

When British Columbia Hydro, which was constructing a powerline on Vancouver Island, notified John Marton of its intention to take some of his land, he raised concerns about possible health risks, especially cancer. The company gave him a copy of a letter by a questionnaire expert named David Savitz in which he had said there was no proof that powerline EMFs caused cancer. Marton asked BC Hydro whether he or the company had the burden of proving safety, but received no reply.

In the meantime Sophie Antigone, another property owner, had become suspicious when the company would not guarantee that the powerline would not pose a health risk to her family. She had begun searching for information on EMF health effects, and came across various scientific articles that appeared to support her concerns about EMFs, including some articles that I had written. Antigone, who was a young mother with no education, complained to a local government board that the powerline might cause cancer, and she organized a citizens committee to work toward rerouting it away from populated areas. The committee filed a complaint with the Canadian provincial ombudsman.

At a meeting with Marton and Antigone, BC Hydro reiterated its position that there was no scientific evidence to indicate a conclusive relationship between EMFs and an increase in disease. Nevertheless, the company offered to purchase their properties at fair market value on the condition that they not pursue their complaint. Marton immediately accepted the offer. Antigone insisted that it be extended to everyone whose property was adjacent to the right-of-way, but the company refused.

In defiance of the scientific advice she had received from the company, Sophie made presentations about EMF health concerns to an elementary school parents' group, a teachers' association, and to the school board, and all three groups requested that BC Hydro reroute the line because of possible health effects. But the company, citing the increased costs, turned down the requests and said it saw no substantial evidence that the powerline EMFs would be a health risk. The company then hired the Environmental

Information Corporation, a consulting firm that specialized in reviewing research on EMFs, to give lectures to the residents about powerline EMFs. The EIC experts said that living near powerlines was no different than using microwave ovens, and that many blue-ribbon committees had concluded after thorough investigations there was no reason to believe that exposure to EMFs posed a risk to human health.

Despite these steps, public pressure on BC Hydro continued to rise, and the ombudsman turned the matter over to the British Columbia Utilities Commission. The company attempted to defuse the situation by extending the buy-out offer to all the residents along the powerline, as Sophie Antigone had requested earlier. The offer extension, however, had the opposite effect because many people who lived beside existing powerlines interpreted it to mean that BC Hydro recognized EMFs as health risks. The commission was then flooded with questions and complaints, and it responded with press releases attributing the furor to misinformation and lack of information. But that didn't stanch the public's concern, so the commission decided to hold a public hearing with John McIntyre, the commission chairman, as the judge.

British Columbia Hydro announced who their lawyers and experts would be, and McIntyre appointed an attorney named Karl Gustavson to represent the commission. The local residents, however, had no money to hire a lawyer or an expert. British Columbia Hydro had initially promised to pay for the services of an expert chosen by Sophie's committee, but the company withdrew its offer when it learned that I had been picked. The committee then organized bottle drives, telephone contacts of local businesses, and a flea market to raise the money to hire me. Donors were assured of a seat at a public lecture that I had been scheduled to give. The committee could not afford to hire both me and a lawyer, but the provincial government donated the services of a lawyer who, I soon learned, was worth exactly what the committee paid him.

I arrived on the island and was taken to a dinner in my honor where we had salmon that had been cooked ten different ways. Afterwards, at a school auditorium, hundreds of island residents gave me standing ovations, both before and especially after I had finished my lecture.

That night I decided to have a drink at my hotel before I went to my room. As I sat on a couch in the lobby a stranger approached and sat opposite me, and after a few moments he asked, "Did you notice anything unusual about this island?"

"What do you mean?" I asked.

"I've been here for three days but I haven't seen any houses with aluminum siding."

"I hadn't noticed that," I said, "but I've only been here for a few hours."

"I used to install aluminum siding," he said.

"I know nothing about that," I said. "Is it a good business?"

"It was," he said, "but people switched to vinyl, so I decided to try something new."

"What was that?" I asked.

"I went back to school and got my Ph.D.," he replied." I taught for a while but now I work for a company called EIC. I've been there almost two months, specializing in a new subject called electromagnetic fields. They're all over the place, especially near high-voltage powerlines."

"Is there money to be made in electromagnetic fields?" I asked.

"Yes," he said, "for people who can talk well about them."

"Are electromagnetic fields good or bad?"

"I'll be giving a speech about that tomorrow," he said.

Just then a man came running up to us. He was extremely thin from side to side but not from front to back, like a herring. "Dr. Marino," he said, "I'm Karl Gustavson. I represent the commission. It is grossly improper for opposing experts to talk to one another. You should immediately stop talking with Dr. Erdgas." Upon hearing that, Erdgas departed.

The next morning, at the hearing, Sophie Antigone told McIntyre that BC Hydro had not been forthright in explaining the potential health hazards of the powerline. "We are not radical people, and we are not trying to hurt anyone. But we feel as if we are part of a massive experiment, and we choose not to be experimented on."

When Erdgas took the witness stand, BC Hydro's lawyer performed a *voir dire* to persuade McIntyre that Erdgas was a true expert. He testified that he worked for EIC, but didn't mention that the company was owned by former employees of the Electric Power Research Institute or that EPRI was EIC's biggest client. He said he had earned a Ph.D. from the University of Oklahoma and, after completing fellowships in neurobiology and pharmacology at the National Institutes of Health and at Cornell, he had become an Assistant Professor at Johns Hopkins, which he left to work for EIC. He didn't reveal that fellowships were no big deal because any

Ph.D. could get one, or that he had been asked to leave Hopkins because his research had been below par. He said he had conducted research on the electrical properties of cells, but he didn't make it clear that the work had nothing whatever to do with powerlines, or EMFs. At that point the lawyer offered Erdgas as an expert on the subject of the biological effects of electromagnetic fields. McIntyre said, "He certainly seems qualified." The lawyer then asked Erdgas to give his opinion about the suggestion that powerline EMFs were hazardous to health. In response, Erdgas gave one of the best pro-industry speeches about EMFs I had ever heard.

"At the outset, I think it would be helpful to indicate the methods of analysis that I used to evaluate the scientific evidence. First, I identified the available scientific research that was relevant to the question of whether powerline EMFs can produce biological effects of any kind. The gold standard consists of data from laboratory and animal studies, because people won't participate in studies if they are expected to donate tissues for analysis. Of course it's not possible for me to discuss every single study, but I have considered all the EMF studies in forming my opinion.

"Second, I analyzed the reports to determine whether the experimental methods used were correct, the data was reliable, and the conclusions drawn from the data were sound. The criteria I used to make these judgments were those used routinely by experts. These include insuring that the results of a given experiment were internally consistent, quantifiable, replicable, and that rigorous statistical analysis was used to test whether the effect was real or due to chance.

"Third, I considered collectively the body of the individual studies that were analyzed in order to assess their consistency, reliability, and coherence.

"Adhering to this three-step analysis is particularly important because many of the EMF studies have been inconclusive and contradictory. It's not difficult to discern why. The conduct of experiments in this arena requires use of sophisticated engineering concepts, fundamental principles of physics, and thorough knowledge of biology. If one of these factors is missing, the results obtained will be artifactual.

"Although a broad range of responses to EMFs by animals, isolated tissues, and cells have been reported, few of the reported responses have been replicated. Of those that have been replicated, none are serious enough to be considered hazardous. Some of the animals sensed the presence of EMFs because of stimulation of body fur, much in the same way that we

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sense static electricity when combing our hair in dry winter weather. Graves showed that such reactions come and go in an instant, like the Cheshire cat which disappeared, leaving only a smile.

"Reduction of melatonin from the pineal gland has been reported sporadically in rodents and monkeys. However, the melatonin levels returned to normal after a few days.

"Graham performed thorough and well-controlled studies of possible effects of powerline EMFs on human performance and physiology. He evaluated physiological, sensory, neural, motor, perceptual, and cognitive function including respiration, heart rate, visual acuity, focused attention, short-term memory, time perception, information processing, and decisionmaking. No significant effects were observed on sleep, appetite, sexual activity, cognitive and physical functions, anger, fatigue, confusion, and depression, blood pressure, or temperature. There was a small change in heart rate, only about 3 beats per minute, which can be caused by a person taking a deep breath. There were a few minor changes in brain waves, but they were so slight that they fell within the normal range. Thus, powerline EMFs do not appear to affect animal or human health, or mental perception or performance.

"Animal experiments have been performed to examine the possible effects of EMFs on reproduction and fetal development. As a whole, these reports provide no conclusive evidence that EMF exposure constitutes a reproductive health hazard. Marino was the first investigator to conduct experiments in this area. He reported increased fetal mortality in animals exposed to powerline EMFs. However, Phillips, Graham, Seto, Sykov, and Rommerein all were unable to reproduce his results. Either Marino is wrong, or all of the other investigators were wrong, and in my opinion the former conclusion is more reasonable.

"A number of responses have been documented in cells and tissues. They include altered calcium levels in the brains of chicks, decreased RNA levels in the salivary glands of flies, enhanced DNA synthesis and enzyme production in various types of mammalian cells. These findings, however, have been extremely difficult to apply to the resolution of uncertainties about human risks associated with EMFs. The strength of the EMF used was well above that produced by powerlines. Moreover, there were no dose-response relationships. That is, the cell, tissue, or animal effect does not increase correspondingly with increased exposure level. The ab-

sence of a dose-response relation is contrary to the known mode of action of toxic agents.

"It is clear from all this evidence that there is no scientific basis for claiming a link between exposure to EMFs and health risks to humans."

When Erdgas finished his story McIntyre said, "I don't profess to be able to understand this at all. I never got past high school biology, so I couldn't possibly understand this science. But I want to say that I think your testimony was thorough and complete. Thank you very much."

For the longest time, the poor lawyer who represented the residents remained slouched in his chair with his head pointed down and one hand cupped over his eyes. Finally, he arose and walked toward the witness stand and began his cross-examination of Erdgas, who looked more confident and self-assured than when he had first taken the stand, if that were possible.

"Dr. Marino's research was published in well-respected and prestigious journals. Doesn't that indicate that the results were correct?" he asked.

"Not necessarily. Publication is evidence of merit, not perfection. The purpose of publishing articles is to allow other scientists to see and evaluate them."

"Then is it your opinion that the powerline will be safe?"

"There is no indication of potential health risks of concern."

"Doesn't it matter how long someone is exposed to the EMF?"

"I don't like to make sweeping generalizations, but a health risk is usually related to the amount of exposure only if something is proven to be a potential hazard to begin with, which is not the case with EMFs."

"Is it fair to say the causes of many diseases are unknown?"

"We have different amounts of information on different diseases, but there are very few where we know all the factors."

"How can you say that the powerline is safe if the causes or potential causes of various health effects are unknown?" the lawyer asked.

"If we don't know what causes leukemia, that doesn't mean that this powerline causes it, unless we have evidence," Erdgas responded, and then smiled broadly. After his testimony ended I told the hapless lawyer, "Congratulations, you had him eating out of the palm of your hand."

When I took the witness stand, that sorry excuse for a lawyer who represented the committee asked me to give my opinion regarding whether the EMFs from the proposed powerline would be hazardous to health. I said, "If you look at the many hundreds of studies, and you discount the ones that lead nowhere, that is the industry-funded studies, you're led to the conclusion that powerline EMFs are biological stressors. It is well established that chronic exposure to stressors promotes disease because it taxes the body's adaptive capacity. So, I expect that people who live beside the powerline will become sick more often, earlier, or both, than would otherwise have been the case. Exposing people to these EMFs without their consent amounts to involuntary human experimentation. If a proposal were made in a medical school to expose people to exactly the same EMFs without first obtaining informed consent, the proposal would never be approved. Maybe it would be approved in Nazi Germany, but not in America."

At that point McIntyre, who had been more or less somnolent during the day's proceedings, spoke up and asked me, "Could an honest and objective scientist conclude, based on the evidence to date, that EMFs from powerlines do not pose a health risk?"

"That would be against the weight of the evidence. To reach that conclusion you must ignore part of the data," I replied.

"Dr. Erdgas told us that it has not been proven that EMFs cause cancer or other diseases. Isn't that a true statement?" he asked.

"A better question would be to ask what Dr. Erdgas means by that statement. The laboratory definition is that a cause is a factor linked to an effect that doesn't occur when that factor is absent *but all other conditions remain the same*, or nearly so, which is a situation that can be created in the laboratory. Outside the laboratory there can never be such a cause, however, because the conditions in the world cannot be controlled. For cancer, therefore, we can only speak of predisposing factors, not laboratory-type causes. If Dr. Erdgas meant to apply the laboratory definition to the world outside the laboratory, his statement is true, but meaningless because such proof is impossible. If he intended the proper meaning of cause, his statement is false."

"Well I suppose we have a situation where there are conflicting opinions," McIntyre said.

"It's not the scientific situation that is the cause of the conflict," I said, "it's money. Every study that Erdgas relied on for support was paid for and run by the power companies. It's been my experience that if a power company has anything to do with a study, if it designs it, pays for it, analyzes it, or pays to have it analyzed, then the study is tainted and worthless."

"My paycheck comes from the provincial government," McIntyre said,

"and BC Hydro is a Crown corporation, but that doesn't mean I can't be fair to its opponents. I do not understand your reasoning."

"It's not a matter of reasoning," I said, "but one of power. He who has the gold has made the rules."

When McIntyre had finished, the lawyer he had appointed to represent the commission, Karl Gustavson, began his cross-examination by announcing to me, "During the course of your evidence you've made a number of what can only be characterized, even in the most conservative terms, as highly controversial statements. Some would characterize them as inflammatory and potentially slanderous or libelous. You've made allusions to Nazi Germany, branded a host of scientists as little more than dishonest prostitutes, and made allegations regarding international –"

"Now wait a minute," I said, "wait a minute -"

"Allow me to finish my question and I'll let you -"

"This is ridiculous," I said. "I didn't make any slanderous statements, and I'm prepared to back up my testimony if you want to go into it. If you do, then ask me questions. Don't give a speech. I didn't come here to listen to your opinion."

"I want to ask you a serious question," he said.

"That's better," I said.

"You've made allegations concerning a conspiracy to suppress information. You said that certain studies had been kept secret and couldn't be accessed."

"What are you referring to?"

"Did you not say that power companies had worked together to suppress certain scientific data?"

"No, you're misrepresenting my testimony. It's possible that the decision to suppress scientific data was made independently by each company."

"Did you not say that certain studies had been kept secret?"

"Certainly. Anyone who knows the first thing about the powerline EMF controversy knows that. And that's not half the hanky-panky the power companies have done."

"Well, what I'm concerned about is that many of the statements that you've made have been cast in extremely strong terms. Have you given any consideration to the effect of that kind of statement on your position as a research scientist, and to the weight that people will attach to the results of your research, given the strength of your convictions and the way you phrase them in this kind of forum?"

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"I told the truth," I said. "If you can't handle the truth, that's your problem. Although there are exceptions, the general rule is that the studies performed by industry are rigged to support whatever conclusion best serves the industry."

"Rigged studies implies that people are deliberately seeking to disguise or to hide the truth, or to falsify results. Scientists wouldn't do that," he said.

"You just don't know the territory, and you don't know what you're talking about," I said. "Richard Phillips received many multi-million-dollar contracts, which supported his lifestyle and thirty employees that answer to him. In return he provided power-company witnesses like Dr. Erdgas the ammunition to argue that powerlines were safe." With that, McIntyre brought my testimony to an abrupt halt.

As far as I could tell, no minds were changed as a result of the hearing, and the affair ended at more or less the same point it had been before I became involved. Some of the residents along the right-of-way accepted BC Hydro's buy-out offer and went to live elsewhere. The company quickly resold the land, subject to the provision that neither the new owners nor their heirs or assigns would object to powerline EMFs.

Just as the powerline conflict on Vancouver Island was ending, a similar problem was beginning in Palm Beach County, Florida, where some businessmen had built a gated subdivision of expensive houses. Their spokesman was a world-class diver who had won many Olympic medals, and his reputation had helped to sell many of the houses. A high-voltage powerline ran along one edge of the subdivision into a switchyard; there, power was delivered underground to the homes. The homeowners had young children, and the businessmen offered to donate land to the school board of Palm Beach County provided it built an elementary school on the donated property, which contained the powerline and switchyard. Land in the county was expensive, so the board accepted. The board built Sandpiper Elementary School beside the switchyard, and used the open space under the powerline as the playground.

Sherry Robinson was the mother of one child who attended Sandpiper. The Robinsons once had a son, but he had died from a brain tumor. At that time they had lived near a high-voltage powerline and an Air Force radar installation. Sherry had not immediately connected her son's tumor with EMFs, but after a while she had begun to wonder about it. She bought an EMF meter, and began to take measurements at Sandpiper. As she moved

from place to place around the school, the meter needle danced wildly. When she placed it on a desktop, the needle wandered randomly during the course of a day. On the playground, underneath the wires, the needle became pinned against the stop on the right side of the meter.

Sherry told other parents about the measurements. Many of the fathers were dismissive because they knew that Sherry was no expert in measuring EMFs, much less in interpreting their significance. Some of the mothers, however, had read about a possible connection between EMFs and cancer, and they particularly worried about the implications of various questionnaire studies that linked childhood cancer and powerlines. When some of the apprehensive parents approached the school board, the superintendent told them that engineers at Florida Atlantic University had measured EMF values at Sandpiper that were comparable to those found in the average house. The superintendent also said that twenty-four schools in Palm Beach County were located next to powerlines, and that there had not been any problem with unusually high numbers of cancer among the children. When Sherry pointed out some alarming news reports, including my interview with Mike Wallace on 60 Minutes, that had occurred more than a decade earlier, he told her that his children had attended the schools in Palm Beach County and that they had all survived. "Kids are used to EMFs," he said. "They've grown up with TV's, microwave ovens, electric blankets, and clock radios." When the power company told the parents that it would not consider undergrounding the powerline without conclusive evidence of harm, some of them petitioned the school board to allow their children to attend a school that was not located next to a powerline, but the board denied their requests.

The parents continued to complain, so the superintendent hired a local physician to determine whether the EMFs were harmless or harmful. He concluded, "I certainly believe that there are some effects on humans from exposure to EMFs. The question of whether or not this exposure causes disease is really the problem. To date, there are *no* scientifically reproducible data that EMFs cause cancer or any other human disease." The physician's opinion did not satisfy the parents, so the superintendent decided to hold a workshop to educate them about EMFs and powerlines. The list of scientists who might be hired to run the workshop included me, but the superintendent chose Phillip Keine, an expert in questionnaire studies.

At the workshop Keine told the people that the school was as safe as

an individual's home, and that he would not be fearful in sending his children there. The parents, however, continued to worry about what the consequences might be if the children sat in an EMF all day and played in the even stronger EMF under the wires. When the school board refused for a second time to allow children to transfer to another school, the parents sued the school board. The power company volunteered to defend the school board and hired a famous lawyer named Patty Ryan. I agreed to testify on their behalf *pro bono*, and to encourage other volunteers to appear in court on behalf of the parents.

I did not ask David Savitz because I knew that most of his money for conducting questionnaire studies about EMFs came from the Electric Power Research Institute which, in my experience, had never permitted anyone in its herd of EMF contractors to testify in court. The questionnaire expert I did ask to testify was Nancy Wertheimer, who had written the famous report about powerline EMFs and childhood cancer. But she declined, as did Dr. Becker. They both had testified in an EMF case in Wisconsin where a federal judge had treated them contemptuously, almost calling them incompetent and ignorant. With their eyes fixed on the stars, those well-meaning but naïve people had stumbled into every kind of trap imaginable that had been set for them by the lawyers who opposed their testimony. I asked Harris Busch, the pharmacologist who had testified with great success against a power company in Houston that had built a powerline next to a school, and Allan Frey, who had become well known for his interest in the health consequences of EMFs. I asked Stephen Smith who was famous for his theory of cyclotron resonance which some thought could explain at a deep level how EMFs affected cells, and Ross Adey, who was the acclaimed inventor of the "window" theory by which EMFs were said to affect cells. All of those whom I contacted were unable, for one reason or another, to travel to Florida to testify on behalf of the parents. I went alone.

As I walked to the courthouse with a group of the parents on the first day of the trial, we saw a hawk attack a pigeon and knock it down. "That's a good omen," one of the mothers said. "It means we will win our case." Some of the other mothers smiled in hopeful agreement, but one said, "Maybe it means we will lose." One of the fathers, a computer engineer, said, "It doesn't mean anything."

Soon after the trial started, Patty Ryan called his expert, the same Phillip Keine whom the school board had chosen to run its EMF workshop. He was an old man with dark eyes, hair the color of lamp black, and a deeply furrowed brow; his demeanor seemed that of a melancholy man.

"What position do you hold?" the lawyer asked.

"I'm professor and head of the Department of Epidemiology at the University of Alabama," he replied.

"What is epidemiology?" Ryan asked, and Keine replied, "Epidemiology is a branch of science that tries to uncover the causes of diseases by actually studying people as opposed to studying animals."

"How do you go about that work?"

"By conducting surveys and analyzing questionnaires."

"Are there laws or equations for doing this, as in engineering?"

"No. It's all based on common sense and experience."

"What education do you have in epidemiology?"

"I have a doctorate from Harvard."

"Are you also a physician?"

"Yes. I earned an M.D. degree from the University of Vermont."

"What is your specialty?"

"I am board certified in preventive medicine by the American Board of Preventive Medicine."

"What sorts of studies have you made in relationship to electromagnetic fields?" Ryan asked.

"I have spent a considerable amount of time reviewing the literature and trying to come up with an overall picture of what is going on here," Keine replied.

"Were your efforts in relation to environmental or occupational hazards due to EMFs?"

"Well, I wouldn't call them hazards. Hazard, to me, implies something that it is known to be dangerous."

"Do you have opinions concerning powerline EMFs and cancer?"

"Yes. In my opinion there is no evidence that powerlines cause cancer. Even if there were, we could never know about it. And if we could, we could never prove it."

"Please explain the basis for your opinion," Ryan asked, and then riveted his attention on Keine, as if he expected Keine to disclose the secret of the universe.

"If powerlines caused cancer, there would be evidence of it. Some authors said that they thought there was a slight increase in cancer cases, but others reported the opposite result so, overall, the work amounts to nothing. Furthermore, production of electric power is ten times greater than it was in 1950, but there has been only a fivefold increase in cancer, which also shows that it is unrelated to EMFs. But even supposing that powerline EMFs caused cancer, we cannot do an experiment to prove it because no one can observe EMFs actually causing the cancers. If that were possible, whoever said that he saw it might be lying, so there is no reliable way to communicate the information. Therefore any effects of powerlines on people are unknowable, and even if they were known, they couldn't be proved."

"Is the Wertheimer study one of those surveys you referred to?" "Yes."

"What was her conclusion?"

"She said that the likelihood of cancer was higher the closer the children lived to powerlines."

"What about the Tomenius study?"

"He claimed that there was some association between cancer risk and powerlines. However, the closer the home was to the powerline, the lower the risk. So this work went directly against the earlier one."

"Does that result make any sense to you, based on what we know about the laws of physics?"

"No. EMFs decrease in intensity as you move away from a powerline. So, under the laws of physics, the greatest risk for cancer should be among people who live closest to the powerline."

"What about the McDowell study?"

"It was a good study. He showed that the mortality rate for people who lived near powerlines was identical to that of the general population."

"What about the Savitz study?"

"He found an extremely modest relationship between living near powerlines and cancer risk, but no relationship between actual EMF measurements and cancer risk."

"I don't understand that. How could there be a relationship between living near powerlines and cancer, but not a relationship involving measurements?"

"The implication is that the EMFs could not have caused the cancer."

At that point Patty Ryan held up his hand as if to say, "Stop," adopted what was surely a feigned expression of surprise because everything he did in a courtroom was always well scripted, and said, "Isn't that illogical?" whereupon Keine answered as they had planned.

"Not at all. Powerlines attract lightning. Maybe lightning caused the cancer. Who knows? There are a million possibilities. Even if there were a link between powerlines and cancer, which there isn't, the EMFs couldn't be responsible."

"Why not?"

"Because there are no powerline EMFs in the homes near powerlines, thanks to vectorization. That explains Savitz's results."

"I don't think I understand that, doctor, could you explain your answer?"

"Well, EMFs don't just come from powerlines, they come from all electrical appliances. Now, EMFs are vectors, which means they point someplace as, for example, the earth's magnetic field always points to the north. If you take a vector that's pointing in one direction and add a vector of similar strength but pointing in the opposite direction, the two vectors cancel out by means of a process called vectorization. I think that EMFs from electrical appliances canceled out the EMFs from the powerlines, and consequently the people who lived near the powerlines weren't exposed to EMFs. That's why Savitz couldn't find any relation between EMFs and cancer."

"Building on that idea, doctor, we all know that in some places the power companies have run more than one powerline in a right-of-way. Is the EMF greater if there are more powerlines in a right-of-way?"

"Multiple powerlines produce EMFs that tend to cancel out by vectorization. Typically, therefore, more powerlines means less EMFs."

"If the power company built enough powerlines, could the EMFs disappear altogether?"

"It's certainly possible."

"How many studies are there relating cancer to EMFs?"

"Probably more than fifty. The important thing to recognize about these studies is that we're dealing with human beings, and all their diversity, and that epidemiologists are merely observers because they don't really have any control over the exposure circumstances. As a result, epidemiological studies are notoriously unreliable. The really crucial question, I believe, is whether or not, considering the totality of the studies, there is any consistent link between EMFs and cancer. In fact, there isn't."

"Are you saying that maybe twenty-five studies show some correlation

and twenty-five studies do not show it?"

"Yes, it's about an even split. But those that showed a link are not very convincing."

"What about those that did not show a link. Are they convincing?"

"Yes. They were good studies. They settled the matter, so there is no need to keep digging."

"What studies were not good?"

"Well, we've just talked about the Wertheimer, Tomenius, and Savitz studies. They are the major ones."

"What's an example of a good study?"

"McDowell."

"What are the major problems with the bad studies, those that appear to be positive?"

"For one thing, they don't have measurements of the EMF itself, so they just assume that because people lived near powerlines they received high EMF exposure. Another problem involves whether the amount of disease that occurred was really greater than what was expected due to chance. Epidemiology has some pretty serious problems because of its non-experimental nature. It's all just based on filling out questionnaires. Human nature being what it is, people who do these studies sometimes come up with interpretations that are at the edge of their data, or even beyond it."

"Doctor, what is beyond it?"

"Fantasy," Keine replied.

"Doctor, what about laboratory studies of EMFs on amoebas or cells or animals, or clinical studies of bone healing? Do you think these effects are real?"

"Some probably are. The important question is whether they are harmful."

"Do you know of any circumstances where harm was proven?"

"No," Keine replied confidently.

By the time the trial ended for the day, the spirits of the parents were at a low ebb. Keine's performance had impressed the judge, as anyone could plainly tell from the expression on his face, like that of a sports fan looking at his favorite athlete. What made the judge's reaction even more ominous, and intensified its meaning, was a newspaper article he had given to the lawyers. There had been a case in Georgia in which epidemiologists had reviewed twenty surveys and concluded that the birth defects of a little girl

named Katie had not been caused by the contraceptive jelly her mother had used. Some pharmacologists and geneticists, however, had reached the opposite conclusion based on their analysis of laboratory studies. The judge had accepted their evidence and ruled in Katie's favor. The article that the hero-struck judge had given the lawyers was not the decision of the Georgia court, but rather an editorial in the *New York Times* which had excoriated the judge's decision as an "intellectual embarrassment" because it was against "the best scientific evidence." Only a fool, the editorial suggested, would take the word of laboratory scientists over that of an epidemiologist in a matter relating to human health.

The daunting task of assaulting Keine's testimony fell to the lawyer who represented the parents, a youngster named John Smith who was still imbued with the idea that there was a social purpose for practicing law beyond that of simply making a living. In that respect he reminded me of Bob Simpson, whom I remembered fondly from our work together when we had fought to dispute the rosy picture of EMFs that had been painted by the power companies in New York. But unlike Simpson, Smith had not prepared for the assault, and it was impossible for me to remedy that problem in the few hours we had together. So I quickly wrote a cross-examination for him to carry out that required no effort or knowledge on his part.

Smith began by asking, "Dr. Keine, do EMFs cause cancer?"

"There is no convincing evidence," Keine replied.

"Do herbicides cause cancer?"

"The data does not support that link."

"Does asbestos cause cancer?"

"Only in people who smoke."

"Does saccharine cause cancer?"

"Perhaps in laboratory rats but not in people."

"Do insecticides cause cancer?"

"There is no scientific basis to believe in that."

The rest of the cross-examination revealed that Keine had testified on behalf of many different companies, saying that their products didn't cause cancer notwithstanding the evidence that suggested otherwise, and that he had been paid \$400 an hour in each of the cases. By the time he left the witness stand it was apparent from the judge's body language and comments that his respect for Keine had evaporated, which pleased the parents. In the beginning the mothers had pressed the case against the school board while the fathers humored what they perceived to be their wives' emotional but irrational fears of EMFs. The minds of some fathers had softened following Keine's direct testimony because his story had seemed to them to be an instance of an opinion determining the evidence and not one where the evidence determined the opinion, which is the way they had thought science always worked. But even for those men, it was more like a whiff of suspicion rather than a definite taste of something bad. Keine's performance during his cross-examination, however, led many of the fathers to voice the same emotions as their wives.

Although the parents had been pleased, I was ashamed of myself. Keine was a man trapped by his perceptions. No expert really wants to think that his science is incapable of adding meaning to the world, but that was exactly the situation in which Keine found himself. He had followed his perception of the world right off the edge, into nihilism. But even though his thinking was extreme, it was pure, and for that reason perhaps worthy of respect or at least of being confronted directly, not by means of eristic. Keine's other testimonies could have been grossly biased, as we suggested in the cross-examination, but his testimony regarding the EMF surveys could still have been true. Thus the judge was deceived twice, and a direct confrontation that could lead to the best truth was avoided, as it had been since the EMF issue had first arisen.

When I took the witness stand I tried to refute Keine as best I could, considering I was not speaking to him. I told the court that the proper way to make judgments regarding the hazards to humans was to evaluate the results of honest studies on animals and, in the limited area where they are permissible and not abhorrent, studies on human beings. I said, "Professor Keine shuns the correct methodology and instead resorts exclusively to analysis of surveys which he concludes lead to an aporia. Since his arguments apply to every factor in the environment suspected of causing disease, he showed only that the kind of activity he practices can never lead to certain knowledge, which was only a tiny point because nothing can. I accept his conclusion, but it is not relevant to this case. The issue here is not whether EMF survey studies are conclusive, but rather whether they add any weight against the school board's claims that the powerlines will be safe. Clearly, they do."

I thought my presentation was decidedly sub-par. For one thing, Smith had not gone over my testimony sufficiently and was therefore not in a po-

sition to maximize the impact of what I had to say. There were gaps in his presentation, and he asked many unnecessary questions, resulting in wasted time and momentum. We lost arguments that we should have won as, for example, when the judge would not allow me to answer questions regarding the process of vectorization. Smith himself did not understand what it was and therefore could not defend me against a side-bar argument by Patty Ryan that I was not qualified to testify about the physics of EMFs.

Another example involved the key concept of our case, that the average field in the school was much higher than that in other schools. I had prepared charts and illustrations that depicted this fact, with the idea that they would leave a lasting impression on the judge. Unfortunately, Smith did not lay a proper foundation in court for these exhibits, so the judge refused to accept them into evidence; that decision cut short my testimony because Smith had no props to use.

Smith's shortcomings was only one of the problems. The obsessiveness of the parents wore me out, psychologically. They always wanted to talk about the case, and since I worked on their behalf for free it cost them nothing to hound me. I was fatigued and tired, and concerned that I might not make my flight home. Smith asked me to stay for the remainder of the case to help him, but I returned to my real life.

While I was going about my business in Louisiana, Ryan presented an engineering expert who testified that he had measured EMFs at different locations inside Sandpiper, and also inside other schools in Palm Beach County that were not near powerlines. He told the court that when he had averaged the results he found that the children at Sandpiper were not exposed to more EMFs than children at other schools in the district, a fact that he explained on the basis of the vectorization gimmick. He never said how he chose the locations within each of the schools for his measurements which, of course, was the dirty trick he used to make the averages come out the way he wanted.

Soon thereafter the judge issued a decision in which he ordered the children to be kept away from the playground directly under the powerline, but allowed the school buildings themselves to be used without restriction because, he concluded, there were no unusual risks due to EMFs thanks to vectorization. He said that if the power companies built another powerline, perhaps vectorization would allow the children to use the playground again. Soon after the case in Florida had ended, I was contacted by a lawyer from California who had brought a suit against the Pacific Telephone Company on behalf of his clients, Meyer and Muriel Silverman. They lived in a large house on scenic property in Riverside County, and the company had built an antenna on adjacent land and begun sending out a microwave beam, part of which passed directly through their house. The company told them that living in the beam was nothing to worry about, and that they would be just as healthy as they had ever been. But the Silvermans didn't trust the company so they sued under a theory of inverse condemnation, claiming that the company had taken away their right to be safe in their own home and therefore that they should be paid for their loss.

When the Silvermans' lawyer asked me for my opinion, I told him that there were numerous Russian and U.S. reports of biological effects due to many types of EMFs, including microwaves, that fields could affect the body's chemistry, and that I interpreted these facts to mean that an exposure to EMFs was a potential hazard, even though nobody could say exactly what would happen to the Silvermans or when.

He hired me to testify in court, and so notified the phone company. Shortly thereafter I was called by Don Justesen, who frequently emerged when there was an issue involving EMFs. When I had been fighting Philip Handler, Justesen had sent me a letter inviting me to Washington to meet with a man on Handler's staff so that "we can solve your teapot tempest." It was Justesen who, when he was president of the Bioelectromagnetics Society, had encouraged me to deliver what he called my "philippic" against Richard Phillips, thinking, I supposed then and still supposed, that I would be defeated in our battle of speeches. It was Justesen who came to Syracuse in the summer of 1980 and testified under oath that yet another tower planned for Sentinel Heights, where Dr. Becker had already found a high rate of cancer, would be "perfectly safe." He told the court in Syracuse that some people think otherwise because "human beings are a suggestible lot, witness the success of voodoo." It seemed that Justesen was shadowing me, as he had also shadowed Milton Zaret.

"I understand that you will be testifying in California in a case involving a cell telephone tower," Justesen said.

"Yes," I said, "unless the case is settled. How does that concern you?"

"I think that kind of testimony would be bad for you and bad for the country," he said. "These are still dangerous times."

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"I don't see that my testimony on behalf of two people who are worried about being forced to live in a microwave beam has any larger significance than whether they should be compensated and allowed to move somewhere else."

"It's the principle, Andy," he said. "We are talking about a minuscule microwave beam, and it's not good for the country to foster a fear that, somehow, that would be a hazard."

"Wouldn't you be worried about consequences of living in the beam, if it were you?" I asked.

"Let me tell you what I did," he said. "I exposed myself for thirty minutes to an EMF that was strong enough to raise my body temperature by more than half a degree, and an hour later my body temperature had returned to normal and I suffered no ill effects. If I can withstand an EMF of that strength and suffer no ill effects then I think we can say there won't be any damaging effects due to microwave beams at the nanowatt level, which is what the tower will produce."

"So your opinion is that the Silvermans would get used to living in the beam."

"Certainly, like diamond miners in South Africa. If you or I had to do that work we wouldn't survive the first day. But they adapt. Even if there were effects produced by the minuscule beam, prolonged stimulation leads to acclimation, so the Silvermans would adapt."

"Well," I replied, "take the Russian reports, for example. They studied workers who were exposed on the job over a long period, but didn't find acclimation. On the contrary, they found that the workers suffered from chronic fatigue and tiredness, what was called a neurasthenic syndrome."

"Russia is a different story," he said. "In a socialistic environment, the state is required to take care of you from the cradle to the grave. So the state sets up safety levels to prevent disease and minimize health impacts. I have to agree that they are very safe, but in many instances, that number is not really enforceable. It's a goal to which the bureaucrats aspire, more or less pie in the sky. There is no real science there, only fear about what could be."

"This is the way I look at the situation," I replied. "The telephone company is run by businessmen, and they surely have access to more facts than I do about what sorts of medical problems might be caused as a result of living in a microwave beam. It would have been foolish for them not to have inquired into the matter, which has become an increasingly popular topic everywhere. Surely they made discreet arrangements with private outfits to research the topic. If I had been a lawyer for Pacific Telephone, I would have recommended such an inquiry, and I would have counseled the necessity of constructing effective firewalls to shield adverse results from prying eyes so that not even the possibility of concern could be detected by those outside the company. It would have been my professional responsibility to give such advice. So, I'm confident that the phone company actually received that kind of advice from its lawyers, which are the best money can buy. Now, had the evidence obtained supported the company's position that living in a microwave beam was safe, the company would surely have produced the scientific studies attesting to that supposed fact. But they have produced no such studies, which suggests to me that they have evidence locked away somewhere that leads to the conclusion that EMFs from the antenna aren't safe."

"Assuming, for the sake of argument," Justesen said, "that evidence exists which could be interpreted as indicating a hazard, you have to agree that EMFs aren't responsible for some kind of a rampant epidemic. At best, there are some isolated cases. Look at what the cost would be to try to prevent them."

"What cost?" I asked.

"I can tell that you have never been on a Navy warship," he said.

"True," I replied.

"If you go on an aircraft carrier and look around you will see a thousand antennas, more than half of them operating at any given time. They are the means by which all of the weapons and communications systems are able to function. Without the antennas, the ship would be useless. The sailors on the ship are constantly immersed in their EMFs, and at levels vastly greater than the minuscule levels on the Silvermans' property. What kind of a message do you think it sends to the sailors when you say there is a hazard on the Silvermans' property?"

"I suppose it tells the sailors that they too might have a similar problem, only worse," I said.

"Do you think such a message is a good thing, particularly considering the absence of clear scientific evidence of a problem?" he asked, more or less rhetorically. I told him that I just didn't see things the way he did, and I would not quit the case. Shortly thereafter the phone company announced that Justesen had been hired to testify on its behalf.

At trial, he began by telling the jury that he was a tenured professor of psychiatry in the school of medicine of the University of Kansas, and also the head of the Committee on Man and Radiation which, he said, was sponsored by engineers to educate and enlighten the general public about EMFs. When he started talking about EMF studies, he said there were two categories of problems, excessive exposure and misinformation. Excessive exposure came from EMF-producing equipment such as heaters and sealers in the plastics, leather, and lumber industries. All that these workers needed to know was that, when they felt heat, they should move their hands away from the EMF beam.

"Misinformation about EMFs," he said, "is a far bigger problem. If faith can move mountains, false beliefs can mount movements in which the shared illusion of danger creates psychological and even somatic disabilities in sensitive individuals. The false belief that low levels of EMFs have destructive affinity for biological systems is widespread, and has been fostered and perpetuated by accounts in the popular media. The fact is, however, that there is no objective evidence of a clear and present danger for the general population from chronic exposure to EMFs at current environmental levels."

I did not expect that the Silvermans' lawyer would make even a dent in Justesen's testimony during cross-examination because he was a hard nut to crack. It was also plain that the lawyer himself was not looking forward to the confrontation, and viewed it more as a task than an opportunity. I therefore proposed to him that I be withdrawn as the designated expert for the Silvermans and then appointed as counsel for the purpose of conducting a cross-examination of Justesen. I knew that the court would accept anyone with a Ph.D. or an M.D. as an expert, and that consequently it would not be difficult to hire someone to give the testimony I would have given. But the ability to deconstruct Justesen's testimony was a rare expertise, but one that I possessed. He leapt at my suggestion and asked permission to approach the bench, where he and the lawyer for the company held an extended side-bar conference - the upshot of which was that the judge admitted me to the bar in California for the purpose of conducting the cross-examination. At that point the lawyer for the company asked for an adjournment until the new expert was named and the company could prepare to cross-examine him, and the judge granted the request. The next

day the phone company settled with the Silvermans.

. . .

How natural it was that experts should appear to be authoritative witnesses. Erdgas, Keine, and Justesen had academic degrees, so when they said in the courtroom that there is no reason to suppose that people exposed to EMFs will be more likely to get sick, they knew their words would be respected without any inquiry into why they spoke them or how they knew them to be true. Their message was inherently negative – that the research implicating EMFs as hazardous was meaningless – and people found this view comforting. All I could do was try to describe the meaning of that research, and in the process I probably appeared vague and alarmist.

They could pick and choose their evidence to support their message to the court; all they had to do was ask themselves what would help or hurt their case, and choose accordingly. By avoiding anything that might complicate their task, it seemed as if they had reached their conclusions inexorably. The choir I belonged to was quite different. My approach to scientific explanations was nothing like theirs. My answers to questions about the significance of experiments or about the conclusions to which they summed were never certain but always open to debate because the body of work was so vast and interconnected, and because, after all, it was only science and therefore inherently imperfect. Nevertheless, I believed in my heart that my views were far better and more defensible than theirs, even when the circumstances damaged my cause, as when I was confronted in court with the research results of Richard Phillips. When I laughed at that, I must have seemed frivolous. When I tried to explain why his work deserved only scorn, I must have seemed mean-spirited or biased.

These experts could deliver persuasive cases because they were permitted to give speeches and were never interrupted and asked to defend the particulars. Whenever I had the opportunity to directly ask them how they could maintain that it is right for people to be exposed to electromagnetic fields, even children and the elderly, I never got a satisfactory answer. But juries and others who sit in judgment are predisposed to believe whatever is said by anyone who sounds scientific and is not plainly biased, and lawyers do not take the trouble to teach the jury that experts deal in opinions, not exclusively in facts as is generally but wrongly supposed.

Nobody knows how this fault developed, but it was probably something like this. One day, word spread throughout the countryside that a

woman had given birth to a sheep. The uproar greatly troubled the king, so he summoned his ministers to discuss how best to calm the people. Someone said: "My liege, the people distrust the opinions of the clergy. Let us choose scholars and doctors to investigate the matter," and so he did. It so happened that a woman had indeed given birth to a sheep, and that upon seeing the monstrosity and believing it to be the work of the devil, her family slew both. So, when the scholars and doctors held their meeting in the great hall and asked all who had evidence concerning the matter to come forward, the woman did not appear and the sheep was not produced. They then announced that no man's knowledge of the supposed event was more than hearsay and that no book in the great library recounted an observation that a woman had given birth to a sheep, and concluded that no such event had occurred. In the following years, the king called on the scholars and doctors more and more to resolve issues that concerned the people, who accepted all manner of opinions that they offered because it was presumed that they knew the world in a special way that was beyond the province of ordinary men. And so the people fell into the habit of never expecting nor demanding an answer in plain language from the learned men to the plain question, "How do you know?"

The danger in making scientists the objects of hero-worship arises because there are two kinds of scientists, neither of which deserves worship and only one of which deserves respect. The true scientist is free to pursue truth as best he can, but the counterfeit version has relinquished the free spirit he must have had when he was young because everybody starts off wanting to understand the truth. As he got older, he fell into grievous error. Some, like Keine, came to believe in nothing and hence to deny everything except the perfectly obvious. Others decided that truth, whatever it was, didn't matter as much as wealth, like Erdgas, or as the respect of authorities, like Justesen.

Keine, Erdgas, and Justesen had M.D.'s and Ph.D.'s, so what was lacking in their character that made them counterfeit versions of true scientists? It was that they lacked justice. This is where they failed. They ignored the reality that opinions about the presence or absence of a health risk due to EMFs always involve an element of justice. They were unscientific because they opined as if there was a right and wrong that was solely within EMFs themselves, and therefore that justice was irrelevant.

Experts are part of the modern world, so it will always be necessary to

expend effort to distinguish between the two kinds. It is a deep problem because experts are chosen by lawyers, lawyers are chosen by clients who are desirous of winning, and sooner or later, everybody is a client.