Cellular Basis of EMF Sensitivity

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Abstract

Electromagnetic fields (EMFs) interact with all living and nonliving material bodies, but EMF-induced bioeffects necessarily involve detection processes unique to living systems. Sensory transduction is an example of a process that occurs only in metabolizing organisms.

We reviewed the entire EMF bioeffects literature (1) and concluded that most laboratory phenomena, clinical symptoms and disease were caused indirectly by the field, and that actual EMF detection was a form of sensory transduction. Unlike ordinary sensory modalities, however, detection of EMFs was governed by nonlinear laws.

To establish the occurrence of EMF transduction, we developed a new form of data analysis that allowed observation of any kind of EMF-induced effect, whether linear or nonlinear (2), and then performed human and animal experiments aimed at obtaining evidence supporting our nonlinear transduction hypothesis.

Our work was based on the principle that all known sensory stimuli produce both onset and offset evoked potentials that are measurable in the electroencephalogram. We reasoned that if evoked potentials were also produced by EMFs, they must be sensory stimuli and therefore detectable by the body via sensory transduction (the flow of ions through ion channels in the membrane of a specialized detecting cell).

In a study involving 22 volunteers, we reported that every subject exhibited an onset and/or offset evoked potential triggered by 1–2 G, 60 Hz ($p < 0.05$ for each volunteer) (3), thus establishing the existence of a human magnetic sense. In follow-up studies we showed explicitly that EMF-induced evoked potentials were consistent nonlinear phenomena (4), and could also be produced using high-frequency EMFs (5). In the latter study we concluded that each of the 217 pulses produced per second in a typical cell phone was capable of producing an evoked potential.

Electromagnetic fields consist of electric and/or magnetic fields that are fixed in space or propagating. We addressed the important question of which aspect of the EMF was actually detected by the body. In a series of studies on human volunteers we established that the electric field alone was sufficient to explain all known effects of EMFs on human brain-wave electrical activity (6).

In electrophysiological experiments on rabbits we showed that the electroreceptor cell (the specialized cell that interacts with the EMF, akin to the retina cell for detecting light and the hair cell for detecting sound) was located in the head (7). In positron emission tomography studies on rats we showed that the electroreceptor cells were probably located in the cerebellum (8).

To estimate the sensitivity of the human electroreceptor cell we studied the electroreceptor cell in the glass catfish, which is one of the few examples in nature where the complete neuroanatomy of an EMF-sensing system is known. On the basis of measurements and theoretical calculations we determined that catfish electroreceptor cells were capable of detecting an electric field of 1 μV/m (well within the fields created in the human brain by environmental EMFs) (9). We constructed a theoretical model of an electroreceptor-cell membrane protein that was capable of detecting such a weak field. We expect that a similar protein will ultimately be found in human electroreceptor cells.

We developed antibodies against the membrane proteins of the catfish electroreceptor cell, and showed that the antibodies were capable of blocking the ability of the fish to detect an electric field (9). It is reasonable to expect that similar antibodies may be developed for human use, thereby forming an effective therapy for human sensitivity to EMFs.

References

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