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# LETTERS

## High Tension

It is a disservice to the readers of *The Sciences* to discuss exposure to fields of "high tension wires" amid a smog of statements dealing with microwaves, radiowaves, and even x-rays, as Robert O. Becker and Andrew A. Marino do in their article, "Electromagnetic Pollution" [January]. Observations of biological effects from radio frequency or higher frequency radiation have no value in assessing the possibility of effects from the extremely low frequency (ELF) fields of transmission lines.

Just consider the ELF question alone: The central theme of the article appears to be that "until recently, scientists believed that electromagnetic radiation had no effect on life" but now that "abundant evidence establishes that both natural and artificially produced NIEMR (nonionizing electromagnetic radiation) can produce some biological effects it raises the serious question of possible health hazards for humans." The premise is extremely misleading, since it has been known since the classic experiments performed by the eighteenth century Italian anatomist Luigi Galvani that electric fields could affect biological materials. The question, then, is not whether NIEMR in general can have effects but whether a given field strength of interest—electric or magnetic fields under transmission lines—can.

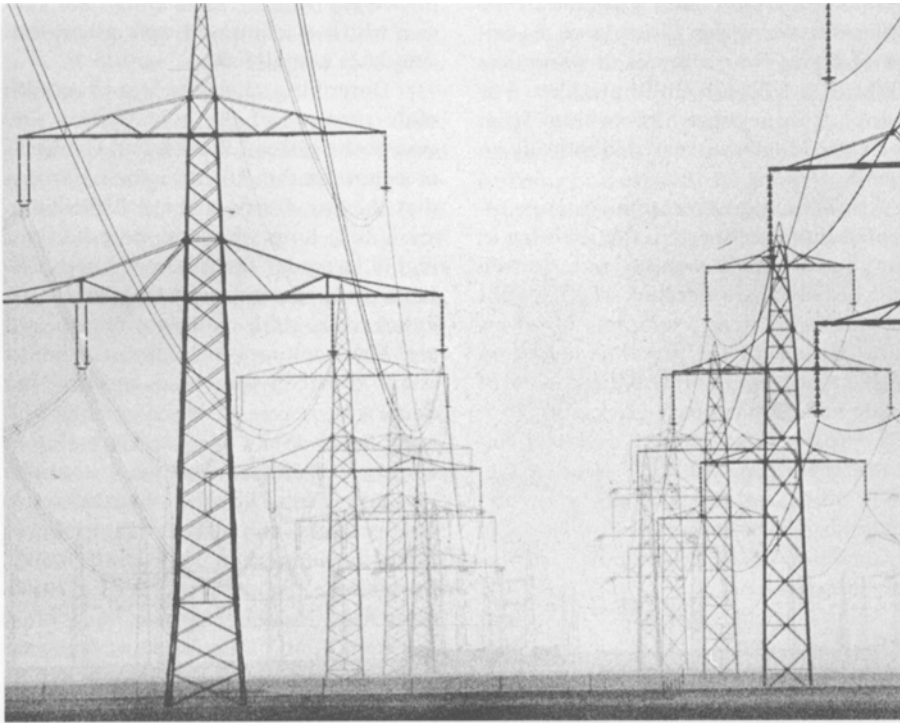
Briefly, let us review their reports as quoted: "Beischer... reported that certain levels of artificially produced field exposure to humans result in elevated serum triglycerides..." Dietrich E. Beischer of the Naval Aerospace Medical Research Laboratory did not publish his experiments in a journal but simply made the results of this preliminary study available in a technical report. The work is subject to a number of criticisms involving control of diet, matching of subjects, absence of pre-confinement baseline data and lack of evaluation of the effect of confinement. However, the important point is that Beischer, himself, concludes: "No effects were seen that could be definitely linked with

the magnetic fields." Thus, the statement by Becker and Marino is a misrepresentation of the Beischer experiment.

Becker and Marino fail to mention that several better controlled studies have now been completed on the effects of magnetic fields on triglyceride levels—all with negative results. These include a study by Beischer on mice, two studies using Rhesus monkeys (one by James D. Grissett and one by John O. de Lorge, both of the Naval Aerospace Medical Research Laboratory), and a study by Juan P. Rupilius of the Albert-Ludwigs University on human subjects exposed to magnetic fields.

Or consider their remarks based on work by James H. McElhaney, who at the time of writing his article was at West Virginia University. McElhaney, according to Becker and Marino, "showed that certain levels of low frequency electric fields can cause bone tumors in rats." First, let us dispel the spectre of malignancy, which may be connoted by the word tumor. No investigator, including McElhaney, has suggested that exposure to ELF electric fields produces cancer. McElhaney's observation came from a single experiment with a small number of animals. The experimental protocol alone rendered one half of the animals non-usable. It is strange that Becker and Marino should single out this one ten-year-old, unconfirmed study. Becker and Marino have investigated the effects of electrical stimulation on bone growth in the intervening period. Yet neither they nor any other of several investigators in the field have reported any tumors related to the application of electric fields to tissues.

Turn now to this statement: "Gordon Marsh of the University of Iowa found that even lower doses can interfere with the growth pattern of flatworms." Here we have a tremendous distortion of scientific "facts." In Marsh's experiments, the electrical fields were produced by electrodes placed directly in the conducting medium containing the organisms. The physical situation was similar to that of a person sitting in a bathtub when a radio falls in. Indeed the *threshold* current density at which Marsh noted effects is similar to that at which people perceive electric shock. To achieve this threshold current density using electrodes coupled to the conductive medium by air (as in the case of transmission lines) would require a field strength far in ex-



cess of the dielectric strength of air (the point where air breaks down as an insulator and corona or flashover occurs). Thus, the obvious conclusion from this study is that no effects would be expected at field strengths which could be induced by transmission lines.

According to the article, "James R. Hamer of UCLA reported that an electric field about one hundred times weaker than that employed by Marsh can affect animal reaction-time performance." Hamer's experiments were conducted in an air field of four volts per meter (about the field strength in a typical home) so that *within* the subjects (who were people rather than animals) the field strength was about one hundred *million* times less than that used in Marsh's experiments. In conducting the experiments the data were collected in sets of twenty-four measurements made back-to-back under a given field condition, yet in analysis the results of each of these serial measurements was treated as if it had been made independently. This erroneous statistical procedure tremendously magnified some very small differences in reaction time, and is probably responsible for a false indication of statistical significance. It is interesting to note that elsewhere Becker and Marino have cited the results of H.L. Konig of the Technical University of Munich as supporting Hamer's, even though under similar field conditions Konig re-

ported changes the opposite of Hamer's.

Becker and Marino's discussion of biological effects of the Earth's electromagnetic environment is vague and highly speculative. However, it is clear that Rutger Wever's experiments at the Max-Planck-Institute für Verhaltensphysiologie did not establish "...that circadian rhythms are affected by the existing atmospheric electromagnetic environment." Wever's experiments were conducted in underground bunkers so that neither experimental nor control subjects were exposed to the "existing atmospheric electromagnetic environment."

"In our laboratory," the authors report, "we found that rats exposed to a sixty-Hertz electric field for one month exhibited hormonal and biochemical changes similar to stress." The statistical significance of their results is in doubt since prior to analysis these scientists arbitrarily deleted high and low values in their data, yet used tests for significance which ignored the deletion of data. When these data are properly analyzed, the only consistent difference between exposed and control rats is that the exposed group drank slightly less water. This is not surprising since the rats were electrically "floating" in the cages but had to touch grounded water bottles for drinking. Thus, the animals may have received small transient electric shocks as they drank. Two independent investi-

gations (by Richard D. Phillips and his co-workers at Battelle Northwest Laboratories and by Curtis C. Johnson and his co-workers at the University of Utah) have failed to demonstrate the effects claimed by Becker and Marino.

In another experiment Becker and Marino claim that they "continuously exposed three generations of rats to the electric field and found increased infant mortality and severely stunted growth." This statement was based on a single unconfirmed experiment (described earlier by the authors as preliminary) with several internal inconsistencies which make it difficult to draw definite conclusions. However, of the two exposure regimens, horizontal and vertical, only the vertical exposure *appeared* to bring about significant effects. The physical arrangement for this part of the experiment was almost identical to that used in the rat experiment, and again there is a strong possibility of transient electric shocks. In a previous article Becker and Marino wrote, "the possibility must therefore be considered that the greater weight depressions and increased mortality in the vertical mice may be related to grounding microcurrents." The three-generation mouse experiment does not support the conclusion that exposure to electric fields will influence growth or development.

The authors indicate the "use of electromagnetic energy in the U.S. continues to expand..." and that "The U.S. Navy has proposed to build a gigantic antenna in Michigan which would radiate at very low frequencies." The proposed Seafarer system will operate at about one one-hundredth of the electric field in one's office. The National Research Council has recently published an extensive review of nearly all the "ELF literature." The committee writing the report concluded: "the likelihood of serious adverse biologic effects of Seafarer is very small."

Like almost any major construction, electric power transmission lines affect both people and the environment in a variety of ways. However, claims that the electric and magnetic fields from such lines cause biological effects appear to be without basis. No one has identified a single effect which will occur from direct exposure to a transmission line's electric or magnetic field. The types of investigations undertaken to test for biological effects of extremely

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low frequency (ELF) electric and magnetic fields have been varied and numerous. For example, there have been investigations on the growth and development of plants and animals, on the cellular and molecular aspects of metabolism, and on cell physiology, on whether or not there are alterations in behavior, on the health of people living near transmission lines, and on the health of utility linemen working (for a period of nine years) on energized 345,000 and 765,000 volt transmission lines. The general conclusion from these investigations is that there is an absence of biological effects from field levels comparable to those experienced by persons or other living objects underneath an operational 765,000 volt transmission line.

MORTON W. MILLER, GARY E. KAUFMAN,  
EDWIN L. CARSTENSEN  
*The University of Rochester*

### **R.O. Becker and A.A. Marino reply:**

High-voltage transmission lines create electric and magnetic fields which extend for several thousand feet beyond the wires. This electrical environment has been shown to cause biological effects in test animals, including human beings, in more than seventy independent investigations conducted throughout the West. Numerous additional studies within the Soviet Union have also demonstrated that transmission line fields cause adverse biological effects in humans and animals. We refer the interested reader to our recent review article, published in the *Journal of Physiological Chemistry and Physics* (Volume 9, No. 2, 1977). We believe that involuntary exposure of the public to the same electrical environment which causes biological effects in laboratory experimentation is a form of involuntary human experimentation and is therefore abhorrent in our society. Living or working near high-voltage transmission lines constitutes human experimentation because we cannot pinpoint the specific effects and yet we know from many independent studies that there is a risk.

Beischer found that one gauss for one day caused elevated serum triglycerides in human volunteers. There have been no studies that are either later, better, or which report a different result; one earlier study, however, reported the same result. The earlier study was de-

scribed in a Navy report released by Senator Gaylor Nelson of Wisconsin in December 1975.

Beischer has an international reputation in the area of biological effects of magnetic fields. At the time he conducted his triglyceride experiments, he was the director of the Naval Aerospace Medical Research Laboratory. The research facilities available to him were among the best in the world. The criticisms of his work are without foundation.

The full quote from Beischer's report is: "No effects were seen that could be definitely linked with the magnetic fields; however, serum triglycerides in most subjects appeared to be affected by some factor associated with the experimental protocol." Later in his report Beischer notes, "Barring the oversight of a crucial factor, the results of the present study strongly indicate that certain mechanisms of lipid management in the human body are influenced by an external, comparatively weak, alternating magnetic field of low frequency."

The bone tumors observed by McElhaney were produced by an experimental procedure that has never been duplicated. The non-appearance of tumors during quite unrelated research is fortunate, since much of the work involves human beings, but certainly it is not strange.

Marsh applied to flatworms an electric field of a strength equal to that produced by a 765,000-volt transmission line at a distance of 256 feet. Since flatworms live in an aqueous environment, Marsh applied the electric field through it. If flatworms lived in stone, then in the interests of realism, Marsh would presumably have applied the field through the stone. The significance of Marsh's work, and indeed that of all of the ELF investigators, is that they describe effects due to ELF fields which are unpredicted by present physical theory.

Hamer and Konig each used ELF fields of strengths equal to that produced by 765,000-volt transmission lines at distances of one thousand to two thousand feet. Both investigators reported that the fields altered human reaction time; the studies are entirely consistent, and neither contains statistical errors.

We believe that it is incumbent on Miller, Carstensen and Kaufman to make an effort to duplicate research which they criticize as false. As of January 1978, Miller has written various doc-

uments for the electrical utility industry, claiming that about 45 different groups of ELF investigators published results that were probably false; Carstensen condemned about 32 groups. Neither

Wever's research has provided the scientific community with one of the most important advances in human biology in the last decade. He isolated human volunteers in underground bunkers for three to eight weeks and measured their temperature and activity circadian rhythms. He found that the subjects living in the electromagnetically shielded bunker exhibited periodicities in body temperature that were significantly different than those of subjects living in a non-shielded bunker. He also reported that desynchronization between the two rhythms occurred only in the shielded bunker. He found that both effects ceased when he applied a very weak ELF field to the subjects in the shielded bunker. Wever's research strongly indicts the current practice of injecting ELF fields into human living space. It is therefore unjustifiably attacked by utility industry consultants.

We did not arbitrarily delete data. In a letter to the editor of the *Journal of the Electrochemical Society* (June 1977), Miller, Carstensen and Kaufman made similar false accusations against us. We do not understand why they continue to make such scurrilous charges. We shudder to think what they consider to be "properly analyzed data;" except for outright fraud, no manipulation of our data could obscure the stress-induced biochemical changes which we observed.

Our animals did not receive shocks. Miller, Carstensen and Kaufman, in cooperation with engineers from the Rochester Gas and Electric Corporation, constructed a duplicate apparatus to that which we employed in our studies. Color films made by this team are presently on file at the Public Service Commission in Albany; they establish conclusively that the animals were not shocked in our apparatus.

The work of neither Phillips nor Johnson duplicated our work; it was therefore not possible for them to demonstrate the effects which we observed. On the other hand, the research of both Joseph Noval, of the Temple University Medical School, and N.S. Mathewson, of the Armed Forces Radiobiology Research Institute, were both similar to

ours and both found results which confirm our results.

We observed stunting of growth in mice in three successive generations which were exposed to an ELF electric field. Miller, Carstensen and Kaufman have not accurately described our work.

There is not even one study whose conclusion is that 765,000 volt transmission lines don't cause biological effects. How could there be when there are about seventy studies which show that such fields *do* cause biological effects?

The present generation of high-voltage transmission lines are designed in a manner which affords the public no protection against exposure to electromagnetic fields. Thus the present design is a benefit to the stockholders of the investor-owned utilities, because properly designed lines would be more expensive. The correlative risk to health is borne by the people who live and work along the right-of-way. This situation, that some people endure the risk while others enjoy the benefits, is unjust and must be ended.

Our research involves the study of the effects of electricity on animals and human beings. The research of Miller, Carstensen and Kaufman involves the study of plants, and the effects of sound on cells. It is healthy for scientists outside a given speciality to criticize those within that speciality. Such criticism, however, to be effective, must be offered with a sense of humility by independent and disinterested individuals. Where, as here, the criticism is offered by industry consultants, a major credibility issue is created. We call on the Rochester trio to end their individual fiduciary relationships with electrical utility interests, including those of stockholder, consultant and grantee. Perhaps their subsequent criticism of the ELF scientists might then ring true. □