Voodoo SCIENCE
The Road from Foolishness to Fraud

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SEVEN CURRENTS OF FEAR
In Which Power Lines Are Suspected of Causing Cancer

IT'S BEST TO AVOID POVERTY

PAUL BRODEUR WAS NOT THERE in 1996 when the National Academy of Sciences (NAS) released the results of an exhaustive three-year review of the possible health effects of exposure to residential electromagnetic fields. He no longer wrote for the New Yorker; there had been a major shake-up at the magazine in the summer of 1992, and Brodeur did not fit into the new style. It was his series of sensational New Yorker articles in 1989 that first aroused widespread public fear about power lines and cancer. Without Paul Brodeur there would have been no Academy review. Now retired from the environmental health wars, Brodeur would return to active duty one more time after learning of the Academy’s conclusions.

The large conference room at the classic Academy building on Constitution Avenue near the Lincoln Memorial was crowded with reporters, TV cameras, and a few scientists. This was the most extensive, most current, and most prestigious study yet conducted of the huge body of scientific evidence on the relationship between power lines and cancer. The chair of the review panel, Charles Stevens, a distinguished neurobiologist with the Salk Institute, began by explaining the difficulty of trying to identify weak environmental hazards. Scientists had labored for seventeen years to evaluate the hazards of power-line fields; they had conducted epidemiological studies, laboratory research, and computational analysis. “Our committee evaluated over five hundred studies,” Stevens said, “and in the end all we can say is that the evidence doesn’t point to these fields as being a health risk.”

There had been concern in the scientific community about the composition of the committee, which was generally viewed as packed with scientists who might have reason to prefer that the controversy not be quite resolved. The vice chair of the panel was David Savitz, a University of North Carolina epidemiologist who had staked his reputation on a link between EMF and cancer. It was his presence on the panel that had most concerned many scientists, but perhaps half of the sixteen panel members were involved in research related to the health effects of EMF. A report exonerating EMF could lead to the elimination of funding for their research. They might be inclined to decide it was better to err on the side of caution and simply call for more research, as some previous groups had done.

In any event, the unanimous conclusion of the panel was that “the current body of evidence does not show that exposure to these fields presents a human health hazard.” There were reporters in the room, however, who had been writing stories about the dangers of power-line fields for years, following the lead of Paul Brodeur. For Lou Slesin, the editor of Microwave News, an influential newsletter devoted entirely to the EMF-health issue, the controversy was his livelihood. For these reporters to now write that it had all been a false alarm would be miraculous. They were scrounging the report looking for soft spots.

Was there conclusive evidence that EMF is not a risk, one reporter wanted to know? It was the classic difficulty of proving a negative. If no clear link is found between prolonged exposure to
power-line fields and cancer, could it be that just certain people have a natural susceptibility to EMF? Or is EMF dangerous only in combination with some other environmental factor? The number of possibilities is infinite, and each of them raises a new question that can only be answered by more research. And when that research is done, it can always be asked if a larger study, or more sensitive measurements, might yet reveal a problem at some lower level. At what point should researchers decide that the connection, if there is one, is too weak to identify, or the hazard, if a hazard exists, is too insignificant to be concerned about?

Stevens did acknowledge that there seemed to be a weak statistical association between living near power lines and childhood leukemia. "The question," he said, "is what causes that association." It could not be the fields; when the fields in homes were actually measured, studies showed, the association with cancer all but disappeared. What, then, accounts for the excess incidence of leukemia in such homes? "We just don't know," Stevens said, but he pointed out that neighborhoods with heavy concentrations of power lines are usually poor, congested, and polluted—all of which are risk factors for cancer.

It was clear that many of the reporters had trouble with the concept that there could be an association between childhood leukemia and living near power lines without the power lines being the cause. If the panel could not explain the statistical link between power lines and cancer, one reporter persisted, wouldn't a policy of "prudent avoidance" be justified? Prudent avoidance is a term coined by Granger Morgan of Carnegie Mellon University. Morgan had made something of a career of going about the country preaching prudent avoidance to worried parents, but it seemed to mean something different to everyone. Did it mean doing away with electric hair dryers or converting to candles? "We wouldn't know what to suggest people avoid," Stevens patiently explained. Since proximity to power lines and the incidence of childhood leukemia are both greatest in congested, low-income areas, the most prudent course might be to avoid poverty.

That evening on the ABC news, Peter Jennings summed up the report in one line: "Power lines do not cause cancer—and that's that." Some reporters, however, concluded that the door had been left open just a crack by the slight statistical link between childhood leukemia and proximity of power lines. For them, as for Brodeur, it was a matter of common sense: if children living near power lines have a higher risk of leukemia, power lines are to blame.

To understand how the power-line controversy could have been sustained for so long, on the basis of so little evidence, we must first go back to an earlier false alarm over a very different form of EMF: microwaves. Once again, the public alarm was sounded by Paul Brodeur.

MONKEY BUSINESS

Ellie Adair's children were off at college, and the colony of squirrel monkeys had become the outlet for her mothering instincts. Squirrel monkeys are New World primates with prehensile tails and large eyes set in tiny, expressive faces. They are gentle, affectionate, naturally clean animals. Adair worried if there were long periods between experiments. During such periods the monkeys tended to become listless, lost weight, and began to neglect their grooming. She believed they were bored and missed the extra attention. When the experiments started up again, they would perk up, their appetites would return, and their coats would become glossier. So she tried to see that all the monkeys got as much "work" as possible. Among researchers, she had the reputation of always having the healthiest monkey colony. She liked to think it was also the happiest.

Ellie Adair, a research fellow at the John B. Pierce Foundation Laboratory, associated with Yale University, was a leading authority on the body's temperature-regulating mechanism. Mammals and birds maintain almost constant temperature over wide variations in the air temperature or internal heat generation from exercise. The area of the brain called the hypothalamus is the control center of the temperature-regulating system. The hypothalamus senses the temperature of the blood that is pumped through it; at the slightest rise in temperature, it sends out instructions to increase sweating and respiration and to dilate the blood vessels that carry blood to the skin. The instructions are conveyed by a delicate interplay of chemical messengers and nerve stimulation.
In Adair's experiments she exposed the monkeys to microwaves, just as you would heat food in a microwave oven, and monitored their physiological response. There was no reason to believe microwaves at the levels used in the experiments harmed the monkeys. The monkeys could even be trained to control the level of microwaves themselves.

But in December of 1976, Adair got a call at the lab from a colleague. "You'd better take a look at the latest issue of the New Yorker," the caller said. She picked up a copy on her way home. In the understated style of the magazine at the time, there was an article with the simple title "Microwaves-I," by a staff investigative reporter named Paul Brodeur. One line in the article read: "It is known that microwaves exert a profound effect on the central nervous system of rhesus monkeys and other primates." Known to whom, she wondered?

Microwaves are electromagnetic radiation, waves of electric and magnetic fields that travel at the speed of light, differing from visible light only in the frequency at which the fields oscillate. We are constantly bathed in electromagnetic radiation, most of which is unseen and felt. Visible light makes up a very narrow region of the electromagnetic spectrum. At frequencies just below the visible spectrum, infrared radiation can be felt on our skin, warning us before we actually touch it that a stove is hot. Microwaves correspond to still lower frequencies. Although our senses do not respond directly to microwave radiation, microwaves are absorbed by certain molecules in the body, increasing the amplitude of their atomic vibrations. That amplitude is a measure of the body's temperature. At sufficient intensity, as in a microwave oven, the heating would begin to destroy cells, but in Adair's experiments, the heating was not nearly enough to cause cell damage.

Adair had assured herself that microwaves were harmless before she ever began her research with monkeys. The biological effects of microwaves had been studied for thirty years and were the subject of hundreds of papers in the open literature. The research began during World War II with the development of radar, when a technician walking near an experimental transmitter discovered that a chocolate bar in his pocket had melted. The army set up a program to evaluate any hazard to technicians and operators directly exposed at close range to the radiation from high-powered radar systems. Much of the research into the effects of microwaves is still supported by the Department of Defense.

Microwave ovens, originally called radar ranges, were a product of that research. At the time of Brodeur's article, radar ranges were just beginning to be marketed to the public. Manufacturers relied on the same experts that Adair had consulted for information about safety. There had been some initial concern about the effect of microwaves on the eyes, which dissipate heat less effectively than other organs. Washington columnist Jack Anderson had exploited this particular concern earlier, reporting an increase of cataracts associated with the use of radar ranges. There can be a slight "leakage" of microwaves outside the range. However, more careful studies found no effect, even at levels far higher than the leakage. As long as there was adequate screening, and interlocks to prevent someone from sticking a hand in when the range was on, there seemed to be no cause for concern.

But the same facts that had reassured Ellie Adair were seen through a very different lens by Paul Brodeur. A cold-war investigative reporter who began his journalistic career exposing dark secrets of the CIA, Brodeur had switched to exposing environmental and occupational hazards in 1968. Beginning with asbestos and moving on to microwaves, he found a niche sounding the alarm about the dangers of technology. Brodeur had no technical background. Instead, he approached environmental issues with a cold-war mind-set: Who had something to gain? And what were they covering up?

Since World War II, Brodeur warned, electromagnetic radiation from radar, television, and microwave communication had risen to one hundred million times the "natural" background level in New York City, due to radar, radio, and television. It was an alarming-sounding statistic but completely meaningless. In terms of power, this was still a totally insignificant level. "Natural" microwaves are due to so-called black-body radiation, the radiation given off by all warm objects, but at ordinary temperatures, most black-body radiation is in the infrared region of the spectrum. There is very little in the microwave region. That's one reason microwaves are so useful for radar and communications. It's a "quiet" part of the spec-
trum. Brodeur made no distinction between the insignificant levels of background microwave radiation from television broadcasting and the exposure you might get from standing in front of a radar transmitter. The list of health problems he connected to microwaves expanded beyond cataracts to include miscarriages, birth defects, and cancer.

The fact that most research on the biological effects of microwaves had been supported by the Department of Defense became for Brodeur evidence that the government was attempting to control information about its hazards. When industry scientists reported similar findings, he saw it as proof that the electronics industry was in collusion with the military. When academic scientists scoffed at the background-microwave hazard, they too became part of Brodeur's conspiracy theory.

If we have learned anything about the environment in recent years, it is that we cannot take warnings lightly or accept uncritically the soothing reassurances of authorities. We have seen the tobacco companies suppress their own studies of nicotine addiction and the health effects of tobacco smoke; the nuclear industry, chemical companies, drug manufacturers, car makers—all at times have engaged in cover-ups. The federal government has conspired with civilian contractors to withhold information about the spread of radioactive contamination around nuclear weapons production facilities. Was there any reason to expect the electronics industry and the federal government to behave in a more principled fashion with regard to microwaves?

Still, Ellie found Brodeur's conspiracy claims preposterous, and she was offended by the implication that any scientist who disagreed with him must be part of a cover-up. With so many scientists holding open meetings and freely exchanging results on microwaves, a cover-up would be impossible to sustain. But the question remained: Could there be some unrecognized interaction of microwaves with the body that causes serious health problems? And if there is, why were her monkeys, which were exposed to relatively huge doses of microwaves, in perfect health?

Help in answering such questions was close at hand. She recruited her husband Bob, a physics professor at Yale. Ellie met Bob in graduate school at the University of Wisconsin. She had decided to take her Ph.D. in both experimental psychology and physics, even though it meant taking a lot of additional math. It was in the Physics Department that she met Bob—who was very good at math. They were married in 1951. Ellie spent the next years raising a family. Not until the children were in school did she resume her own career. Meanwhile, Bob had gained recognition as one of the nation's foremost nuclear theorists.

Bob Adair had grown up in a staunchly union, blue-collar family in Fort Wayne, Indiana. His father had not been to college, but he had studied physics in high school and delighted in explaining to his precocious son the physics of the world around them. From the earliest time Bob could remember, when anyone asked him what he was going to be when he grew up, he always answered, "A mathematical physicist." Bob also loved baseball, but he had no aptitude for it, failing even to make a sandlot team. Years later, however, when he had become a renowned experimental physicist, occupying an endowed chair in the Physics Department at Yale University, he would write the definitive book on the physics of baseball.

Bob was sure Brodeur had to be wrong. The effect of all known cancer-inducing agents—ionizing radiation such as ultraviolet or X rays, chemical carcinogens such as tobacco smoke, and certain viruses—is to damage DNA. The damage consists of broken or altered chemical bonds, creating a mutant strand of DNA. Microwave photons can cause chemical bonds to stretch and bend but cannot come even close to severing the bonds. One of the great triumphs of quantum mechanics was the discovery that electromagnetic radiation interacts with matter only in discrete bundles of energy called photons. The energy of a photon is expressed mathematically as the product of a universal constant, called the Planck constant, multiplied by the frequency. Photons that have enough energy to break chemical bonds are called ionizing radiation. Whether electromagnetic radiation is ionizing is independent of the intensity, or number, of photons; it depends only on the energy of the individual photons.

Breaking a chemical bond with a photon is like throwing stones at something on the other side of a river. If you can't throw that far, it won't matter how many stones you throw. The lowest-energy
photons capable of directly breaking chemical bonds are in the near-ultraviolet region of the spectrum, just beyond the region of visible light. These photons are about a million times more energetic than the microwave photons Ellie Adair was using. Breaking chemical bonds with microwaves would be like trying to throw a stone across the ocean.

Meanwhile, the New Yorker published “Microwaves-II,” in which Brodeur focused on the strange situation at the American embassy on Tchaikovsky Street in Moscow. For reasons that were a mystery at the time, the Soviets had been beaming microwave radiation at the embassy for more than a decade. It is now known that the microwaves supplied the tiny amount of power needed to operate electronic eavesdropping devices that had been concealed in the building during its construction. Brodeur, however, suspected that the microwaves were meant to addle the brains of embassy workers or induce depression. What shocked him was that the government had not warned employees of the health hazard. He noted that Ambassador Walter Stoessel had developed some mysterious blood ailment, and two former ambassadors had died of cancer. To Brodeur it seemed the microwaves must be to blame. People were exposed to microwaves and they got sick—it was the belief engine at work.

A few months later, Brodeur published a book titled The Zapping of America, drawn from his New Yorker articles. Spurred by Brodeur, environmental activists embraced microwaves as a new cause. The immediate impact was to almost destroy the budding microwave oven market, but the problem didn’t stop in the kitchen. Every microwave relay tower, every air traffic control radar, was suddenly suspect. Roused to near fury by Brodeur, a citizens’ group went to court to block the National Weather Service from installing a weather radar at Brookhaven National Laboratory, on the grounds that it would lead to miscarriages and cancer. Long Island, which juts out into the Atlantic, had found itself in the path of numerous killer hurricanes. The radar was meant to track such storms and provide timely warning to those in their path. But people feared the known dangers of howling wind and crashing ocean waves less than they feared the unproven hazard of silent, invisible micro-
waves. Scientifically, the issue was one of relative risk: a history of property damage and loss of life from storms, against an unproven hazard that most scientists believed was nonexistent. But judges are not scientists, and a federal judge ruled against the Weather Service. The Long Island weather radar was canceled.

Over the next few years, however, most of the public seemed to gradually lose its fear of microwaves. New studies failed to confirm the link to cataracts or other health effects, and people were discovering the wonderful convenience of microwave ovens; sales were beginning to rebound. Within a decade, there would be a microwave oven in almost every home in America—and no related increase in health problems.

Bob Adair, meanwhile, had begun going with Ellie to scientific conferences on the effects of microwaves. He was asked to present a physicist’s perception of the problem at one of the conferences and, encouraged by the positive reaction, he wrote his work up and published it in the Physical Review. He relied on well-established physical principles to show that there was no known mechanism that could account for reports of health effects from low levels of microwave radiation. Unknown to the Adairs, however, events were underway in Denver that would shift the conflict to a new arena and again thrust the Adairs into conflict with Paul Brodeur.

THE CURRENT CONTROVERSY

In 1979, an unemployed epidemiologist named Nancy Wertheimer obtained the addresses of childhood leukemia patients in Denver and drove about the city looking for some common environmental factor that might be responsible. What she noticed was that many of the homes of victims seemed to be near power transformers. Could it be that the fields from the electric power distribution system were linked to leukemia? She teamed up with a physicist named Ed Creeper, who devised a “wiring code” based on the size and proximity of power lines to estimate the strength of the magnetic fields. Together they eventually produced a paper relating childhood leukemia to the fields from power lines. They concluded
that children from homes with “high” magnetic fields from power lines were three times as likely to develop leukemia as children from homes with “low” fields.

Few scientists were aware of the Wertheimer-Leeper work at the time, and fewer still took it seriously. In the first place, the study was not “blind”: she knew in advance which were the homes of leukemia victims. In the second place, the relative strength of the power-line fields was not actually measured but merely estimated on the basis of the size and proximity of power lines. The situation was ripe for investigator bias; the tendency to judge the wiring of victims’ homes more critically would be almost unavoidable. If the result for a particular home disagreed with the researcher’s expectation, for example, there would be a tendency to double-check the result and see if something had been missed the first time. To the researchers, it may only seem that they are being careful, but unless all the homes are double-checked, it introduces a powerful bias. The numbers, after all, are very small—childhood leukemia is a rare disease—and the shift of only a few victims’ homes from “low field” to “high field” is sufficient to change the conclusion.

Scientists must constantly be on guard against this sort of self-deception. Unless studies are carefully designed to avoid it, the biases of the epidemiologist have a way of creeping into the results. To minimize the opportunity for bias, scientists rely on double-blind studies. An independent researcher might be given a list including both the homes of victims of childhood leukemia and an equal number of addresses of nonvictim children matched in age, gender, race, family income, etc., but without any indication of which are which. Without knowing which were the homes of victims and which were “controls,” the researcher would rate them by whatever criteria were used to estimate the field strength. Someone else would then apply the key after the judgments were made.

But even if the study had been double blind, a “risk ratio” of only three for a rare disease such as childhood leukemia would be regarded by many epidemiologists as barely credible. The risk ratio for lung cancer from smoking, for example, is well over thirty—that is, a 3,000 percent increase in the incidence of lung cancer among smokers. Yet it took years of checking and rechecking the figures, as well as a highly plausible mechanism in terms of known carcinogens in tobacco smoke and, finally, confirming laboratory studies on animals before the cancer link was firmly nailed down.

In spite of its obvious flaws, the Wertheimer-Leeper report could not be dismissed. We are all exposed to EMF every day of our lives, and even the most slender link to cancer would be a cause for concern. There were soon reports that electrical workers suffered high cancer rates; women using electric blankets or working at computer terminals were said to suffer frequent miscarriages; suicides were reported to be occurring at an alarming rate among people living under power lines; farmers with fields crossed by power lines claimed that their cows stopped giving milk and chickens stopped laying eggs. Although none of these stories were backed up by reliable statistical evidence, each new anecdote added to the sense that something was going on.

The Wertheimer-Leeper study was soon followed by the usual “confirmations,” most of which were as seriously flawed as the Wertheimer work. We saw in chapter 1, in the case of cold fusion, that important new claims tend to attract followers who see what they expect to see. Evidence that would seem much too weak to stand on its own is taken seriously if it seems to agree with what others are reporting. There was one “confirming” study, however, that had to be taken more seriously. In 1988 David Savitz of the University of North Carolina, a highly respected epidemiologist, set out to check the Wertheimer-Leeper results, using the same “wiring code” method of estimating the 60 Hz magnetic field. He also found an increased risk of leukemia among Denver children living in homes with “high field” wiring. The very important difference was that Savitz had used accepted double-blind methods. Although the increased risk was only about half as great as that reported by Wertheimer and Leeper, Savitz thought future study was clearly called for. Most scientists, however, remained highly skeptical of the purported EMF-cancer connection. Microwaves, as we saw, can induce heating. At a mere 60 Hz, however, there is not even that.

To understand the power-line controversy, we need another brief physics lesson. At such low frequencies, it’s no longer meaningful to think in terms of radiation and photons. What is measured are separate electric and magnetic fields. Perhaps the greatest achieve-
ment of nineteenth-century physics was Michael Faraday's discovery in 1831 of the relationship between electric and magnetic fields: moving electric charges, such as an electrical current flowing through a wire, generate a magnetic field. Conversely, a moving or changing magnetic field will induce a current in a stationary conductor. A power line is surrounded by both an electric and a magnetic field. The strength of the electric field depends only on the voltage; the strength of the magnetic field, only on the current. Both the electric and magnetic fields surrounding a conductor drop off rapidly with distance.

Everyone agreed that the electric fields from power lines do not represent a health hazard. Because human tissue, including skin, conducts electricity rather well, the outermost epithelial layers of the skin act as a shield, preventing electric fields from penetrating into the body. The concern is with the magnetic fields, which penetrate the body—in fact, most materials—almost unimpeded. The public tended to be most concerned about high-voltage lines. Strung on gigantic towers that resemble a file of mechanical monsters marching across the countryside, high-tension lines look threatening, but the whole purpose of the high voltage is to transport power with as little current as possible. High-voltage lines therefore minimize the magnetic field.

Humans, of course, have always been exposed to a magnetic field. Electrical currents circulating in Earth's molten core act like a huge dynamo, turning Earth itself into a giant magnet. But today, we are also exposed to man-made electromagnetic fields, generated by the electrical wiring that is ubiquitous in modern society. Over the past fifty years, the per capita consumption of electric power in the industrialized world has increased twenty-fold, and our exposure to the electromagnetic fields generated by power lines and appliances has increased by a similar amount.

In spite of the enormous growth in consumption of electricity, however, in most homes and workplaces magnetic fields produced by electric power are still only about 1 percent as strong as Earth's natural magnetic field. There is one difference: electric power is supplied as alternating current. In the United States, the frequency at which the current reverses direction is 60 Hz or sixty times each second; in Europe, it is 50 Hz. Thus, as a result of Faraday's law, an alternating magnetic field interacts with our bodies in a way that the relatively constant magnetic field of the Earth does not. The result is to induce weak electrical currents in the body. It is prudent to ask if these currents affect our health in any way. Could they somehow interfere with the body's cancer defenses? If that were the case, power-line fields might not cause cancer, but might influence the growth of cancers caused by something else.

In June of 1989, The New Yorker carried a new three-part series of highly sensational articles by Paul Brodeur, this time on the hazards of power-line fields. The articles drew heavily from his earlier attacks on microwaves. Indeed, he seemed to draw no clear distinction between 60 hertz and 100 megahertz, which is typical microwaves—it was all just EMF. The series reached an affluent, educated, environmentally concerned audience. Suddenly, Brodeur was everywhere: the Today show on NBC, Nightline on ABC, This Morning on CBS, and, of course, Larry King Live on CNN. In the fall, Brodeur published the New Yorker series as a book with the lurid title Currents of Death. A new generation of environmental activists, led by mothers who feared for their children's lives, demanded government action.

I was asked by the "Book World" section of the Washington Post to review Currents of Death. The book was frightening all right. Brodeur was a skilled writer, and he used all his skill to build a case against EMF. His approach was taken right out of The Zapping of America. He described power-line fields as the most pervasive—and covered up—health hazard facing Americans. The overwhelming consensus among scientists, that no hazard existed, was for Brodeur evidence of a massive cover-up, this time involving the utilities, the government, and the scientific community. Once again he related frightening anecdotes of suffering and death from cancer. It was easy to connect the suffering to EMF; power lines are everywhere. It was the belief engine at work: people are exposed to EMF, and people get cancer. I pointed out in my review that life expectancy in the United States had doubled in the past hundred years—and most of that increase had come since the advent of electricity.

Feeling the pressure from power-line activists, the Environmental Protection Agency (EPA) convened an internal panel to set "safe
silent, invisible fields invading homes and schools—and a conspiracy to hide the truth from the public. He went into great detail about all the sickness suffered by folks living on Meadow Street in Guilford, Connecticut. They were coming down with everything from brain cancer to Osgood’s knee—and there was an electric substation on Meadow Street. Such anecdotes appeal directly to the belief engine and have a powerful emotional impact. For every Meadow Street, however, there may be a Forest Street somewhere, also with a substation, where no one seems to get sick—but Brodeur wasn’t interested in Forest Street. By including only data from isolated cases that supported his belief, Brodeur was committing the same error that Irving Langmuir had discovered in the ESP studies of J. B. Rhine, discussed in chapter 2. Brodeur’s focus on cancer clusters is called the Texas sharpshooter fallacy by statisticians. The sharpshooter empties his revolver into the side of a barn—and then walks over and draws a bull’s eye. If you’re going to argue from statistics, you must use all the statistics. Few of us are statisticians, however, and the story of Meadow Street in Guilford, Connecticut, was convincing to many readers.

This latest New Yorker series was also turned into a book. In The Great Power-Line Cover-up, Brodeur fumed that the delay in issuing the EPA report meant that “Thousands of unsuspecting children and adults will be stricken with cancer, and many of them will die unnecessarily early deaths, as a result of their exposure to power-line magnetic fields.” And the person responsible was Allan Bromley. He not only leveled this shocking accusation at Bromley, he charged that Bromley had acted on my advice.

I had by that time written op-ed articles for Newsday and for the New York Times cautioning that there was scant evidence connecting EMF to cancer and advising readers to await the results of the four-year study that had just been undertaken by the National Cancer Institute. It was to be the largest and most thorough epidemiological study of the EMF-cancer connection ever attempted. Even using the worst-case numbers from published studies, it was clear that EMF could not be a very significant factor in the incidence of cancer and probably was not a factor at all. There was, I argued, little risk in waiting for a more definitive answer.

Bromley was deeply stung by Brodeur’s accusation, but he was
not intimidated. He commissioned Oak Ridge Associated Universities, a group of research universities with no stake in the outcome, to carry out a thorough review of all the scientific information on the subject—some five hundred technical papers. The study took two years, and the panel concluded that it was not possible to establish safe exposure levels since “no hazard has been demonstrated.”

The report did little to allay public fears. There was even a 1992 movie, *The Distinguished Gentleman*, starring Eddie Murphy as a petty con man who gets elected to Congress. He is transformed into a crusading environmentalist after a chance meeting with an eight-year-old who got cancer from a power line that runs by the playground. He proceeds to battle the greedy power companies from his seat on a fictitious Power and Industry Committee.

By now, however, results were beginning to come in from larger and more sophisticated epidemiological studies—and the EMF-cancer connection was getting weaker. In particular, the newer studies actually measured field strengths in homes or workplaces rather than relying on estimates using some sort of wiring code. It is a general rule in epidemiology that if a better measure of a suspected agent results in a lower risk, there is almost certainly an unidentified “confounding factor.”

A study of rapid weight loss, for example, might show a correlation with premature death. Does this mean weight loss programs are unsafe? Not necessarily. It may just mean that the researcher has failed to account for the fact that many fatal diseases cause the body to waste. In this case, chronic disease would be a “confounder.” “Bias and confounders are the plague upon the house of epidemiology,” according to Philip Cole, chair of the Department of Epidemiology at the University of Alabama.

In 1994 a four-year study of 223,000 Canadian and French electrical workers was completed. It was the largest and most sophisticated study yet conducted. The study found no overall increase in cancer risk associated with occupational exposure to EMF. Of the thirty types of cancer included in the study, only one, a rare form of leukemia, showed an increased risk, and that was based on only five cases. The director of the study, Gilles Theriault, expressed surprise at the low numbers. “I don’t think we have the right agent,” he said.

A year later, a very similar but even larger study of U.S. electrical workers was released. The study examined the same thirty types of cancer included in the Canadian/French study. However, the American study found no increased risk for any form of leukemia, but did find a slightly elevated risk of one rare form of brain cancer. The head of the U.S. study, David Savitz of the University of North Carolina, called for an even larger study to resolve the difference. It was Savitz, you will recall, who had repeated Nancy Wertheimer’s 1979 study of childhood leukemia.

In a study breaking cancer down into thirty types, one or two false positive findings would be just about what you would expect if there was no link at all. The reason is that, by general agreement, a statistically significant finding is defined as anything above the 95 percent confidence level. Using the 95 percent standard, you might expect a false positive about one time in twenty. If the convention were, say, 97 percent rather than 95 percent, there would have been no positive findings in either study.

In fact, both studies found the cancer rate among electrical workers to be lower than for the general population. In the Savitz study, for example, the cancer rate among electrical workers was just 86 percent that of the rest of the population. This, epidemiologists explain, is merely the “healthy worker syndrome.” For a variety of reasons, people with good jobs tend to be healthier—and have fewer cancers—than people who don’t; they may have a better diet, more frequent medical checkups, live in less polluted neighborhoods, experience less stress, etc. These are confounding factors.

To avoid being “misled” by the healthy worker syndrome, the incidence of cancer among electrical workers with “low” levels of EMF exposure was compared to the incidence among workers with “high” exposure levels. This, however, leaves the question of where to draw the line between “low” and “high.” If the statistics are poor—that is, if the number of cases of a particular cancer is small—choosing a different boundary between “low” and “high” can reverse the outcome. Epidemiology was dredging for results in the statistical noise.
By the spring of 1995, the American Physical Society had completed its own review of the EMF literature. Scientific societies are normally reluctant to give the appearance of deciding scientific truth, feeling that their job is to provide a forum for the exchange of scientific results and ideas. In the case of EMF, however, it was felt that information coming from outside the scientific community, Paul Brodeur and Microwave News in particular, had given the public a seriously distorted view of the scientific facts. A statement released by the APS concluded that “conjectures relating to cancer to power-line fields have not been scientifically substantiated.” It was the strongest position on the EMF issue taken by a scientific society.

SLAMMING THE DOOR SHUT

By that time, sixteen years had passed since Nancy Wertheimer took her historic drive around Denver. An entire industry had grown up around the power-line controversy. Armies of epidemiologists conducted ever larger studies; activists organized campaigns to relocate power lines away from schools; the courts were clogged with damage suits; a half dozen newsletters were devoted to reporting on EMF; a brisk business had developed in measuring 60 Hz magnetic fields in homes and workplaces; fraudulent devices of every sort were being marketed to protect against EMF; and, of course, Paul Brodeur’s books were selling well.

Scientists, one might argue, were also thriving. Federal agencies had responded to the public alarm by funding more and more research into the interaction of electromagnetic fields with living organisms. The Bioelectromagnetic Society, formed the year before Nancy Wertheimer published her notorious leukemia study, had grown to more than six hundred members, largely on the basis of the power-line controversy.

It was into this climate that the Stevens Report was released by the National Academy of Sciences in 1996 with its unanimous conclusion that “the current body of evidence does not show that exposure to these fields presents a human health hazard.” For Brodeur, retired and living in southern California, it was just more of the conspiracy. He bitterly attacked both the report and the National Academy of Sciences in Secrets, a book recounting his thirty years at the New Yorker. Brodeur seemed not to understand confounding factors; if children living near power lines have a greater incidence of leukemia, it seemed to him that power lines must be to blame.

Ironically, Brodeur’s memoirs had no sooner reached the bookstores than, on July 2, 1997, the National Cancer Institute (NCI) finally announced the results of its exhaustive epidemiological study, “Residential Exposure to Magnetic Fields and Acute Lymphoblastic Leukemia in Children.” In contrast to the National Academy study, which had surveyed the entire body of literature dealing with possible health effects associated with magnetic fields, the NCI study focused on the question that started it all: are power line fields associated with childhood leukemia? The NCI study would answer the question, not by reviewing the existing literature, but by undertaking its own epidemiological investigation. And it would do so on such a scale and with such thoroughness that the results would not be subject to challenge.

What was to have been a four-year study ended up taking more than seven. It was the most unimpeachable epidemiological study of the connection between power lines and cancer yet undertaken. Every conceivable source of investigator bias was eliminated. There were 638 children under age fifteen with acute lymphoblastic leukemia enrolled in the study along with 620 carefully matched controls, ensuring reliable statistics. All measurements were double blind and included the magnetic fields in the children’s bedrooms and other locations in and around their homes. Each home was also assigned a wire code based on the distance and configuration of power lines.

If the National Academy of Sciences report a year earlier left the door open a crack, it was slammed shut by the NCI study. It concluded that any link between acute lymphoblastic leukemia in children and magnetic fields is too weak to detect or to be concerned about. But the most surprising result had to do with the proximity of power lines to the homes of leukemia victims: the study found no association at all. The supposed association between proximity to power lines and childhood leukemia, which had kept the controversy alive all these years, was spurious—just an artifact of the
statistical analysis. As is so often the case with voodoo science, with every improved study the effect had gotten smaller. Now, after eighteen years, it was gone completely.

The NCI study was published in the prestigious *New England Journal of Medicine*. An accompanying editorial concluded:

It is sad that hundreds of millions of dollars have gone into studies that never had much promise of finding a way to prevent the tragedy of cancer in children. The many inconclusive and inconsistent studies have generated worry and fear and have given peace of mind to no one. The eighteen years of research have produced considerable paranoia, but little insight and no prevention. It’s time to stop wasting our resources. We should redirect them to research that will be able to discover the true biologic causes of the leukemic clones that threaten the lives of children.

Research funds were redirected to other priorities. The Department of Energy closed down the EMF Research and Public Information Dissemination (RAPID) Program, created by Congress in 1992. It would no longer be needed. Now, surely, the false trail had petered out.

One year later, however, an international “working group” of experts who had been involved in the EMF issue assembled in Bethesda, Maryland. Many of those on the panel had staked their reputations on a link between power-line fields and cancer, and were working on projects whose funding depended on continued public concern. Some—like Lou Slesin, the editor of *Microwave News*, whose livelihood was directly linked to the controversy—were not even scientists. The working group treated the NCI study of childhood leukemia as just one more study. It had not, after all, been replicated. After ten days of deliberation, the group issued a call for more research. By a vote of nineteen to nine, EMF was classified as “a possible carcinogen.”

That depends, of course, on what you mean by possible. Richard Wilson, a Harvard physicist who had researched the problem, illustrated possible this way: Suppose someone tells you a dog is running down the center of Fifth Avenue. You might think it unusual, but it’s certainly possible, and you would have no reason to doubt the story. If the claim is that it’s a lion running down Fifth Avenue, it’s still possible, but you would probably want some sort of supporting evidence—perhaps a report of a lion escaping from the Bronx Zoo. But if someone tells you a stegosaurus is running down Fifth Avenue, you would assume that he’s mistaken. In some sense it might be “possible” that he’s seen a stegosaurus, but it’s far more likely that he saw a dog and thought it was a stegosaurus. Indeed, most reasonable people would agree that the possibility that there could really be a stegosaurus running down Fifth Avenue is too small to even bother checking out. Wilson concluded that the EMF working group saw a possible stegosaurus—not a possible dog or even a possible lion.

On May 1, 1999, results of a long-awaited Canadian epidemiological study of childhood leukemia were released. The massive study, covering five provinces of Canada, closely matched the NCI study in the United States. The Canadian study found no relationship between exposure to residential electromagnetic fields and leukemia in children.

By now, the total cost of the power-line scare, including relocating power lines and loss of property values, was estimated by the White House Science Office to be in excess of $25 billion. In all that time, however, there had not been a single successful lawsuit based on health effects from electromagnetic fields. In the next chapter we will learn why.