrochemistry"; "Nerve-Muscle Function", based on the 4th Erice (Italy) course; "Electromagnetic Fields: Biological Interactions and Mechanisms" for the American Chemical Society series, *Advances in Chemistry*.

Q.6. Please state other relevant professional experience

A.6. I worked for the United States Office of Naval Research (ONR) as a Liaison Scientist in London (UK) and as a Program Officer in Arlington (US), where I developed and managed a research program in biomembrane electrochemistry. I have also consulted for other research agencies, including the American Institute of Biological Sciences (AIBS) and Electric Power

Research Institute (EPRI), as well as private corporations, helping to evaluate proposed and ongoing research programs. In 2008, I was invited to address the Brazil Chamber of Deputies on EMF safety.

I have served as an officer of various scientific societies, editor of scientific journals, reviewer of scientific papers for publication and proposals for funding, as well as an expert advisor in the evaluation of the performance of research laboratories for various government agencies.

Q.7. Do you have a particular perspective on research?

A.7. The various research and teaching roles I have assumed in my career have generally involved an interdisciplinary approach to complex problems. This has given me a broad perspective on scientific research and specifically in bioelectromagnetics.

I reported on interdisciplinary research in biology at ONR-London, and organized interdisciplinary symposia as Chairman of the Biology Division of the Electrochemical Soc., as Bioelectrochemical Soc. President, and as Bioelectromagnetics Soc. President. This was also true of other scientific meetings I organized, such as the 4th International Symposium on Bioelectrochemistry (1976), the first Gordon Research Conference on Bioelectrochemistry (1980), and four interdisciplinary courses at the Majorana Center, Erice (Italy). The Gordon Conference enabled our group to organize the First (1992) and Second (1997) World Congresses on Electricity and Magnetism in Biology and Medicine. My editorial work for the Journal of the Electrochemical Society, and American Editor of Bioelectrochemistry and Bioenergetics was also interdisciplinary. My most recent activities have been more directly related to research and safety issues in Bioelectromagnetics. I was one of the organizers of the Bioinitiative working group that published the online Bioinitiative report (2007) evaluating electromagnetic safety

standards. I am also Editor of the special issue of Pathophysiology devoted to Electromagnetic Fields that will be published in August 2009.

Q.8. How do you see the role of science in determining EMF safety?

A.8. The need to base EMF safety standards on science is widely recognized. The IEEE guideline for revision of C95.1-1991 safety standards begins with that principle (*Bioelectromagnetics, Supplement 6*). Science is both a body of information and a method to obtain new information. Scientific research is designed to answer questions, and 'scientific proof' is best understood in terms of the old meaning of 'proof' as 'test'. Scientific proof does not rely on 'weight of the evidence', where one keeps a scoreboard of positive versus negative results and merely tallies the numbers. In scientific proof, number and weight do not count. It is the continuing accumulation of relevant data from all sources and the testing of scientific hypotheses regarding the biological effects of EMF that has provided useful information. It is in this way that scientific data from both epidemiology and laboratory studies continue to contribute to our understanding of the health risks associated with exposure to EMF. What started as an epidemiological link between EMF and childhood leukemia is now better understood in terms of EMF interactions with DNA. This current understanding of the scientific data underscores the need for greater protection from EMF exposure, especially for children.

Q.9. Please provide a brief history of biological effects of EMF as it relates to the proposed PSEG powerline project?

A.9. Years ago when EMF safety standards were first considered, they were meant to protect only against large and acute effects, such as electric shock or the firing of nerves, and not against chronic effects at low level EMF exposures. Recent research has shown potentially harmful biological effects at low level EMF exposures for extended periods of time, so there is a great

need to reconsider EMF safety. This is especially true for magnetic fields. Unlike electric fields that are attenuated at cell membranes by a factor of over a million, magnetic fields pass easily into cells and are biologically active. For this reason, even weak magnetic fields constitute a significant risk to living cells, especially to the rapidly growing cells in children.

Recent awareness of EMF risk started in 1979, when an epidemiology study by Wertheimer and Leeper suggested an association between magnetic field exposure and an increased risk of leukemia. The evidence from subsequent epidemiology and laboratory research led to the May 1999 National Institute of Environmental Health Sciences (“NIEHS”) Report to the Congress (see Executive Summary, **Exhibit B**) to recommend “*that the power industry continue its current practice of siting power lines to reduce exposures and continue to explore ways to reduce the creation of magnetic fields around transmission and distribution lines without creating new hazards.*” The NIEHS-EMF review panel announced in June 1998 that magnetic fields should be considered a “*possible human carcinogen*”, and two pooled analyses (*Greenland et al, Epidem 2000; Ahlbom et al, Brit J Cancer 2000*), the first analyzing 15 major studies and the second 9 major studies, subsequently showed a statistically significant doubling of the risk of childhood leukemia at EMFs exceeding 3-4mG. (The analyses are **Exhibits C and D.**) The epidemiological evidence was strong enough to serve as a basis for practical recommendations, and laboratory research has provided data on plausible mechanisms.

Q.10. Is the 3-4mG level similar to EMF thresholds for other biological effects?

A.10. Low EMF thresholds in several biological systems have been published in peer reviewed journals. The first five values in the following Table are from our laboratory at Columbia University, and the measured thresholds for changes in enzyme activity and in biosynthesis of stress proteins are in the range of the epidemiology threshold.

Biological EMF Thresholds (60Hz range)

Reactions:	Na,K-ATPase	2-3mG
	Cytochrome C Oxidase	5-6mG
	Malonic acid oxidation	1-2mG
Stress response:	HL60 cells	<8mG
	Sciara larva cells	<8mG
Cancer cells:	Block inhibition by melatonin (Breast cancer cells)	2-12mG
Epidemiology:		3-4mG

The biochemical reactions are central to biological function. Electron transfer to cytochrome C oxidase is a critical step in converting foodstuff into ATP, the fuel used to power living cells. The Na,K-ATPase utilizes the ATP to drive the biological 'pump' that maintains the ionic composition of living cells. The 'stress response' is a reaction to potentially harmful agents, such as high temperature, toxic metals, alcohol, etc, that leads to stimulation of DNA and the synthesis of stress proteins. Stimulation of the stress response by EMF shows that cells react to relatively low EMF levels as potentially harmful. EMF blockage of the inhibition of breast cancer cell growth by melatonin will be discussed in Q.14.

Q.11. How extensive is the health risk due to EMF levels near power lines?

A.11. All of the biological systems listed above, as well as many inter-connected ones, would be stimulated within the ROW of existing powerlines. In addition to the risk of leukemia, there would be changes in the fundamental cellular processes of energy production and utilization, as well as activation of DNA that contains genetic information. It is clear that the 3-4 mG level set in the NIEHS report to Congress would be exceeded along the proposed powerline route that

includes areas near the school and summer camp where children would be exposed to an increased health risk. It is also clear that the added 500 kV line would raise the EMF above the present level.

Actually, a 3-4 mG field does not indicate safety below that level. It is important to realize that doubling the risk at 3-4mG implies a lesser but still existing non-zero risk at levels just below that. Even when the PSE&G quoted fields are below 3-4 mG, the values quoted are **median values** with fields being higher half the time and lower half the time. EMF is bound to vary according to the power demands, and the median values are bound to be exceeded. Since there is no indication how high the values can go, they could exceed the thresholds of many additional biochemical reactions.

There are other issues that are difficult to evaluate, but, undoubtedly contribute to adverse biological effects.

- There is evidence that the radiofrequency RF 'noise' that accompanies a 60Hz signal may cause harmful effects (e.g., cancer, diabetes).
- The ground currents that account for a percentage of the AC return current are an indeterminate additional source of magnetic field exposure and depend on grounding, local circuitry, usage, etc.

A desirable optimal design would generate peak magnetic fields that are as small as possible, and as 'clean' (pure 60 Hz sine wave) as possible.

Q.12. How long must one be exposed to EMF to result in a biological change?

A.12. There is relatively little information about the effect of exposure duration on adverse health effects. Recent evidence from the Alzheimer's disease and dementia study discussed in Q.14. shows an increased incidence with exposure duration over a period of 15 years. Studies of

radio frequency EMF and cell phone use show an increased risk of brain tumors at 10 years. The peak incidence of leukemia in children at 3-4 years of age indicates that it can occur in a much shorter time. Current ideas of mechanism suggest that EMF initiates the change in DNA, which then follows a different course.

At the cellular level, there are indications that in addition to very low thresholds, some biological changes occur after very short exposure durations. Studies on EMF stimulation of the enzyme ornithine decarboxylase (*Litovitz et al. Biochem Biophys Res Comm 178: 862-865, 1991; Bioelectromagnetics 14: 395-403, 1993*) showed that a full response could be obtained when cells were exposed for only 10sec. The studies used either pure low frequency sine waves or modulated radiofrequency (RF) sine waves. In both cases, the EMF signal had to be continuous, since gaps in the sine wave resulted in a reduced response. The very short time to be effective would be expected if EMF acts as an initiator of DNA strand separation, as in the mechanism discussed below in Q.13.

Q.13. Please show how EMF interaction with DNA helps in understanding the stress response and the possible link to cancer.

A.13. The DNA molecule in a cell nucleus is a long, tightly coiled, double helix. The two strands of the helix are connected by four interacting chemicals called bases given the symbols C, G, A, and T. In human DNA there are about 3 billion bases that interact as pairs, C with G and A with T, one base from each strand. The sequence of the bases along the DNA is in a code needed to make the proteins essential for life, and that has been deciphered in the "Human Genome" project. Each protein is encoded in a separate segment called a gene, and individual genes are activated by specific chemicals in regions of the gene called promoters.

The integrity of the DNA is essential for life, since changes in the information for making proteins generally damage the cell. An accumulation of changes (mutations) in the DNA is associated with the development of cancers, diseases that are believed to arise from a multi-step process: initiation (damage to DNA in at least two places), promotion (effect on cellular processes that causes loss of control over protein synthesis) and progression (tumor growth). Cancer mechanisms are not well understood, and different mechanisms may be operating in each tissue. However, there is agreement that interaction with DNA and damage to DNA is a key factor.

Protein synthesis in a cell is regulated by a system that activates DNA to supply particular proteins when more are needed. When there is a potentially harmful change in a cell's environment (a stress), stress proteins are synthesized. The stress response, first identified in reaction to elevated temperatures, is used by all species in response to harmful environmental stimuli (e.g., high temperature, low oxygen, toxic metal ions).

Research has shown that cells react to EMF as a stress and make stress proteins. Stimulation of the stress response indicates that cells react to EMF as a potentially harmful stimulus at field strengths slightly above normal background levels. The response to **EMF requires remarkably low energy input** - over a trillion times lower than the thermal energy needed to evoke a response, as shown in the following Table:

ENERGY to STIMULATE STRESS RESPONSE

Form of Energy	Stimulus	Energy Density
Magnetic	8mG	2.6×10^{-7} joules/m ³
Thermal	+ 5.5°C	$2.3 \times 10^{+7}$ joules/m ³

Our laboratory was the first to report EMF stimulation of the stress response, and we identified EMF responsive regions with -CTCT- sequences in the promoter of the stress protein (hsp70). Inactivating these sequences by removal or mutation, eliminates the response to EMF. Inserting these sequences into an artificial construct containing a gene, causes the gene to be activated by EMF. (See **Exhibit E**) Linkage of EMF responses with specific regions of DNA provides a non-invasive, precise technique for gene activation. Columbia University has a patent for this process based on our research.

Recent studies show that DNA conducts electrons along the bases within the double helix, and we have shown that EMF accelerate electron transfer reaction rates. The velocity of charge movement calculated from experiments with the enzyme, Na,K-ATPase, 1000 m/s, is similar to ultrafast electron transfer in DNA of 400 m/s. The forces at low field strengths that affect enzyme reactions are large enough to move electrons in DNA and could lead to repulsive forces that cause chain separation. The physical properties (electron affinity, fluorescence depolarization) of the chemical groups (CTCT) activated by EMF could contribute to interactions with DNA. From estimates of the balance of forces (repulsion-attraction) at the DNA bases, sites rich in C and T, as in the identified -CTCT- sequences, appear to be more likely to come apart when repulsive forces are generated by EMF. These calculations (*Blank and Goodman, J Cell Physiol, 2004*) suggest a plausible mechanism for stimulation of DNA by EMF, and provide a rationale for EMF specific sequences that are effective in this process. A more general discussion of plausible EMF mechanisms can be found in *Blank, Electromagnetic Biology and Medicine, 2008*. (The two papers are attached as **Exhibits F and G.**)

Q.14. Has EMF been linked to diseases other than leukemia?

A.14. As mentioned in the reply to Q.10., EMF exposures have been shown to modify

the tumor suppressing action of melatonin secreted by the pineal gland in the brain. (*Liburdy et al. J Pineal Res 14:89-97, 1993*). Studies replicated in four labs show that 2mG blocks the growth-inhibiting action of melatonin on human estrogen receptor-positive, breast cancer cells, as well as the near-complete blockage of the anticancer (chemotherapeutic) drug Tamoxifen. A field strength of 2mG has no effect, indicating that the threshold for this effect lies between 2mG and 12mG.

There are currently many studies of tumors in the head (gliomas, acoustic neuroma, parotid gland tumors) correlated with the use of cellphones. These are generally discussed in terms of the radio frequency EMF that carries the cellphone signals, although there are low frequency components (12Hz, 217Hz) associated with the transmission that could be involved.

A recent study from Switzerland (*Hus et al., American Journal of Epidemiology, January 2009*) (**Exhibit H**) found that exposure to relatively low EMF from 220-380 kV power lines is correlated with an increase in the incidence of Alzheimer's disease and senile dementia. The risk for those living within 50m compared to over 600m, increased with duration of exposure over 5, 10 and 15 years, with a doubling of the risk at 15 years. The fields were not measured, but it is possible to estimate that the fields at 50m were in the range of 8-10mG, based on data published by the Bonneville Power Administration.

EMF interaction with DNA is important, because cancer is associated with changes in DNA (mutations) and a probable explanation of epidemiology results. We know that EMF activates DNA in the stress response at very low intensities, and can cause damage to DNA at higher intensities (*Lai and Singh, Bioelectromagnetics 18:156-165, 1997*). The relevance of DNA damage induced by EMF is reinforced in a recent epidemiology study where children missing the DNA repair genes were found to have a 4 fold greater incidence of leukemia from

exposure to EMF as low as 1.4-1.8mG (*Yang et al, Leukemia and Lymphoma 49: 2344-2350, 2008*) (**Exhibit I**).

Q.15. Please summarize the evidence linking EMF and cancer

A.15. From what we have learned about EMF interactions with cells, the plausibility of a link between low frequency EMF and childhood leukemia, and the possibility of other diseases, can be stated with growing confidence:

- Epidemiology studies show a doubling of the risk of childhood leukemia associated with EMF exposures in excess of 3-4mG. EMF is also associated with greater growth of breast cancer cells and an increase in the incidence of Alzheimer's disease and senile dementia.
- At the cellular level, stimulation of the cellular stress response (a cellular protective mechanism) by EMF indicates that cells react to EMF as harmful. The same low level of EMF can also affect fundamental cellular processes.
- A plausible molecular mechanism has been proposed for stimulation of protein synthesis by EMF, based on interaction with electrons in DNA and identification of a specific DNA sequence that has been shown to respond to EMF.
- Children missing the genes needed to repair DNA have a four fold greater incidence of leukemia from exposure to EMF as low as 1.4mG. This recent result links DNA damage by EMF to leukemia.

Q.16. Please assess the cancer risk from EMF of the proposed PSEG powerline.

A.16. The proposed addition of the 500kV PSEG line to the existing 230kV line is designed to minimize the EMF produced by distributing the current in three cables that carry current out of phase. However, there can be no doubt that the added 500 kV line would add to the level of EMF from the existing 230kV line and thereby create an additional potential hazard. This would

be contrary to the recommendations of the May 1999 NIEHS Report to the Congress. The studies cited here indicate that even the weak magnetic fields that extend beyond the ROW of the proposed power lines have the ability to cause significant changes in living cells by affecting fundamental biological processes, and predisposing them to the development of cancer and other diseases. It is therefore essential to minimize exposure to EMF, where errors in DNA that can occur during cell division are most likely in rapidly growing children.

Because of the wide range of biological systems affected, the low response thresholds, the possibility of cumulative effects by repetitive stimulation and the inadequacy of exposure standards, it is urgent that the proposed powerline be moved to a distance where the anticipated magnetic fields will not pose a hazard to the community. At the very least, **peak EMF levels should not exceed 3-4mG**. The recent study linking the absence of DNA repair genes to EMF induced leukemia (**Exhibit I**) suggests that half that value, **1.4-1.8mG**, would be a more **prudent peak limit** to aim for.

EXHIBITS

- Exhibit A** Curriculum Vitae - Martin Blank
- Exhibit B** Executive Summary, National Institute Environmental Health Sciences (“NIEHS”) Report to the Congress, May 1999.
- Exhibit C** Greenland, Sheppard, Kaune, Poole, Kelsh. 2000. A Pooled Analysis of Magnetic Fields, Wire Codes, and Childhood Leukemia. *Epidemiology* 11:624-634.
- Exhibit D** Ahlbom, Day, Feychting, Roman, Skinner, Dockerty, Linet, McBride, Michaelis, Olsen, Tynes, Verkasalo. 2000. A pooled analysis of magnetic fields and childhood leukemia,” *Brit J Cancer* 83:692-698.
- Exhibit E** Lin, Blank, Rossol-Haseroth, Goodman. 2001. Regulating genes with electromagnetic response elements. *J Cellular Biochemistry* 81:143-148.
- Exhibit F** Blank, Goodman. 2004. A mechanism for stimulation of biosynthesis by electromagnetic fields: charge transfer in DNA and base pair separation. Published online *J Cellular Physiology*, 9 July 2007.
- Exhibit G** Blank. 2008. Protein and DNA reactions stimulated by electromagnetic fields. *Electromagnetic Biology and Medicine*, 27: 3-23.
- Exhibit H** Hus, Spoerri, Egger, Roosli. 2009. Residents near power lines and Mortality from neurodegenerative diseases: longitudinal study of the Swiss population. *American Journal of Epidemiology* 169:167–175.
- Exhibit I** Yang, Jin, Yan, Tian, Tang, Shen. 2008. Case-only study of interactions between DNA repair genes and low frequency electromagnetic fields in childhood leukemia. *Leukemia and Lymphoma* 49: 2344-2350.

EXHIBIT A

Columbia University, College of Physicians & Surgeons

Department of Physiology and Cellular Biophysics
630 West 168 Street
New York, NY 10032
mb32@columbia.ed

Telephone: (212) 305-3644
Telefax: (212) 305-5775
EMAIL:

January 10, 2006

Mr. Robert J. Pellatt,
Commission Secretary
British Columbia Utilities Commission
900 Howe Street, Box 250
Vancouver, BC V6Z 2N3

sent via Email: Commission.Secretary@bcuc.com

Dear Mr. Pellatt,

**Re: FortisBC Inc. Order No. G-114-05 / Project No. 3698407CPCN Application for
Nk'Mip Substation and Transmission Line**

Mr. Hans Karow, Coalition to Reduce Electropollution (CORE), has asked me to provide testimony addressing the electromagnetic pollution issue associated with the proposed project cited above. As indicated in my CV (attached), I have spent many years studying the effects of low frequency electromagnetic fields (EMF) at both the cellular and molecular levels, and I have published extensively in peer reviewed journals.

Before addressing the main points, let me state that EMF from a 63kV power line will exceed the 3-4mG level within about 70-80 feet of the line, at typical power levels, based on the Bonneville Power Administration data. This level field will extend over an even wider range at peak power levels. Many biological systems are perturbed at relatively low EMF, but it has been shown that the risk of leukemia in children is doubled at the 3-4mG level. This field level is well within current safety limits, but the scientific basis of these limits is open to serious questions (Blank and Goodman, 2004) that challenge the capacity of these limits to be protective.

The main points I wish to emphasize are the following:

- recent epidemiological studies in the power frequency range suggest increased risk of leukemia associated with exposure to EMF
- current safety guidelines are not based on biological thresholds, and are many times above the levels that epidemiological studies have correlated with elevated risk of leukemia in children
- EMF thresholds of biological reactions are very low. Very low field strengths stimulate the stress response, the protective cellular reaction to potentially harmful stimuli

- the mechanism by which EMF cause changes in several well-documented biochemical systems involves interaction with electrons. Such a mechanism would affect many biological reactions, and possibly lead to cancer on interaction with DNA

Recent epidemiological studies indicate need for caution

Since the Wertheimer, Leeper paper of 1979, there have been many epidemiological studies of the effects of EMF in the power frequency range. Two recent meta analyses by groups of experts (Greenland et al, *Epidem* 2000; Ahlbom et al, *Brit J Cancer* 2000), of 15 and 9 major studies respectively, have shown a statistically significant doubling of the risk of childhood leukemia when exposures to low frequency EMF exceed 3-4mG. While the small number of cases of high exposure has resulted in a lack of statistical significance, the doubling of the risk of leukemia has persisted in many studies near the "significant" level. By pooling cases, it has been possible to demonstrate statistical significance. There is now quite general agreement that the epidemiological evidence indicates an association of EMF with childhood leukemia when exposures exceed 3-4mG.

Current safety guidelines are not based on biological mechanisms

In assessing the potential biological impact and risk of exposure, one would generally turn to the safety standards set by professional agencies such as ICNIRP and IEEE. However, the standards set by these agencies are unrelated to biological thresholds. They are based solely on the heating of tissue that results from the energy deposited by EMF. The energy deposition rate, the SAR, does not take into account many biological properties that change long before a change in the SAR can be detected. This fundamental flaw in the current standards makes them unreliable as a basis for safety:

- they assume that there are no biological reactions unless heating of cells occurs. The EMF thresholds discussed below, show that significant biological reactions occur in cells at very low EMF, in the absence of heating. These 'non-thermal' reactions raise an alarm regarding questions of safety.
- the standards were derived assuming that in EMF, the magnetic fields do not act directly, but only through the relatively weak electric fields they induce. This is not so. We have shown that both electric and magnetic fields can affect cells. In fact, magnetic fields penetrate cells far more effectively than electric fields at low frequency.

The SAR is a valid measure of energy deposition rate, but not of safety. It was derived at a time when all one could measure was temperature increase. Because of scientific advances, it is now possible to show many biological changes due to EMF that occur within the current safety guidelines. The current guidelines have been challenged by scientists, e.g., by an international commission that met in Catania, Italy in September 2002.

EM fields stimulate the cellular stress response

Regarding the question of safety, the most important observation is activation of stress protein synthesis in cells by EMF at both power and radio frequencies. The stress response occurs in reaction to a variety of potentially harmful influences in the environment, such as high temperature, toxic metal ions, alcohol, deviations of pH from neutrality, etc. For this reason, stimulation of the stress response by EMF can be seen as a direct answer by cells to the safety question. Cells react to EMF as a significant departure from a normal environment and as potentially harmful.

The stress proteins are the same whether stimulated by fields or by an increase in temperature, but the response to EMF requires much lower energy input. In *Sciara* salivary gland cells, the threshold energies of the EMF and thermal stimuli needed to evoke a stress response differ by 14 orders of magnitude, as shown in the Table below.

ENERGY to STIMULATE STRESS RESPONSE

Form of Energy	Stimulus	Energy Density (joules/m³)
Magnetic	8mG	2.6×10^{-7}
Thermal	5.5°C	$2.3 \times 10^{+7}$

In addition to the stress response, many biological reactions, such as enzyme systems and electron transfer reactions, are affected by weak EMF. Low thresholds have been measured in several systems, and the values have been published in peer review journals. The Table below shows that the measured thresholds for changes in reaction rates of enzymes, the BZ reaction (oxidation of malonic acid), and reactions in DNA leading to biosynthesis of stress proteins, are in the range of cut-off thresholds in epidemiological studies. The table also has an entry for EMF needed to block the inhibition of breast cancer cell growth by melatonin. That study has been replicated in six labs, and it shows that a low EMF of 12mG blocks the growth-inhibiting action of melatonin on human estrogen receptor-positive, breast cancer cells, as well as the near complete blockage of the anticancer (chemotherapeutic) drug Tamoxifen. An EMF of 2mG has no effect, indicating that the threshold for an effect on these cancer cells lies between 2mG and 12mG.

Biological EM Field Thresholds (power frequency range)

Reactions:	Na,K-ATPase	2-3mG
	Cytochrome C Oxidase	5-6mG
	BZ (redox) reaction	1-2mG
DNA:	Stress proteins (HL60 Cells)	<8mG
	Stress proteins (Sciara Cells)	<8mG
Cells:	Block inhibition by melatonin	
	(Breast cancer cells)	2-12mG
	Epidemiology threshold (leukemia)	3-4mG

Stimulation of the stress response by EMF shows that they activate DNA as the first step in protein synthesis. Several labs have shown that DNA can conduct electrons within its structure. Therefore, it appears possible for EMF to activate DNA by generating repulsive forces when interacting with electrons in DNA. We have shown that specific regions of DNA are associated with the response to EMF, and inactivating these sequences by removal or mutation eliminates the response to EMF. Inserting these DNA sequences into an artificial construct containing a gene makes the gene EMF-responsive. In brief, our understanding of mechanism has reached the point where we have identified an EMF sensitive DNA sequence, have transplanted it and have reactivated it with EMF. (We have obtained a patent for this process.) That experiment, together with the breast cancer cell study indicate that EMF can enter into health related mechanisms at very low field strengths.

Recommendation

Based on recent research on biological changes induced by EMF, it is wise and prudent to recommend minimizing exposure by all reasonable methods, especially of school age children, with the aim of being below 3-4mG at peak power levels. **ALARA** (As Low As Reasonably Achievable) has been a policy with regard to radiation safety, and the European Union has adopted a related measure, the **Precautionary Principle**, as a general approach to environmental issues. Italy and Austria have applied this approach to EMF, and I have organized a symposium on the Precautionary Principle for the next meeting of the Bioelectromagnetics Society.

On request, I am prepared to provide additional information and clarification. Please feel free to contact me via e-mail mb32@columbia.edu , or telephone provided above.

Martin Blank, PhD
Associate Professor of Physiology and Cellular Biophysics
Columbia University

Enclosure: Curriculum Vitae

CC: Mr. George Isherwood, Director Reg. Affairs, FortisBC George.Isherwood@fortisbc.com
Mr. Hans Karow, CORE hkarow@shaw.ca

CURRICULUM VITAE

Address	Home	157 Columbus Drive, Tenafly, N.J. 07670 (Tel: 201-266-4076; FAX: 201-266-4076; email: mbphd32@yahoo.com)
	Office	Dept. of Physiology, College of Physicians and Surgeons, Columbia University, 630 West 168th Street, New York, NY 10032 (Tel: 212-305-3644; FAX: 212-305-5775; email: mb32@columbia.edu)
Personal	Born	February 28, 1933 New York, New York
	Married	Marion Sue Hersch July 3, 1955 (3 children)
Education	1950-1954	City College of New York, BS Magna Cum Laude (Chemistry)
	1954-1957	Columbia University, PhD (Physical Chemistry)
	1957-1959	Cambridge University, England, PhD (Colloid Science)

Academic Appointments

1954-1955	Assistant in Chemistry, Columbia University
1955-1957	Research Fellow (Chemistry), Columbia University
1957-1959	Postdoctoral Research Fellow, Cambridge University, England
1959-1964	Instructor in Physiology, Columbia University
1964-1968	Assistant Professor of Physiology, Columbia University
1968-present	Associate Professor of Physiology and Cellular Biophysics, Columbia University

Other Appointments

Summer 1956	Chemist, California Research Corp, Richmond, CA.
Summer 1957	Chemist, Esso Research and Engineering Co, Linden, NJ.
Fall 1961	Research Fellow, Cambridge University, England
Summer 1964	Chemist, Unilever Research Lab, Cheshire, England
Summer 1966	Visiting Scientist, Polymer Dept, Weizmann Institute, Israel
Summer 1967	Chemist, Unilever Research Lab, Hertfordshire, England
Summer 1968	Visiting Scholar, Bioengineering Dept, University of California, Berkeley
Summer 1969	Research Chemist, Unilever Research Lab, Vlaardingen, Netherlands
1970	Visiting Professor, Pharmacology Dept, Hebrew University, Israel
1974-1975	Physiologist, Office of Naval Research, London, England
1982 (6 mo.)	Visiting Lecturer, Biochemistry Dept, Monash University, Australia
1984-1985	Biologist, Office of Naval Research, Arlington, VA
1986-1988	Part-time IPA Biologist, Office of Naval Research, Arlington, VA
1989 (May)	Visiting Professor, Acad Sci USSR, Inst Electrochemistry, Moscow, and Dept of Biophysics, Univ of Warsaw, Poland
1992 (Nov)	Visiting Professor, Tata Institute, Bombay, India
1995 (spring)	Visiting Professor, Dept of Chemistry, University of the Negev, Beersheba, Israel
	Visiting Scientist, Dept of Biology, University of Victoria, BC, Canada
2005 (July)	Visiting Professor, Dept of Theoretical Physics, Kyoto University, Japan

Honors

- 1953 Elected to Phi Beta Kappa, City College
 1956 Elected to Sigma Xi, Columbia University
 1955-1957 Consumers Union Research Fellowship, Columbia University
 1957-1959 Postdoctoral Research Fellowship, National Heart Institute, Cambridge University
 1960-1970 Research Career Development Award (USPHS), Columbia University
 1975 Certificate of Appreciation, Office of Naval Research, London
 1982 (June) Distinguished Visiting Professor, Univ Western Australia
 1984 Distinguished Lecturer in Physiology, Wayne State University
 1985 Certificate of Commendation, Office Naval Research, Arlington
 1987 Invited Lecturer, International Biophysics Congress, Jerusalem
 1988 Invited Lecturer, Univ of Bologna, 900th Anniversary Symposium
 1989 (May) Visiting Professor, Acad Sci USSR, Institute of Electrochemistry, Moscow
 and Dept of Biophysics, University of Warsaw, Poland
 1990 Certificate of Appreciation, The Electrochemical Society
 Yasuda Award, Bioelectrical Repair and Growth Society
 1992 Invited Opening Speaker, First Congress of European Bioelectromagnetics Association,
 Brussels, Belgium
 (Nov) Visiting Professor, Tata Institute, Bombay, India
 1992-1993 Editor-in Chief, Proceedings, First World Congress on "Electricity and Magnetism in
 Biology and Medicine"
 1993-1999 American Editor; "Bioelectrochemistry and Bioenergetics"
 Certificate of Appreciation, American Chemical Society, Environment Division
 1995 (spring) Visiting Professor, Dept of Chemistry, University of Beersheba, Israel
 Visiting Scientist, Dept of Biology, University of Victoria, BC, Canada
 1997 Plenary Lecturer, Second World Congress on "Electricity and Magnetism in Biology
 and Medicine", Bologna, Italy
 2002 Plenary Lecturer, Bioelectromagnetics Society, Quebec, Canada.
 2005 (July) Visiting Professor, Dept of Theoretical Physics, Kyoto University, Japan
 2005 Plenary Lecturer, Conference 'Biological Effects of Electromagnetic Fields', Kyoto, Japan
 2007 Invited Lecturer, House of Deputies of Brazil on Biological Effects of EM Fields, Brazil

Areas of Research

General Experimental and Theoretical Areas:

- Electromagnetic field effects on cells (stress response, enzyme reactions, DNA)**
- Membrane biophysics and transport mechanisms (active, passive, excitation mechanisms)**
- Biopolymers (surface and electrical properties of proteins, DNA)**

Theoretical Models of Processes in Membranes and Biopolymers:

- Electric and magnetic field effects on electron transfer reactions, enzymes, DNA
- Ion fluxes in excitable membranes and ion gating in channels
- Cooperative reactions in membranes, hemoglobin

Specific Biological Systems:

- Electron transfer reactions: Belousov-Zhabotinski (oxidation of malonic acid), cytochrome oxidase
- Enzymes: Na,K-ATPase, cytochrome oxidase, F₀F₁ATPase (effects of ions and EM fields)
- Proteins: hemoglobin, red cell membrane, lung surfactant, Sciara salivary gland proteomics
- Cells: red blood cells, sperm cells, HL60, Sciara salivary gland, E. coli
- Membranes: red blood cells, sperm cells, membrane enzymes

Interfaces, Monolayers (proteins, lipids, ions), Bilayers:

- Permeability (to water, gases, ions) and Rheology (elasticity, yield stress, flow)
- Electrical effects: Adsorption, Electrode Noise, Surface Potential

Teaching

Faculty of Medicine - College of Physicians and Surgeons, Columbia University

Medical Physiology - from 1961 to 1991

Lectures- physical biochemistry, membranes, transport.

Demonstrations- membrane properties, lung surfactant, analog computer.

Laboratory teaching including mammalian experiments.

Course Director, 1989-1990

Computerized syllabus and administration (30 faculty, 310 students)

Introduced lab reports and new lab exercise

Summer Science Teachers Program, 1995, 2000, 2004

Faculty of Pure Science - Graduate School of Arts and Sciences, Columbia University

Basic Principles in Membrane Biophysics - Physical biochemistry (1970 - present)

membranes, electrical properties, ion transport

Membrane Biophysics - Surfaces, membranes, channels, model systems.

Graduate Seminar - Basic papers on membranes and transport.

Control Mechanisms in Physiology - Lectures and lab on analog computer.

Principles of Physiology - Lectures on biophysics (membranes, biopolymers)

Ettore Majorana Center, Erice, Italy-International School of Biophysics (Co-Director of 4 courses)

1981 Bioelectrochemistry I: Redox Processes

1984 Bioelectrochemistry II: Membrane Phenomena

1988 Bioelectrochemistry III: Charge Separation Across Biomembranes

1991 Bioelectrochemistry IV: Nerve-Muscle Function

National Medical School Review

Lectures on Membranes, Nerve, Muscle

City University of New York (Graduate School)

Surface Chemistry - Lectures on Surface Chemistry in Biology

Tata Institute, Bombay, India

Course in Bioelectrochemistry

University of Beersheba (Department of Chemistry), Israel

Course in Biophysics

Faculty Committees

Admissions, Faculty Council (and Executive Committee of the Faculty Council), By-Laws (Formulation of Stated Rules), First Year Faculty, Divisional Elections Commission, ad hoc tenure and department review committees.

Department of Physiology: Director of Seminar Program 1973-1984, Graduate Committee, Undergraduate Committee

Society Memberships

American Association for the Advancement of Science

Bioelectromagnetics Society

Bioelectrochemical Society

American Chemical Society (Colloid and Surface Chemistry Division)

Biophysical Society

Electrochemical Society (Organic and Biological Division)

Professional Activities

Editorial Boards

Bioelectrochemistry and Bioenergetics - Editorial Board, 1978 -1998;
Co-Editor, 1981 - 1987; North American Editor, 1993 - 1998
Journal of Electrochemical Society - Divisional Editor (Biology), 1978 -1991
Journal of Colloid and Interface Science - Advisory Board, 1978 -1981
Colloids and Surfaces (founded 1979) - Editorial Board, 1979 -1986

Guest Editor, Pathophysiology (2008-2009)

Special Issue of on EMF

Bioelectrochemical (BES) Society

Founding Member, March 1979; Vice President, 1979 - 1988; President, 1988 - 1992.
Co-organizer, 4th International Symposium, Woods Hole, MA, 1977.
Plenary Lecturer, Weimar, DDR, 1979.
Organizing Committee, Topical Lecturer, Jerusalem, 1981.
Scientific Committee, Invited Lecturer, Stuttgart, Germany, 1983; Bologna, Italy, 1985.
Liaison to Bioelectromagnetics Society Board, 1984-1996.
Organizing Committee, Invited Lecturer, Szeged, Hungary, 1987.
Honorary Committee, Invited Lecturer, Pont-a-Mousson, France, 1989; Bielefeld, Germany, 1992;
Seville, Spain, 1994; Israel, 1996.
Organizer, Symposium on Biological Effects of Environmental EM Fields, Israel, 1996.
International Scientific Committee, Invited Lecturer, Denmark, 1998; Bratislava, Slovakia, 2001;
Florence, Italy, 2003.

Bioelectromagnetics (BEMS) Society

Invited Lecturer, BEMS meetings, San Francisco, CA, 1985; Madison, WI, 1986;
Stamford, CT, 1988; Quebec, Canada, 2002
Invited Speaker, BEMS Workshop on Cooperative Phenomena, Bethesda MD, 1988
Invited Speaker, BEMS Gene Workshop, Los Angeles, CA, 1993
Board of Directors, 1989-1992; liaison from BES 1985-1996.
President Elect, 1996; President, 1997-1998; Past President, 1998-1999
(Nominating Comm, Journal Comm, Public Affairs Comm)
Plenary Lecturer, Quebec, Canada, 2002
Symposium Organizer, Speaker (Bioelectromagnetic Mechanisms), Washington, DC, 2004
Symposium Organizer, Speaker (Precautionary Principle), Cancun, Mexico, 2006
Symposium Co-Organizer, (Detecting Risk and Societal Responses), San Diego, 2008

BioInitiative Working Group (2005 - 2007)

An international group of scientists focused on EMF issues (including science, public policy and public health). **The BioInitiative Report**, entitled 'A Scientific Perspective on Health Risk of Electromagnetic Fields' was published on line on August 31, 2007. <http://www.bioinitiative.org/report/index.htm>
Author of Section 7, pp. 1-40. Evidence for Stress Response (Stress Proteins)

World Congress on Electricity and Magnetism in Biology and Medicine

1992-3 Executive Committee, Site Selection Committee, Program Committee.
1992-3 Editor-in-Chief of Proceedings Volume, First World Congress
1994-7 Vice President, Executive Committee for Second World Congress
Chairman, Technical Program Committee, Second World Congress

International School of Biophysics, Erice, Italy; Co-Director and Lecturer in following:

Bioelectrochemistry I: Biological Redox Reactions and Energetics, 1981.
Bioelectrochemistry II: Membrane Phenomena, 1984.
Bioelectrochemistry III: Charge Separation Across Biomembranes, 1988.
Bioelectrochemistry IV: Nerve-Muscle Function, 1991.

Division of Colloid and Surface Chemistry, American Chemical Society

Symposium Chairman, "Surface Chemistry of Biological Systems", 1966; 1969.
VK LaMer Award Committee, 1971-1976, Chairman 1975-1976
Symposium Chairman, "Bioelectrochemistry", Miami, 1978; Cleveland, 1981; Washington, 1983;
Denver, 1987.
Program Committee, Biology and Medicine, Chairman, 1979-1983.
Invited Lecturer, Colloid and Surface Science Symposium, Ann Arbor, 1987.
Invited Lecturer, Biological Interfacial Reactions Symposium, Atlanta, 1991.

Division of Organic and Biological Electrochemistry (Electrochemical Society)

Symposium Chairman, "Electrochemical Processes at Biological Membranes", Seattle, 1978
Officer: Secy-Treas 1979-1981; Vice Chair 1981-1983; Chair 1983-1985.
Board of Directors, Electrochemical Society, 1983-1985.
Symposium Chairman, "Electrical Double Layers in Biology", Toronto, 1985.
Invited Speaker, "Ion Transfer Across Interfaces", Boston, 1986.
Member, Interdivisional Committee on Chemical Sensors, 1984-1987.
Invited Speaker, "Redox and Interfacial Properties", Washington, 1991.

Gordon Research Conferences

Speaker, "Chemistry at Interfaces", 1963.
Speaker, "Sensory Transduction in Microorganisms", 1978.
Day Chairman and speaker, "Chemistry at Interfaces", 1974.
Organizing Chairman, First Conference "Bioelectrochemistry", 1980.
Day Chairman and speaker, "Bioelectrochemistry", 1982.
Speaker, "Bioelectrochemistry", 1984, 1986, 1988.
Speaker, "Protons and Membrane Reactions", 1985.
Speaker, "Physicochemical Aspects, Transport in Microvasculature", 1985.
Discussion Leader, "Bioelectrochemistry", 1990, 1992, 1994, 1996, 1998, 2000 (Oxford), 2002.
Speaker, "Bioelectrochemistry", 2004.

Invitations to Miscellaneous Meetings, Workshops, Panels (Departmental Seminars not listed)

Chairman and Lecturer, "Physical Chemistry of Interfacial Transport: Biological Interfaces - Flows and Exchanges" NY Heart Assoc, 1968
Chairman and Lecturer, "Transport and Rheology of Interfacial Layers", Internat Conf on Surface and Colloid Science, Jerusalem, Israel, 1981
Lecturer, "Structure and Function in Excitable Cells", Biophysical Congress Satellite Conf, Woods Hole, MA 1981
Lecturer, "Biophysics of Cell Surface", Arendsee, DDR, 1981
Guest Speaker, CIBA Foundation, Biological Effects of Electromagnetic Fields, London, 1984
Lecturer, "Electrochemical Growth Stimulation", International Society of Electrochemistry, Berkeley, CA, 1984
Lecturer, "Biophysics of Cell Surface", Heringsdorf, DDR, 1985
Lecturer, Bioelectrical Repair & Growth Soc, Utrecht, Netherlands, 1986
Lecturer, IEEE/Engineering in Biology and Medicine Soc, Fort Worth, TX, 1986

MARTIN BLANK

- Lecturer, International Biophysics Congress, Jerusalem, Israel, 1987
Session Organizer, IEEE/Engineering in Biology and Medicine Soc, Boston, MA, 1987
Lecturer, Bioelectrical Repair & Growth Soc, Washington, DC, 1988
Lecturer, "Chemistry Physics of Electrified Interfaces", Bologna, Italy, 1988 Symposium
Organizer, "Bioelectrochemistry", AIChE, Washington, DC, 1988
Speaker, BEMS Workshop on Cooperative Phenomena, Bethesda MD, 1988
Speaker, National Research Council, "Health Effects of EM Fields", Washington, DC, 1989
Lecturer, "Electrobiology Today", Bologna, Italy, 1989
Speaker, California Department of Health Service Workshop on "ELF Field Exposure and Possible Health Effects", Berkeley, CA 1991
Speaker, FASEB Symposium on "Cancer, EM Fields and Biological Systems", Atlanta, GA 1991
Panelist, EPA- NYC Dept of Health Panel on Health Effects of EM Fields, New York, NY, 1991
Panelist, BEMS Workshop, Research Agenda, Health Effects of EM Fields, Milwaukee, WI, 1991
Opening Speaker, First Congress of European Bioelectromagnetics Association, Brussels, 1992
Speaker, EPRI Workshop on Neurobiology, Asilomar, CA, 1992
Speaker, FASEB Symposium, Biological Effects of Electromagnetic Fields, Anaheim, CA, 1992
Panelist, Molecular Electronics Symposium, First World Congress on Electricity and Magnetism in Biology & Medicine, Orlando, FL, 1992
Lectures (4) on Bioelectrochemistry of Proteins and Membranes, Tata Inst, Bombay, India, 1992
Plenary Lecture, Bioelectrochemical Society of India, Bombay, 1992
Speaker, Biophysical Society Public Policy Symposium on Biological Effects of Electromagnetic Fields, Washington, DC, 1993
Organizer, ACS Symp, Biological Effects of Environmental EM Fields, Denver, CO, 1993
Speaker, Helen Hayes Hospital, Haverstraw, NY, 1993
Speaker, Bell Labs (Series on EMF), Murray Hill, NJ 1993
Speaker, International Society of Molecular Electronics & Biocomputers, Gaithersberg, MD, 1993
Speaker, International Society of Toxicology, New Orleans, 1993
Speaker, ACS Conference on Chemical Health and Safety, Garden City, 1993
Panelist, Deadline Club, "Tension over High Tension", New York, 1993
Organizer and Speaker, Biophysical Society Workshop on Biological Effects of Environmental Electromagnetic Fields, New Orleans, LA, 1994
Speaker, ACS Conference on Environment, Hofstra University, NY, 1994
Lecturer, Hackensack Meadowlands Environment Center, Lyndhurst, NJ, 1994
Plenary Lecture, International Society of Electrochemistry, Portugal, 1994
Seminar Lecturer, Weizmann Institute, Rehovoth, Israel, 1995
Seminar Lecturer, Hebrew University-Hadassah Medical School, Jerusalem, Israel, 1995
Distinguished Lecturer, Wayne State University Medical School, Detroit, MI, 1995
Lecturer, Centre for Environmental Health, Victoria, BC, 1995
Lecturer, Victoria Cancer Clinic, Royal Jubilee Hospital, Victoria, BC, 1995
Speaker, First World Congress in Magnetotherapy, London, UK, 1996
Speaker, Applied Physics Division, CSIRO, Sydney, Australia, 1996
Speaker, Complementary Healing Conference, Baltimore, MD, 1996
Speaker, Vermont Law School Conference "Unplugged", Killington, VT, 1996
Speaker, 9th International Congress on Stress, Montreux, Switzerland, 1997
Speaker, Internat'l Comm Non-Ionizing Radiation Protection/ World Health Org (ICNIRP/WHO) Seminar, Bologna, Italy, 1997
Plenary Lecturer, Second World Congress on "Electricity and Magnetism in Biology and Medicine", Bologna, Italy, 1997
Speaker, EMF - Scientific and Legal Issues, Catania, Italy, 2002
Speaker, Chemistry and Biochemistry Departments, CUNY. 1998

MARTIN BLANK

Speaker, 10th International Congress on Stress, Montreux, Switzerland, 1999
Speaker, Electromed99, Norfolk, VA, 1999
Speaker, Tutorial on Magnetic Fields, Procter & Gamble, Cincinnati, 1999
Speaker, Potential Therapeutic Applications of Magnetic Fields, Vanderbilt Univ, 1999
Speaker, North American Academy of Magnetic Therapy, Los Angeles, 2000
Speaker, 3rd International Conference on Bioelectromagnetism, Slovenia, 2000
Speaker, Electromed2001, Portsmouth, VA, 2001
Speaker, EBFA Conference on EMF, Helsinki, 2001
Plenary Lecturer, Bioelectromagnetics Society, Quebec, Canada, 2002
Speaker, XXVII URSI General Assembly, Maastricht, Netherlands, 2002
Speaker, EMF - Scientific and Legal Issues, Catania, Italy, 2002
Speaker, Physics Colloquium, University of South Florida, 2003
Speaker, RIFE Conference. Topic: Electromagnetic Fields and Living Cells. Seattle, 2004
Plenary Lecturer, Conference 'Biological Effects of Electromagnetic Fields', Kyoto, Japan, 2005
Speaker, Conference on EMF and the Precautionary Principle, Benevento, Italy, 2006
Keynote Speaker, Conference on Cell Towers and Wireless Technologies, Everett, MA, 2007
Invited lecturer on Biological Effects of EM Fields, Chamber of Deputies, Brasilia, Brazil, 2007
Speaker, Conference on Responsible Cell Tower Siting. Cornwall, CT, 2008

Grant Review Consultant

Office of Naval Research, Department of Defense
IPA Biologist, Manager of Membrane Electrochemistry ARI, 1986-1988
Chairman, Panel on Biological Sciences Div, August 1986
Member, Panel on Interdisciplinary Research, April 1979
Electric Power Research Institute, Palo Alto, CA
Member, Basic Sciences Advisory Committee, 1987-1991
National Institutes of Health
Radiation Study Section, 1991
(several ad hoc Study Sections and site visit committees)
National Science Foundation
US Army Research Office
US-Israel Binational Science Foundation
Petroleum Research Fund
Medical Research Council - Canada
Australian Research Grants Committee
Research Corporation (Providence, Rhode Island)
University and Polytechnic Grants Committee, Hong Kong
International Science Foundation (for Former Soviet Union), Washington, DC
Breast Cancer Research Program, University of California
US Army Medical Research and Materiel Command, Neurotoxin Exposure Program, AIBS
US Army Radiofrequency Radiation Research Program, AIBS

Consultant to various environmental groups on biological effects of electromagnetic fields (power frequency and radiofrequency)

PUBLICATIONS - Books, Reviews, Chapters

1. Blank M (1957) The Transfer of Monolayers through Surface Channels. **PhD Dissertation**, Chemistry Department, Columbia University, 54pp.
2. Blank M (1959) The Permeability of Monolayers to Carbon Dioxide and Oxygen. **PhD Dissertation**, Department of Colloid Science, Cambridge University, England, 105pp.
3. Blank M (1967) Editor, Symposium "Surface Chemistry of Biological Systems". **Journal of Colloid and Interface Science** 24:1-127.
4. Blank M and Britten JS (1970) Physical Principles in Monolayer and Membrane Permeation. in "**Physical Principles of Biological Membranes**", edited by F Snell et al; Gordon & Breach, New York, pp 143-163.
5. Blank M (1970) Editor, "**Surface Chemistry of Biological Systems**". Volume 7, "Advances in Experimental Medicine and Biology", Plenum Press, New York, 340pp.
6. Blank M (1972) The Measurement of Monolayer Permeability, in "**Techniques of Surface Chemistry and Physics**", Volume I. Good, Stromberg, Patrick (eds); Marcel Dekker Inc., New York, pp 41-88
7. Blank M (1979) Monolayer Permeability. **Progress in Surface & Membrane Science** 13:87-139.
8. Blank M (1979) Surface Pharmacology: Drug Binding Equilibria and Ion Transport in Membrane Structures. **Pharmacology and Therapeutics** 7:313-328.
9. Blank M (1980) Editor, "**Bioelectrochemistry: Ions, Surfaces and Membranes**", Advances in Chemistry, Volume 188, American Chem Soc, Washington, DC, 527pp.
10. Blank M (1981) Surface Pharmacology: Drug Binding Equilibria and Ion Transport in Membrane Structures, in **International Encyclopedia of Pharmacology and Therapeutics**, Inhibitors of Mitochondrial Functions, M Erecinska, DF Wilson (eds). Pergamon, New York, pp 19-34.
11. Milazzo G and Blank M (1983) Editors, "**Bioelectrochemistry I: Biological Redox Reactions**", School of Biophysics, Erice, Italy. Plenum, New York, 348pp.
12. Blank M (1983) Transmembrane Potentials and Redox Reactions from the Physiological Point of View. in "**Bioelectrochemistry I: Biological Redox Reactions**", G Milazzo, M Blank (eds), Plenum, New York, pp 227-247.
13. Blank M (1983) The Effects of Surface Compartments of Ion Transport Across Membranes. in "**Structure and Function in Excitable Cells**", DC Chang, I Tasaki, WJ Adelman, HR Leuchtag (eds); Plenum, New York, pp. 435-449.
14. Blank M (1986) Editor, "**Electrical Double Layers in Biology**", Plenum, New York, 319pp
15. Blank M (1987) The Surface Compartment Model: A Theory of Ion Transport Focused on Ionic Processes in the Electrical Double Layers at Membrane Protein Surfaces. **Biochimica et Biophysica Acta - Reviews on Biomembranes** 906:277-294.
16. Blank M and Findl E (1987) Editors, "**Mechanistic Approaches to the Interaction of Electric and Electromagnetic Fields with Living Systems**", Plenum, New York, 439pp.
17. Milazzo G and Blank M (1987) Editors, "**Bioelectrochemistry II: Membrane Phenomena**", International School of Biophysics, Erice, Italy. Plenum, New York, 543pp.
18. Blank M (1987) An Electrochemical Perspective on Excitable Membranes, Channels and Gating. in "**Bioelectrochemistry II: Membrane Phenomena**", G Milazzo, M Blank (eds); Plenum, New York, pp. 431-456.
19. Blank M (1988) Recent Developments in the Theory of Ion Flow Across Membranes Under Imposed Electric Fields. In "**Modern Bioelectricity**", AA Marino (ed); Dekker, New York, pp 345-364.
20. Markov M and Blank M (1988) Editors, "**Electromagnetic Fields and Biomembranes**", Plenum, New York, 309pp.
- Blank M (1990) Editor, **Syllabus for Human Physiology Course**, 13th Edition, Physiology Department, Columbia University, New York, 704pp.
22. Milazzo G and Blank M (1990) Editors, "**Bioelectrochemistry III: Charge Separation across**

- Membranes**", Plenum, New York, 337pp.
23. Blank M (1991) Membrane Transport: Insight from Colloid Science. in **"Interfacial Phenomena in Biological Systems"**, M Bender (ed). Dekker, New York, pp 337-366.
 24. Blank M (1993) Electrochemistry of Nerve Excitation, **"Modern Aspects of Electrochemistry"** Number 24, edited by RE White et al, Plenum, New York, pp1-37.
 25. Blank M (1993) Editor-in-Chief, Proceedings of First World Congress on **"Electricity and Magnetism in Biology and Medicine"**, San Francisco Press, 952pp.
 26. Blank M and Vodyanoy I (1994) Editors, **"Biomembrane Electrochemistry"**, Advances in Chemistry Series of the American Chemical Society Press, 605pp.
 27. Blank M (1994) An Electrochemical Model of Voltage Gated Channels. **Advances in Chemistry** 235:429-446.
 28. Melandri BA, Milazzo G and Blank M (1994) Editors, **"Bioelectrochemistry IV: Nerve-Muscle Function"**. Life Sciences Volume 267, Plenum, New York, 376pp.
 29. Blank M (1995) Editor, **"Electromagnetic Fields: Biological Interactions and Mechanisms"**, **Advances in Chemistry**, Volume 250, American Chemical Society Press, 512pp.
 30. Blank M (1995) Biological Effects of Electromagnetic Fields: An Overview. **Advances in Chemistry** 250:3-12.
 31. Blank M (1995) Electric Stimulation of Protein Synthesis in Muscle. **Advances in Chemistry** 250:143-153.
 32. Blank M (1995) Electric and Magnetic Field Signal Transduction in the Membrane Na,K-ATPase. **Advances in Chemistry** 250:339-348.
 33. Goodman R and Blank M (1995) The Biosynthetic Stress Response in Cells Exposed to Electromagnetic Fields. **Advances in Chemistry** 250:423-436.
 34. Blank M (1997) Effects of Electromagnetic Fields on Cells as a Basis for Therapy. in **Proceedings of the First World Congress in Magnetotherapy**, pp. 151-156, London, May 1996.
 35. Blank M (1997) Studies on the Mechanism of Electromagnetic Field Interactions with Cells; I-The Cellular Stress Response in Electromagnetic Fields; II-Electric and Magnetic Signal Transduction in a Membrane Protein. **Electric Power Research Institute Report TR-108947**, 99 pp.
- Goodman R and Blank M (1998) Magnetic Field Induces Expression of hsp70. **Cell Stress and Chaperones** 3:79-88.
37. Goodman R and Blank M (2002) Insights into Electromagnetic Interaction Mechanisms. **Journal of Cellular Physiology** 192:16-22.
 38. Blank M and Goodman R (2004) Initial interactions in electromagnetic field-induced biosynthesis. **Journal of Cellular Physiology** 199:359-363.
 39. Blank M (2008) Protein and DNA Reaction Stimulated by Electromagnetic Fields. **Bioelectromagnetic Biology and Medicine** 27: 3-23.

PUBLICATIONS - Papers

1. LaMer VK and Blank M (1956) The Transfer of Surface Films through Surface Channels- Geometrical Factors. **Journal of Colloid Science** 11:608-616. 1956.
2. Blank M and LaMer VK (1957) The Mechanism of Transfer of Surface Films. Proceedings of the **Second International Congress on Surface Activity**, Vol II, pp 102-108.
3. Blank M and LaMer VK (1957) The Transfer of Monolayers through Surface Channels - II. Mechanism. **Journal of Physical Chemistry** 61:1611-1614.
4. Blank M and Roughton FJW (1960) The Permeability of Monolayers to Carbon Dioxide. **Transactions of the Faraday Society** 56:1832-1841.
5. Blank M (1961) The Effect of Vapors on Monolayer Permeability to Carbon Dioxide. **Journal of Physical Chemistry** 65:1698-1703.
6. Blank M and LaMer VK (1962) The Energy Barrier for Monolayer Penetration, in "**Retardation of Evaporation by Monolayers**", edited by VK LaMer. Academic Press, New York, pp. 59-66.
7. Blank M (1962) The Permeability of Monolayers to Several Gases, in "**Retardation of Evaporation by Monolayers**", edited by VK LaMer. Academic Press, New York, pp. 75-95.
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Book Reviews

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EXHIBIT B



**NIEHS
REPORT on**

*Health Effects from Exposure to
Power-Line Frequency Electric and
Magnetic Fields*

Prepared in Response to the 1992 Energy Policy Act
(PL 102-486, Section 2118)



NIEHS

*National Institute of Environmental Health Sciences
National Institutes of Health*

Supported by the NIEHS/DOE



NIH Publication No. 99-4493

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Health Effects from Exposure to Power-Line
Frequency Electric and Magnetic Fields

Prepared in Response to the 1992 Energy Policy Act
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National Institute of Environmental Health Sciences
National Institutes of Health

Dr. Kenneth Olden, Director

Prepared by the
NIEHS EMF-RAPID Program Staff

NIH Publication No. 99-4493

Supported by the NIEHS/DOE





National Institutes of Health
National Institute of
Environmental Health Sciences
P. O. Box 12233
Research Triangle Park, NC 27709

May 4, 1999

Dear Reader:

In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act. The Congress instructed the National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health and the U.S. Department of Energy (DOE) to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to extremely low frequency electric and magnetic fields (ELF-EMF). The EMF-RAPID Program had three basic components: 1) a research program focusing on health effects research, 2) information compilation and public outreach and 3) a health assessment for evaluation of any potential hazards arising from exposure to ELF-EMF. The NIEHS was directed to oversee the health effects research and evaluation, and the DOE was given the responsibility for overall administration of funding and engineering research aimed at characterizing and mitigating these fields. The Director of the NIEHS was mandated upon completion of the Program to provide this report outlining the possible human health risks associated with exposure to ELF-EMF. The scientific evidence used in preparation of this report has undergone extensive scientific and public review. The entire process was open and transparent. Anyone who wanted "to have a say" was provided the opportunity.

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although sporadic findings of biological effects have been reported. No indication of increased leukemias in experimental animals has been observed.

The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results. The human data are in the "right" species, are tied to "real life" exposures and show some consistency that is difficult to ignore. This assessment is tempered by the observation that given the weak magnitude of these increased risks, some other factor or common source of error could explain these findings. However, no consistent explanation other than exposure to ELF-EMF has been identified.

Epidemiological studies have serious limitations in their ability to demonstrate a cause and effect relationship whereas laboratory studies, by design, can clearly show that cause and effect are possible. Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between exposure to ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiological findings.


The NIEHS concludes that ELF-EMF exposure cannot be recognized at this time as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. In my opinion, the conclusion of this report is insufficient to warrant aggressive regulatory concern. However, because virtually everyone in the United States uses electricity and therefore is routinely exposed to ELF-EMF, passive regulatory action is warranted such as a continued emphasis on educating both the public and the regulated community on means aimed at reducing exposures. The NIEHS does not believe that other cancers or non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern.

The interaction of humans with ELF-EMF is complicated and will undoubtedly continue to be an area of public concern. The EMF-RAPID Program successfully contributed to the scientific knowledge on ELF-EMF through its support of high quality, hypothesis-based research. While some questions were answered, others remain. Building upon the knowledge base developed under the EMF-RAPID Program, meritorious research on ELF-EMF through carefully designed, hypothesis-driven studies should continue for areas warranting fundamental study including leukemia. Recent research in two areas, neurodegenerative diseases and cardiac diseases associated with heart rate variability, have identified some interesting and novel findings for which further study is ongoing.

Advocacy groups have opposing views concerning the health effects of ELF-EMF. Some advocacy groups want complete exoneration and others want a more serious indictment. Our conclusions are prudent and consistent with the scientific data. I am satisfied with the report and believe it provides a pragmatic, scientifically-driven basis for any further regulatory review.

I am pleased to transmit this report to the U.S. Congress.

Sincerely,



Kenneth Olden, Ph.D.
Director

TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
INTRODUCTION	i
NIEHS CONCLUSION	ii
BACKGROUND	iii
<i>Program Oversight and Management</i>	iii
<i>ELF-EMF Health Effects Research</i>	iv
<i>Information Dissemination and Public Outreach</i>	iv
<i>Health Risk Assessment of ELF-EMF Exposure</i>	v
INTRODUCTION	1
<i>Funding</i>	2
<i>Oversight and Program Management</i>	3
<i>ELF-EMF Health Effects Research</i>	3
<i>Information Dissemination and Public Outreach</i>	4
<i>Literature Review and Health Risk Assessment</i>	6
DO ELECTRIC AND MAGNETIC FIELDS POSE A HEALTH RISK?	9
SCIENTIFIC EVIDENCE SUPPORTING THIS CONCLUSION	10
<i>Background on the Limitations of Epidemiology Studies</i>	10
<i>Childhood Cancers</i>	12
<i>Adult Cancers</i>	15
<i>Non-Cancer Findings in Humans</i>	16
<i>Animal Cancer Data</i>	19
<i>Non-Cancer Health Effects in Experimental Animals</i>	23
<i>Studies of Cellular Effects of ELF-EMF</i>	25
<i>Biophysical Theory</i>	29
HOW HIGH ARE EXPOSURES IN THE U.S. POPULATION?	31
CONCLUSIONS AND RECOMMENDATIONS	35
<i>Previous Panel Reviews</i>	35
<i>NIEHS Conclusion</i>	35
<i>Recommended Actions</i>	37
<i>Future Research</i>	38
REFERENCES	41

EXECUTIVE SUMMARY

Introduction

Electrical energy has been used to great advantage for over 100 years. Associated with the generation, transmission, and use of electrical energy is the production of weak electric and magnetic fields (EMF). In the United States, electricity is usually delivered as alternating current that oscillates at 60 cycles per second (Hertz, Hz) putting fields generated by this electrical energy in the extremely low frequency (ELF) range.

Prior to 1979 there was limited awareness of any potential adverse effects from the use of electricity aside from possible electrocution associated with direct contact or fire from faulty wiring. Interest in this area was catalyzed with the report of a possible association between childhood cancer mortality and proximity of homes to power distribution lines. Over the next dozen years, the U.S. Department of Energy (DOE) and others conducted numerous studies on the effects of ELF-EMF on biological systems that helped to clarify the risks and provide increased understanding. Despite much study in this area, considerable debate remained over what, if any, health effects could be attributed to ELF-EMF exposure.

In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID Program) in the Energy Policy Act (PL 102-486, Section 2118). The Congress instructed the National Institute of Environmental Health Sciences (NIEHS), National Institutes of Health and the DOE to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to ELF-EMF. The EMF-RAPID Program had three basic components: 1) a research program focusing on health effects research, 2) information compilation and public outreach and 3) a health assessment for evaluation of any potential hazards arising from exposure to ELF-EMF. The NIEHS was directed to oversee the health effects research and evaluation and the DOE was given the responsibility for overall administration of funding and engineering research aimed at characterizing and mitigating these fields. The Director of the NIEHS was mandated upon completion of the Program to provide a report outlining the

possible human health risks associated with exposure to ELF-EMF. This document responds to this requirement of the law.

This five-year effort was signed into law in October 1992 and provisions of this Act were extended for one year in 1997. The Program ended December 31, 1998. The EMF-RAPID Program was funded jointly by Federal and matching private funds and has been an extremely successful Federal/private partnership with substantial financial support from the utility industry. The NIEHS received \$30.1 million from this program for research, public outreach, administration and the health assessment evaluation of ELF-EMF. In addition to EMF-RAPID Program funds from the DOE, the NIEHS contributed \$14.5 million for support of extramural and intramural research including long-term toxicity studies conducted by the National Toxicology Program.

NIEHS Conclusion

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults. While the support from individual studies is weak, the epidemiological studies demonstrate, for some methods of measuring exposure, a fairly consistent pattern of a small, increased risk with increasing exposure that is somewhat weaker for chronic lymphocytic leukemia than for childhood leukemia. In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although sporadic findings of biological effects (including increased cancers in animals) have been reported. No indication of increased leukemias in experimental animals has been observed.

The lack of connection between the human data and the experimental data (animal and mechanistic) severely complicates the interpretation of these results. The human data are in the "right" species, are tied to "real-life" exposures and show some consistency that is difficult to ignore. This assessment is tempered by the observation that given the weak magnitude of these increased risks, some other factor or common source of error could explain these findings. However, no consistent explanation other than exposure to ELF-EMF has been identified.

Epidemiological studies have serious limitations in their ability to demonstrate a cause and effect relationship whereas laboratory studies, by design, can clearly show that cause and effect are possible. Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between exposure to ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this