THE RESEARCH FRONTIER

WHERE IS SCIENCE TAKING US? *In the realm of magnetism, one direction is clearly pointed by Nobel laureate Albert Szent-Gyorgyi in his elegant little book, "Introduction to a Submolecular Biology." He tells how he started his own researches in histology, found cells too complicated, took up physiology, found physiology too complex, turned to bacteriology, found bacteria too complicated, and turned to muscle. After twenty years of studying muscle, he still couldn't understand the fundamental workings of muscle without first understanding the processes through which the energy of electrons is transferred. He is now engaged in meticulous examination of the relationship between electron charge transfer and growth. Recently he published, in* Proceedings of the National Academy of Sciences, *what time may prove to be the beginning of a table of elements for cancer. The table correlates the strength of positive and negative charges of specific chemicals with the known relative abilities of those chemicals to trigger malignant growth.*

By ROBERT O. BECKER, M.D.
(State University of New York)

CHARLES H. BACHMAN
(Syracuse University)

THE literature of bioclimatology is replete with attempts to relate psycho-physiological disturbances in the human population to various physical parameters of the environment. Recently, considerable interest is being expressed in the possible effect of air ionization in this regard. Relatively few papers of note have been published on the possible relationship of magnetic fields to these parameters. Two major objections have been raised to all of these studies. First, the mechanism of action is completely unknown since no known physiological system exists to be influenced by such physical parameters. Second, the naturally occurring magnitude of change in the physical parameter is generally much less than that noted to result from common, manmade disturbances (e.g, the magnetic and electrical fields produced by sixty cycle alternating current electric power).

Within the past few years, however, evidence has been presented which has a direct bearing on the validity of these objections regarding particularly geomagnetic force fields. The presence of free radicals, semi-conductors, and conduction bands has been demonstrated in a variety of physiologically important systems. Some evidence has been presented for an organized neural control system in vertebrates based upon similar solid state direct current flow in elements of the central nervous system. This system has furthermore been observed to correlate with certain behavioral changes in the human.

The presence of such charge-transfer based systems would provide a mechanism whereby environmental force fields could exert an influence upon the organism. If the system influenced by such physical force fields was itself responsible for any aspect of behavior, then some behavioral effect would be noticeable. Some observations have recently been reported indicating that organisms do respond to such fields.

Certain marine fish demonstrate a remarkable sensitivity to magnetic and electrostatic fields, apparently by a system sensing the presence of low direct current potentials. Humans have been shown to sense the presence of low density UHF (radar) fields, and protozoa demonstrate orienting responses to low frequency electromagnetic fields. Many organisms demonstrate biological cycles of activity linked to the cyclic variation in environmental force field patterns and influenced by local application of low magnetic fields.

In the physical sciences knowledge has also increased leading to the concept of much more complex force field interrelations, both planetary and solar-terrestrial in scope [such as those described in the preceding contributions to this issue of *SR*/Research]. Short period fluctuations in the magnetic field have theoretically the greatest probability of being the physiologically active portion of the geomagnetic environment. While the exact origins are in doubt, the presence of diurnal variations, magnetic storms, and high frequency fluctuations have been demonstrated. The resultant electrical currents occasionally reach magnitudes amply high enough to produce disturbances in delicately balanced biological charge transport systems.

A statistical study, relating a simple index of geomagnetic activity to a gross index of psychological disturbances over a long period of time, appeared to be a logical method of preliminary investigations. In view of the widespread nature of geomagnetic disturbances, data gathered at two geographically distant points offered the possibility of obviating local effects such as air ionization, etc.

As a pilot study, the daily magnetic intensity (K-Sum) determined at Fredricksburg, Va., was correlated against the daily rate of psychiatric admissions to two hospitals in Syracuse, N. Y., for a period of approximately four years. It was realized that the data used had several inadequacies. The K-sum is a gross index of geomagnetic activity that is only loosely related to short period fluctuations. In addition, the K-sum is probably related to other nonmagnetic geophysical parameters such as cosmic ray flux and electrostatic fields. The rate of patient admissions is governed by such factors as the availability of beds and the disposition of the examining physician. Nevertheless, a statistical analysis of the data produced interesting results.

The daily data was tabulated on IBM punch cards and subjected to various correlations. Correlations on a day-to-day basis, and a small number of various phase-shift combinations thereof, showed very low levels of agreement, although all were positive and statistically significant. However, when the K-sums for thirty consecutive days and the admissions for the same thirty day period were handled as blocks of data, higher order correlations were obtained.

A sliding scale of one day, giving 1391 consecutive data points, was utilized. The coefficients of correlation, etc., for non-linear relationships proved to be 0.27 and 0.26. The probability of obtaining such a relationship by chance alone is less than one in a thousand.

These results would suggest that a relationship does exist between the incidence of psychiatric disturbances in the human population and some geophysical parameter coupled with the magnetic field. It appears likely that a more ambitious program based upon broader data gathering procedures, both clinical and physical, would reveal the identity of the responsible geophysical parameters and make possible controlled laboratory studies.

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We recognize that we are working far out on the boundaries of present knowledge. To avoid suspicions

The energy of electrons is, of course, electricity. As far back as the 1880s, electric currents had been detected in areas of growth in bone. If growth could induce electricity, could electricity induce growth? An answer to this question was sought in a Syracuse, N.Y., laboratory in the 1950s by an Assistant Professor of Orthopedics at the Upstate Medical Center of the State University of New York, Dr. Robert O. Becker. The answer was affirmative. It was also possible to inhibit growth. How? Dr. Becker turned to the nervous system, enlisting the help of Syracuse University Physics Professor Charles H. Bachman and State University's Assistant Professor of Psychiatry Howard Friedman. The trio discovered that the nervous system is regulated by the magnetic fields of the earth and the sun. Their report below is divided into two parts. The paragraphs preceding the asterisks were read at an international conference on magnetism at MIT last November. The remainder was written especially for Saturday Review. *Sketches of human figures chart primitive guiding current of our species.*

HOWARD FRIEDMAN
(*State University of New York*)

of quackery and fakery that have discredited this general area of research in the past, we must be more than ordinarily vigilant. Our precautions have taken two directions.

First, the scope of our statistical study must be broadened to define exactly what it is that we are dealing with. At present, we can only suspect a general relationship of some kind between the whole of the human species and the whole of the electromagnetic phenomenon that engages the sun, other stars, and the galaxies. We are now organizing to gather data from eight hospitals instead of two and from 16,000 instead of 3,000 psychiatric patients at these institutions. The geographical region of the human end of our experiment is thus being expanded to cover one hundred miles of northern New York state. At the cosmic end of our equations, we are preparing experimental routines to separate the effects of the three axes of magnetic force to which man is subject and so perhaps to identify their individual influences. We are also correlating the admission rates of mental patients in the hospitals with the appearance of solar flares, cosmic ray activity and each of the three types of storms on the sun that are now known to be related to magnetic fluctuations.

Our second line of confirmatory research is, in our view, even more important than the first. To observe a relationship between magnetic forces and the mental state of humans is, in itself, merely a chance freak. To explain the relationship in terms acceptable to the science of clinical medicine is the crucial task.

In laboratory experiments with appropriately anesthetized salamanders and frogs, we have detected and measured the electrical currents that flow along the fibers of the central nervous system. We have found that the current flows in one direction along the sensory fibers that transmit the detailed information gathered by our eyes, ears, nose and skin—the descriptions of what we see, hear, smell and feel (pressure, heat, pain). Along the fibers of the motor nerves that command our muscles to contract and expand and move us about, we found the electricity flowing oppositely.

Thus we appear to have discovered the two complementary halves that make up every functioning electrical circuit. The fascinating element in this circuit is that science previously had determined that no flow of electricity was involved in the swift action of sensory or motor nerves.

WHAT, then, is the function of the electric current we have measured as it was traveling along the length of these nerves? It is a slow, steady direct current—the reverse of the alternating impulses heretofore identified with activity in the nerves. How explain this apparent contradiction?

Our experiments lead us to believe that there is in fact no contradiction. We think the current we detect is the most primitive guidance system within man's body. It was through this system, we believe, that the environment originally instructed our oldest ancestors in what behavior they would have to follow in order to survive on earth. As evolution progressed, and the animals that preceded us in the magnetic family line grew more sophisticated, the faster nervous impulse system that makes modern man a quick thinker and agile actor gradually took over the superficial patterns of control. But deep beneath the surface of our lives the ancient data transmission system still directs us. The ability of a nerve to convey sense and motor impulses depends on the presence of that primordial current.

We have several reasons for this belief. Foremost among them is the fact that when we apply local anaesthetic blocks to nerve pathways, through administration of ether or drugs, the electrical current stops flowing simultaneously with the nerve's loss of its customary command. We have demonstrated this coincidence of effects in individual nerves of animals and in the skin potentials of humans.

NOT so long ago it was taken for granted in medicine that any movement of electricity through the mammalian body had to be adapted to a liquid system. By tradition, the transport had to occur by means of ions in suspension. But if this were true the freezing of the system at any point would break the electrical circuit by locking up the ions. Our experience suggests an opposite state of affairs. For when we froze the nerve system at one point, the flow of electricity rose as it would if electrons were moving through a crystal.

It looks to us as though the fundamental control of the human nervous system must be carried out through organic semi-conductors, analagous to the transistor which has revolutionized the study of solid state physics. What we are hunting now, with the help of the Physics Department of Cornell University, is evidence of the presence of free radicals in nerve fibers. We are also trying to devise experimental techniques to determine whether the current carriers are positively or negatively charged and under what circumstances the current changes direction.

We know that the back of the head normally carries a positive charge and the front of the head a negative charge. By introducing a contrary charge into the brain, the Russians several years ago produced electrical anaesthesia, which is now being experimented with in a number of laboratories in this country.

We have a long way to go before we can claim detailed understanding of the relationship between magnetism and the basic rhythms of human life, such as our periods of sleeping and waking and growing. Nevertheless, we believe that in this direction lies the medicine of the future. ■