

An Interview with Andrew Marino

Casey Walker: Is scientific research being done, as most people believe, to learn about public health concerns associated with electromagnetic fields (emf)?

Andrew Marino: Asking whether we get cancer and other diseases from EMF exposures is, most fundamentally, a question of what we can expect from the way that "science" itself operates. When science is viewed in terms of how it works, who it is for, what it serves, and how it is done, we see that it is entirely different in practice and in reality from what ordinary people believe.

Science enjoys an elevated position and independence from public scrutiny unknown to any other field of inquiry. Taxpayers send \$20 billion dollars a year to the National Science Foundation (NSF) and say, "Here, go do science." There are some general tweakings of gross priorities at the very top levels of the NSF, but these priorities have little significant impact on what actually gets done—except to control the general areas in which the scientists play their games. The public trusts scientists to decide what to do. We never, as a society, demand accountability. We never evaluate what we get for what we spend. We always assume that scientists are doing their best and following rules that are, in 99.999% of the cases, above reproach—almost as if scientists who do the work are people above human flaws and frailties. None of these assumptions holds true.

We have an enormous gap between what actually goes on in science and what the public and its elected representatives believe goes on. The nature of the activity we call "science" has undergone a phenomenal change in the last 20—30 years. More so than ever before, science today is done to give certain people an advantage over other people—to make money for certain people. Or it's to serve the concept of national security against other groups of people.

In regard to powerlines, for example, the people who own stock in power companies would prefer that their costs be minimized, so the companies' preferred method of construction will be the cheapest, in the absence of any countervailing factor. This is where groups like the Electric Power Research Institute come in. They create scientific results that imply EMFs are not such a countervailing factor. Thus, you have science being used to give one group, the stockholders of the company in this case, an advantage over others—those who will live near the powerline.

The point is essentially the same with regard to any EMF-producing device in the general environment. Whether it's cell phones, military radar, broadcasting towers, video monitors, or satellite uplinks, it's always the case that (1) EMF exposure is associated with some risk; (2) the proponent of the hardware that produces the EMFs is interested in producing science that exonerates its EMF pollution; and, (3) the public exposed to EMFs is unaware of its exposure, only barely aware of it, or falsely confident in its safety because of misleading representations.

Photo coming soon.

ANDREW MARINO, Ph.D., J.D.

is a professor and research biophysicist in the Department of Orthopaedic Surgery at Louisiana State University, Shreveport. He received a Ph.D. in biophysics, and a J.D. in law from Syracuse University, New York; and is a current member of the bar in New York and Louisiana. He has figured prominently in the International Society for Bioelectricity, serving as editor of its Journal from 1980—1991. He now serves as an associate editor of Electromagnetic Medicine and Biology. His books include Electromagnetism and Life, with R.O. Becker; The Electric Wilderness, with Joel Ray; and Foundations of Modern Bioelectricity, ed. Marcel Dekker. The Electric Wilderness chronicles the highly controversial New York public health hearings on the health risks of high voltage powerlines. Marino and Becker testified in a protracted show-down against the electric power industry, and, for the first time, high voltage lines were found to be a potential health hazard.

Is there a constituency among scientists, however small, savvy enough to characterize their research in ways that meet criteria for funding yet conduct research independent of advantage-seeking interests or pressures?

As I look back over my career, I've studied just about everything related to this issue, and economics turns out to be the most important subject. If we want to understand how things work, and why they work the way they do, then we have to follow the economics of the situation—we have



to follow the dollar. Now, in the context of the scientists you just imagined, we have to ask ourselves, Who pays? Where do those folks get their dollars to do their work? We'll quickly see that there can't be people like you just envisioned, because research costs run a minimum of \$100,000 a year, usually \$200,000, and every scientist needs a sense of continuity to develop his work over a lifetime. I've been doing research for more than 30 years and it's gotten grossly more difficult in the past five to ten years. Our whole institution of the National Institutes of Health would vastly benefit from a hard look at its inner workings.

There's a person here at this university who wants to get a grant from the NIH for a million dollars every year for five years. He is well-known within that community. He knows all the people who are on the study section of the NIH, who will be reviewing his grant. During the process of grant preparation, each of these persons is brought to this university and given a nice honorarium for a speech.

Now, when these people evaluate his grant, what do you think they've got to say? They say wonderful things about his grant. There's an in-breeding to the whole system. If you follow the dollar, you'll find people on committees receiving funds who are, in turn, judging the research that will be funded. The whole system has become a self-reinforcing insiders' game.

Although science does yield some advances, its principal goal is to conserve a system in which scientists live and work. The idea that you as a taxpayer should trust scientists is important, but it's a secondary consideration. The scientists who can do what you just imagined are few and far between. Even more significantly, they don't have a material impact on the way science is done, or on the sheer bulk of science that makes up a body of research, or on the scientific consensus.

If the culture of science is, by and large, obstructing EMF-related research that needs doing in the public interest, and self-correction from within is unlikely, where do you see change coming from?

In my mind the only way to create change, and the reason I'm writing a book, is for people to understand in clear terms how science works—how it *really works*. Somebody's got to do for science what Upton Sinclair did for the meat-packing industry. That's the goal that I've set for my life. From Sinclair's actions, we wound up with food laws. When people see how badly things are done, motivation for correction can follow.

The difficulty I face is that science is a very complicated process. It's a noun, it's a verb, and it's a relationship among people. I've found that there are three classes of deep disorder. Together they add up to a body of knowl-

edge that's not reliable, is not produced for the purposes intended, and not devoted to real problems.

There's nobody in this country, for example, whose goal is to find out what causes cancer. The National Institutes of Health and the National Cancer Institute spend billions of dollars to find out how cancer is mediated—what gene goes up, what gene goes down—but no one dares question: What causes cancer? What triggers the process in the first place? The position among the cancer researchers in my school, and every other school I know about, is that cancer is caused by smoking, by genes, and by being overweight. Period.

There's no sense in looking for causes, only for mechanisms and drugs that can interrupt its runaway process.

They want treatment. Treatment is where the money is—for research, pharmaceuticals, and procedures. But the public has no concept that that's the reality. The public thinks that there are people out there trying to solve cancer in terms of understanding its causes. The natural, tacit assumption is that we all want to know about causes so we can do whatever needs to be done to avoid cancer. But that's not the way science works.

My book will describe my experience with the pathological disorders of science as those disorders have manifested in the EMF area. Without a doubt, all of the problems that are being encountered by people wanting answers to EMF-related questions have to do, first, with the disorders in science itself.

One disorder, for example, consists of outright data fabrication. One simply writes down numbers whose implications are favorable for one's client. One of the clearest examples in my experience was the experiments and related activities carried out for the Department of Energy by investigators at Battelle Pacific Northwest Laboratories in the 1970s and '80s. Among other dodges, they averaged negative and positive data from EMF experiments on animals and concluded there were no effects. I think that kind of activity is widespread in industry-controlled research. How likely do you think the power industry is to give the true results of experiments when those results are adverse to the companies' interests?

Another disorder in science has to do with belief—where you believe that you understand nature, that you've got your hands on what's really going on. Now once you reach a state of belief, any evidence that tends to oppose your belief is dismissed as an aberration. It's like Procrustes, the innkeeper in Greece. If his guests were too short for the bed, he had a machine that stretched their legs, and if their legs hung over the bed, he cut off their feet. Then he wrote a book entitled *On the Uniformity in*

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Stature of Travelers in Greece. It's a very serious problem. I first encountered it when I met Hermann Schwan, a famous physicist, who testified in a state powerline hearing that he didn't bother to check the methodologies of studies that supported his theory that EMFs were safe, yet took a fine-tooth comb to those that didn't. He was a believer.

A different way of saying this is that scientists are by and large, hopeless romantics; the world they perceive is often quite distorted and matches up poorly with the real world. What I've learned in science has come from my character, my observations, my use of logic, and my values—all put to use in the specific situations I've confronted. My method is pure phenomenology. I remember the person who condemned my first paper as "mere phenomenology." My first observation of an EMF bioeffect simply didn't fit into some theory. Most scientists see what they want to see. Also, most scientists believe science is the most valuable thing in the world. But I think if you consider science as a value or a goal, and measure its achievement side by side with its destruction, the latter just about zeroes out the former.

A third disorder occurs when some nonscientific factor such as national security displaces science. For instance, the Navy wanted an EMF antenna to communicate with submarines. It did studies and the studies showed that the fields produce many different kinds of biological effects on many different species. The Navy hid the information because, if it were disclosed, building the antenna would be more difficult. And, the goal of the Navy, which is to protect the country from foreign aggression, would be made more difficult. Therefore, it could not be that fields affect people, because then the Russians would gain an advantage over us. The Navy just held the data and blocked any attempt by others to get the information out. The same kind of thing happened when the Russians irradiated the U.S. Embassy in Moscow in the 1960s—70s. The State Department sponsored studies of U.S. government employees in the embassy, who'd developed cancer, then hid the evidence.

It appears that the whole field of science for EMFs became derailed during the period leading up to WWII when physics began deeply influencing all of the sciences with linear, deterministic models inadequate to biological realities.

That's exactly what happened. One of the key forms of pathology or disorder that shows itself is in the difference between accepted models and methodologies and what we know about the way things are in the structure of the world. The whole problem started with physics becoming the prototype science, particularly in its methods. The accepted idea was that biology, when it grew up, would be like physics.

Now it's apparent to everyone that that's not the case at all. For one thing, in educating biologists today, we don't teach them anything at all about physics. I can go up and down the halls of institutions and talk to 250 biologists and another 250 physicians and not one of them has had any physics beyond their second year of college. To them,

Ohm's Law is an equation of great complexity. Now, biology and physics are not completely divorced. There's nothing in biology to contradict physics, but even with perfect knowledge of physics you don't get anywhere in terms of being able to predict anything in biology.

Physics, and what physics seeks to understand, is restricted solely to inanimate objects and forces that can be explained by equations. When you go to something that's alive, something that's performing activities and consuming energy, you are looking at an open system. A living system can only function by exchanging energy with its environment, and is fundamentally different from a physical system that exists in a closed environment. A car, driving along, is a closed system. We can control it, explain exactly what's going on, and predict what's going to happen next without needing to explain everything that surrounds the car. Only a linear model will allow that kind of predictability. Once you go from a closed system to an open system, you go from physics to biology.

In biology, the whole system is nonlinear and therefore lacks predictability of the type found in physics. Biologists don't do experiments even remotely like physicists. In biology, experiments attempt to find causal relationships between things—apply this electromagnetic field and watch the blood cells change. I'd never expect to be able to write an equation which explains how, when I apply a specific field, these blood cells will change. Instead, I would develop my observations and expect to put the interaction between EMFs and blood cells into a pattern. I could never explain the interaction in the same way as explaining how an atomic bomb works, or how a radio works. Biology is a completely different form of knowledge from physics, as different from equations and predictions as art or music. It's an entirely different sphere of human inquiry and activity.

Yet, there are hierarchical levels of biological organization dependent upon physics?

Yes, in the sense that everything that takes place within a living system follows the laws of physics. Nothing violates, for example, the creation of energy or the second law of thermodynamics. But these are just characteristics of dynamic activities taking place in living systems.

It's like Plato's allegory of the cave with the shadows on the wall. You can see, on one hand, that shadows are fundamentally different from three-dimensional reality, but you wouldn't say that they are irrelevant or unrelated. They are just the palest copy of three dimensions. Three dimensions include two dimensions, but not vice-versa. I think that's about the best way that I can make my point, that what physics really represents, in its laws and its applied models, is only a small subset of what human beings experience in the living world. We tend to be so misled by the accomplishments that are made in physics, with airplanes and computers and atomic bombs and space exploration, and so forth, that most of us have come to think of them as absolutely overwhelming proof that we can do anything. If we could do such things, then we can certainly grow enough food and take care of all our other problems. But



it's like trying to go from shadows to three dimensions. Controlling living systems like that just won't happen.

Physics made impressive achievements possible. To encapsulate a scheme of equations where you can predict how the planets stay parallel to one another and move the way that they do, to come up with a scheme whereby you can build a computer, one cannot call that subjective, one cannot gainsay that achievement. But when you begin to take that model for knowledge, that way of knowing things, and begin to apply it in the places that it doesn't apply, that's where it all goes badly.

A big part of the story of EMF science is the domination of it by physicists and engineers, and the application of the wrong model. The reason the EMF issue became a controversy is that inconsistent results from one experiment to another were interpreted, using the physics model, as contradictory. But in biology inconsistency is a fact. Certainty in biology is impossible.

Will you describe your experiences in researching the effects of EMF exposures?

As a first-year graduate student in the 1960s, I had the great good fortune to work for Dr. Robert Becker—one of the incredibly rare examples of people who have ideas that are different from the norm and the guts to try to discuss them. He had the good luck to keep his head above water for a time before the sharks finally killed him. His idea was that electrical factors must be important in the way the body works—that it isn't all just biochemistry. I came on board as a first year graduate student because I had some formal training in electricity and magnetism. We worked in an orthopaedics lab, attempting to use electricity to grow bone and to grow nerve. Along the way, we had some successes and some failures, but the results of the experiments I did showed that very weak electromagnetic fields could affect the way the body worked.

What I measured were biological parameters that seemed plausible to me at the time as possible targets of EMFs. We were just beginning our work, and there were few established guidelines or reliable guideposts to govern our choices. Also I had learned the skills of measuring certain parameters. I measured the effect of fields on growth rate, blood proteins, and hormones that were indicative of stress. As time went on and we began to understand how the EMFs affected the body, our measurements became more specific, concentrated mostly on the nervous and immune systems.

The results were dismissed by very important people.

My greatest antagonist was president of the National Academy of Sciences, a man named Philip Handler. He was incredibly vicious and vituperative in his attack on our findings. He wound up, in my judgment, being instrumental in closing the lab, our loss of grants, papers forfeited from publication after acceptance, and so forth. He was very powerful, and very aggressive in condemning the idea that electromagnetic fields have biological effects. Such findings were simply unacceptable to him and, presumably, to the interests he represented.

But, given my personal nature and my training and the good luck of my collegial environment, I would not allow myself to be pushed around. Remember the guy in 1984?

To me, the worst thing in the world is being pushed around by people who think right is wrong, or black is white—or think that what is neither black nor white is in fact black and white. I just can't live that way. So I went back to law school. Now it's a lot tougher to push me around. I learned how to argue, and that's what I've been doing—at scientific meetings, in hearing rooms and law courts, in law review articles, in science papers and editorials, public meetings, interviews, books.

The way things are coming down now, I wouldn't trade places with anyone. Even though I was challenged for reasons that were based on authority and clout and power rather than on evidence, it just so happened that I had the help and tools to resist. Now I have papers coming out that demonstrate beyond

all reasonable doubt that electromagnetic fields affect the human body. The body's ability to detect exposure to EMFs is essentially 100% when data are analyzed in such a way that the possibility of a nonlinear interaction can be recognized.

Right now the situation is this: On one side, there are these powerful communities of interest with a lot of money and power—the military, the power industry, the wireless industry, and so on. On the other, we find some basic data and some essential truths, but have no money, no organization, no clout, and no standing. It's only because the evidence that EMFs affect biology is so clear that the concerns have not gone away. Normally the forces with clout would have squashed the issue by now. But they haven't, despite their resources. The issue keeps simmering because there's this essential kernel of truth on the other side.

How do you describe human sensitivity to electromagnetic exposures?

A big part of the story of EMF science is the domination of it by physicists and engineers, and the application of the wrong model. The reason the EMF issue became a controversy is that inconsistent results from one experiment to another were interpreted, using the physics model, as contradictory. But in biology inconsistency is a fact.



The body is an antenna, a living antenna, something that in principle can react to the presence of external fields, just like your antenna on your radio reacts to the presence of a radio signal. Now if you envision a structure that can convert that reaction to a biological signal, then you have some understanding of how "transduction" takes place. Outside the body, all you have are physical forces such as gravity and electromagnetic fields. But inside the body, all of the signaling—all the ways one cell knows what another cell is doing—is by virtue of hormones secreted, messages sent from one cell to another cell, or electrical activity of the nerves. That's the nature of the internal information transfer. When energies outside a living system are transduced, hormone levels or the electrical activity of the living system change.

When I apply external fields to a human being, for example, there are two sets of energy—the external electromagnetic energy I can impose on a human body and the human body's bioelectricity, such as the activity of the nervous system and brain. I have measured changes in brain waves during an individual's exposure to varying electromagnetic fields and have found that human beings are sensitive to virtually every frequency that I have conducted tests on thus far.

From an evolutionary point of view, I've got some theories about how this came about, but they represent quite a different thing from demonstrating that such sensitivity exists. There are certain aquatic species, such as sharks, rays, and catfish, for example, that have the ability to respond to incredibly weak electromagnetic fields. It's quite likely that primitive organisms developed this capability as a means of gathering information. Catfish can sense low frequency fields when predators move, and swim either one way or another to get away. There are other kinds of fish that can generate their own electrical signal and pick up its reflecting signal, just as a bat generates sound and reflects it. The fish species I study can be bought at a pet store for about \$10. These fish generate an electrical signal in their tail and detect it in the sensors located in their head and along the lateral line of their body. The fish sends a signal and it bounces back so it knows where things are, just as a bat does with sonar.

We know from the physics of the situation and from the biology of the situation that, first of all, there must be a protein that's reacting with the external field. Second, we know that that protein has got to be in the surface of the cell. And we know very well where the cells are. I can isolate and view them with a microscope. Since I know where the cells are, I am working to extract the proteins, then clone the gene that makes that protein. I'm predicting that I'll find that same gene and protein in human beings. Now, its purpose in the human being might be—and I expect to find it in the brain's hypothalamus—tied to more complex brain functions than mere environmental information. I expect these sensitivities to be implicated in a wide number of cognitive functions, such as memory.

The EPA once acknowledged in a research agenda that EMF

research on reproduction and development is important for "the propagation of the species." How do we best approach the potential impact of EMFs on biological evolution?

Evolution is a process that takes place over enormous time scales. I can't think about particular factors that might affect evolution in a gradual way (that is, excluding things like nuclear annihilation), and I really don't think anybody else can, at least not in any way that is meaningful. Once you contemplate enormous time scales, you allow for the potential action of innumerable factors. So, it's virtually impossible to predict what will happen. But if you scale your question back to some time scale that I can wrap my mind around, like a generation, or a half a generation, then it's obvious that EMF exposure in the environment will have a profound effect. Present evidence, for example, which undoubtedly vastly underestimates the effects of EMFs, suggests that it is presently causing increased cancer rates of 100-300%. In plain language, the fair import of the data tells me that, on any given day, a minimum of three times more people die from cancer than would be the case if the same people, that is, individuals with the same propensity for health or sickness, had not been exposed to EMF fields. And that is only one manifestation of the consequences of field exposure. The simple point is that field exposures increase disease rates now. What the long-term evolutionary consequences will be of this fact, I can't imagine.

Has law—regulatory hearings, tort cases, and so on—brought the public closer to recognizing the effects of EMFs?

Regulatory hearings are mostly useless. Tort cases have the potential to bring us closer to the recognition of risks, but that hasn't happened thus far. The abrogation of the Frye rule—which had long closed the door to consideration of new scientific information in courtrooms—was a significant development in American jurisprudence. Thus far, the seed has fallen on barren soil, mostly because of the unsurpassed scientific ignorance of the present generation of lawyers, I think. The good news is that everything is in place for important changes to occur. (*Ed. note: The Frye rule, which permitted scientific testimony only if it was "generally accepted," was overturned by the U.S. Supreme Court in Daubert v. Merrell Dow Pharmaceuticals, Inc., 1993. The Court ruled that the reliability of scientific testimony must be determined not by some test of general acceptability but by considering how the individual expert arrived at his opinion.*)

I think that federal safety standards in the EMF area are probably an incubus of progress. Legal safety standards only come about as a result of the acquiescence of the polluter, and the polluter never acquiesces unless he's absolutely forced to do so. And that never occurs unless the effects produced by the pollution are relatively large, immediate, and obvious. In other words, legal safety standards deal with only the most egregious cases, and they insulate the polluter from liability for all other consequences of its activities. A better way, I think, would be to perform honest research, make the results known to the general public, and let them sort out the risks, their impli-



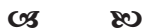
cations, and how to deal with them.

What do you think would specifically improve public knowledge and appreciation of the significance of EMFs?

Every governmental program—NIH, DoE, EPA, or any program that involved the production of data or information concerning the biological effects of EMFs—should be completely transparent to the public. The public should have access to grant proposals or proposed contracts, the deliberations of committees, and the raw data produced by the grantee. The advantages that would result from such a rule are almost too enormous to contemplate.

And, funding should be expanded for an almost completely neglected area of neuroscience, namely electrophysiology. The nervous system is quintessentially an electrical system, but, in keeping with the present fashion for molecular biology, it is studied mostly from its chemical constituents and mediators. One cannot understand function by studying structure, yet that characterizes most of the science done today. A deeper understanding of the electrophysiology of the nervous system will pave the way toward understanding how the body transduces external fields and how it reacts to the consequences of transduction.

It will also, likely, help to explain how the body itself is governed. Life itself is an emergent property that appears only at a certain level of complexity, and not below. Cell nuclei are not alive, ribosomes, mitochondria, proteins, and DNA are not alive. The only concept we have in present-day science that can rationalize how life emerges is a concept based on electrical forces.



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