Statement of Robert O. Becker, M.D. to Subcommittee Public Health of the U.S. House of Representatives in Connection with Hearings on H.R. 10790, Radiation Control for Health and Safety Act of 1967

The normal functioning of solid state of semiconducting electronic devices is much more easily interfered with by interaction with electromagnetic fields than is the function of devices using electron vacuum tubes. Such interfering fields may be steady state or fluctuating in nature. The interference is produced by altering or stopping the flow of electrons within the solid-state materials themselves, or by altering the electronic structure of the semiconducting crystalline material.

It has been postulated for some time that various components of living organisms have semiconducting properties and that they might perform important functions for the organism. If this is so, then we would expect that similar types of interference would be possible and might result in disturbed functioning of the organism. The type and nature of the electromagnetic field or radiation that would produce detectable biological interference, however, would be dependent upon the operating parameters of the biological semiconductors. It is quite likely, from a theoretical point of view, that biological semiconductors are operating quite differently from those in manufactured devices. One would then expect that interference would be noted with electromagnetic fields different from those commonly interfering with electronic devices. Furthermore, such interference would not be noted under the present circumstances but could occur in the future should a technological development produce new devices radiating the necessary electromagnetic fields.

The problem resolves itself into a series of steps, first, detection of semiconducting properties in biological materials, second, determining the function of these properties, third, determining the operating parameters of the biological semiconductors, fourth, based upon all of the preceding steps, a prediction of the type of electromagnetic field that would produce interference and fifth, a search for evidence of such an interference.

My laboratory has been involved in a study of biological semiconducting systems for the past ten years. We have been concerned primarily with the first observations indicating that some types of functionally important interference can occur and we are in a position to predict the possibility of other types also occurring under appropriate circumstances.

We have determined that certain components of living organisms, notably proteins, are semiconductors. Since these components form part of the organized structure of the cells and tissues of the organism these cells and tissues also exhibit organized semiconducting properties. Furthermore, these properties are of considerable functional importance to the organism in that they are the basis for various types of automatic control systems. the flow of electrons through the semiconducting materials provides a control signal for a variety of functions most of which are quite basic or primitive in nature. We have so far determined semiconducting properties and functional control systems based thereupon, in nerve and bone tissue. In the nerve tissue the

semiconducting property and electron flow determines the general level of activity of the nervous system, i.e., how well it responds to stimuli and transmits messages. This is reflected in the rhythmic alteration of sleep–wakefulness known as biological cycles. A further function in the nervous system is the primitive representation of the organism as a whole, in which case the semiconducting system senses trauma or damage to a part of the organism and initiates and controls the cell growth necessary for healing. Bone appears to have semiconducting properties primarily because it is devoid of nerves and still requires some similar system to control its growth processes. In bone, the semiconducting systems are primarily responsible for initiation and control of the various growth processes including fracture healing. We have been very successful in determining the characteristics of bone semiconduction in some detail and in artificially manipulating the system by introducing electrical signals of our own making.

It must be emphasized that this viewpoint of biological semiconductivity and its implications represents a considerable departure from classical biochemistry and physiology and that this concept while becoming more acceptable over the past ten years still has considerable opposition expressed to it. Suffice it to say that this concept has provided answers to questions that physiology and biochemistry have failed to solve, i.e. the mechanisms controlling cell growth.

I would like to furnish you with a few brief illustrations of the types of interactions we have observed between living organisms and electromagnetic fields. In both nerve and bone the operating parameters of the biological semiconducting system are such that interactions with steady state or slowly varying electromagnetic fields would be of primary importance. While resonance phenomena may occur at higher frequencies (up into microwaves regions in fact), we have not investigated this portion of the spectrum.

In nerve functioning since our semiconducting system was controlling the overall level of nerve activity we predicted that an interaction would be present between this function and the naturally occurring magnetic field of the earth, and furthermore that disturbed nerve activity (mental disorders particularly schizophrenia) might be correlated with disturbances in the earth's magnetic field. In a very large study, spanning four years in time and involving more than 16,000 patients we determined that a direct relationship existed between the incidence of schizophrenia (as determined by the number of admissions for this illness) and the incidence of magnetic storms. The higher the number of magnetic storms per month, the higher the number of psychiatric admissions for schizophrenia. This conclusion was substantiated in another study correlating two entirely different but related variables. In addition, we have completed a laboratory study involving exposure of normal humans to low strength, very low frequency magnetic fields. Such exposure for periods of up to 30 minutes produced definite increases in reaction times. Exposure of animals to high strength magnetic fields of certain types produced profound alterations in electroencephalograms and a state resembling general anesthesia. From these data we conclude that the earth's magnetic field is a physiologically important part of man's environment and that exposure to lower or higher field intensities, provided they are steady state or fluctuating at VLF frequencies may produce definite alterations in behavior and

nerve function. At this time we cannot state whether the effects of such exposure would be cumulative or not.

In bone the nature of the semiconducting properties of the bone tissue itself is such that fractures produce the output of a very small electrical current with a specific type of field configuration. The healing of fractures in many animals is produced by an alteration of the red blood cells in the clot at the fracture site. This alteration changes those cells from red blood cells to cells of a type that produce cartilage that bines the ends of the bones together, and produces a healing of the fracture. We have been able to take red blood cells from normal, non-fractured individuals and expose them to exceedingly small electrical currents and cause them to undergo the same alteration. Again, the electrical currents must be steady state (DC) or very slowly fluctuating to produce the effect. the importance of this observation, aside from the fact that it establishes that the healing of a fracture is produced by the electrical current stimulating the cells in blood clot, is that the cellular changes produced are very similar to the changes seen when a normal cell becomes cancerous. As a result, while we have been able to produce bone growth at will in animals by inserting appropriate small electrical currents, we have refrained from extending this technique to humans because of the danger of inducing an uncontrolled, or cancerous, growth. However, by the same token we may predict that effective control over cancerous growths may result from further understanding of this semiconduction system.

From the viewpoint of the present evaluation, the existence of electromagnetic radiation in the environment, that might produce within the body the necessary minute electrical currents could well stimulate certain target cells to undergo these transformations normally associated with healing mechanisms. Since there would be in this case no actual injury to heal, the normal control system would not be operative, and the possibility does exist that these altered cells would undergo unrestricted growth.

I therefore feel that further research in the area of biological semiconducting mechanisms and the results of their interaction with various types of external electromagnetic fields is necessary. At this time, we can delineate a number of circumstances which we would consider to be hazardous. These are not normally present at this time; however, a few proposals have been made for specific applications of magnetic fields that might well be hazardous. I refer to the generation of electrical power by magnetic hydrodynamic techniques and the radiation shielding of spacecraft with high strength magnetic fields similarly generated.