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LETTER TO THE EDITOR

VARIABLES IN RESEARCH INVOLVING ELECTROMAGNETIC BIOEFFECTS

There is, at this time, a growing interest in the biological effects of nonionizing electromagnetic fields. The importance of this research is evidenced by the growing number of retrospective epidemiological studies (1-9) indicating that environmental man-made fields may constitute a health hazard of some consequence. It would appear that two things are required for optimum advancement of research in this area. First, a logical construct to explain why such effects occur at all, and second, a recognition of the large number of variables inherent in such research.

Recognizing that any proposals regarding the above two considerations are necessarily subject to change, and in fact may not be agreed with by all workers in the field, it nevertheless appeared desirable to advance such proposals at this time, if for no other reason than to elicit discussion.

I would, in answer to the first question, propose that living things are naturally responsive to electromagnetic radiation and that this response involves such basic mechanisms as biogenesis (10), evolutionary change (11), and functions of present-day organisms such as biological cycles (12). A mechanism of such antiquity implies organism responses to fields comparable to the earth's normal intensity and frequency, 0.5 gauss, 0.5 kv/meter and 0-30 Hz. Since the sensing unit is of the dimensions of a cell or lower, resonance phenomena appear unlikely at the frequencies noted, and solid-state processes, or detection via magnetically-sensitive units seem more likely. The interaction between the natural fields and the organisms is postulated to be in the nature of information transfer, with frequency as the information carrier. With these assumptions, it is possible to draw some conclusions.

Fields within the normal frequency range will not produce abnormal responses unless their intensity is markedly greater than normal. Fields of abnormal frequency, but close to the normal, i.e. less than 1000 Hz, will have significant effect at low strengths, and as the frequency deviates further away from normal, the effects at any given field strength will diminish. A recent paper (13) seems to support these conclusions. This concept would appear to hold up to 100 MHz, at which point resonance effects would become feasible. A further conclusion may then be drawn; synergistic effects may occur when organisms are exposed to both frequency ranges simultaneously. If this is feasible, then any epidemiological study must consider all environmental fields to which both the test and the control groups are exposed.

In any experiment, both physical and biological variables must be carefully considered. Magnetic fields produced by the flow of electrical current within a coil system, will necessarily contain a corresponding electrical field, because the only pure magnetic field is that produced by permanent magnets. Magnets can be used to produce static or time-varying fields within mechanical limitations. Time-varying fields of all types must be considered from the point of view of the wave shape actually produced within or at the level of the tissues proper. "Normal" conditions within the usual laboratory are invariably not field free; factors such as electrical wiring, lights, heaters and even the possibility of radiation from such external sources as communications signals should be considered. Failure to take such variables into consideration may be related to failure to replicate experiments. Biological variables must be considered to be numerous at both the cellular and organismal levels. In vitro cellular experimentation must consider variability in response of different cell types, including normal, transformed, and malignant cells, as well as the functional state of each cell type. Such functional states, in vitro, include the growth rate (seeded, log phase, confluency) and the presence or absence of mitotic activity. Additional variables to be considered include the culture media, culture temperature, and type of incubator. When the total organism is the test subject, additional variables are introduced. Since it is not presently known whether sensitivity to such fields of the entire organism resides in all of the cells or in one certain functional system (i.e. nervous system) local field exposures may be assumed to produce a different effect from total body exposures. It is obvious that one cannot assume equal sensitivity to field factors for all types and species of living organisms. Furthermore, the functional state of the test organism must be considered, i.e. the state of the reproductive cycles, biological cycle, experimental stress and other hormonal variables. In cases involving total body exposure, the presence or absence of deposits of magnetite within the central nervous system must be considered in evaluating any results.

The biological world is one of great diversity of type and function, and it is characterized by constant change. Identical experiments on the same organism may not always produce the same result and experiments on a limited population type cannot be extrapolated to a generalized population. The universal presence of abnormal electromagnetic fields in our environment renders the question of possible hazardous effects of paramount importance. An accurate assessment of the risk can come only from carefully planned experimentation taking into consideration all of the possible variables. The undersigned invites further discussion of the concepts enunciated above.

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