MODERN BIOELECTRICITY

edited by

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Preface

It has been almost 25 years since I was introduced to bioelectricity by my teacher, Robert Becker. The subject was then in its infancy and had no natural constituency because it did not fit easily within any of the orthodox scientific pigeon-holes. In physiology, electricity usually meant action potentials, within engineering it related to microwave heating, in physics and medicine it was associated with X-rays and radiotherapy treatment of cancer, and in chemistry it was linked to electrode reactions. Against this backdrop, two important themes emerged. What is the nature of the system or process that controls the living organism? Some might hold it to be the finger of God, and declare its inherent mechanics to be unknowable. The other extreme involves focusing on molecular minutiae in the belief that life can be defined at that that level. Modern bioelectricity is a middle-of-the-road approach which began with a crystallizing perception that electrical interactions are more fundamental than biochemical reactions, and hence that they perhaps have a greater probability of explaining the physical basis of life and the processes that control and express it. Bioelectricity's other major theme—environmental electromagnetic pollution—became important beginning in the early 1970's.

Much has happened during the past two decades, and this book is a monument to that work. As with all new initiatives, many questions have been raised, and previously unrecognized problems have become manifest. But it is the business of science to uncover and solve these problems, and it is precisely this effort, which is taking place on a broad scale across many traditional scientific disciplines, that constitutes the chief development in bioelectricity during the past 20 years. To build a new science there must be a group of scientists that are equal to the task, as well as a need for the approach that it embodies. The reader can judge whether the authors of this book meet that test.

As Machiavelli observed more than 400 years ago, any new idea is inherently born in struggle because it has preexisting opponents who are the adherents of the old idea, whereas the idea's potential proponents are still inchoate. If bioelectricity is to become a science and serve as a tool for solving mankind's problems, then the public-health issue of environmental electromagnetic fields must be faced and solved. This issue, which ironically was one of the seminal rationales for bioelectricity, has now come to serve as an incubus on progress because the lion's share of research funding of bioelectrical studies comes from organizations that create the electromagnetic fields whose risk-causing propensity is at issue. This is not a good or even acceptable pattern of funding if our true interest is the unbridled search for truth.

Perhaps the reader is interested in the men who, at least in my view, are responsible for pioneering bioelectrical research. Robert Becker's contributions to bioelectricity span its entire domain—more so than any other investigator. He is a bold innovator and thinker of new thoughts, an indomitable spirit and a great influence on this field. C. Andrew Bassett introduced bioelectricity into the scientific mainstream. The magnetic-field device he developed for clinical use was made available to a wide range of investigators, leading to many reports in the scientific

and medical literature. Such reports were rare when Bassett began his studies in the 1960's; now they are commonplace. Zachary Friedenberg and Carl Brighton have a long involvement with bioelectrical studies, and their career-long commitment has done much to regularize bioelectricity as a science and to underscore its usefulness. As successive chairmen of a clinical department of a prestigious medical school, they have been instrumental in establishing the credibility of the new science. Their attention to methodology, quantitation, and detail has earned them widespread respect. Allan Frey was for many years a solitary witness to the scientific fact that electromagnetic fields are physiologically significant. The effects do not exist, he was told, or if they do they are trivial, and if not, they are classical and hence are no threat to the status quo. Hindsight shows us that Frey was correct, and his tenaciousness has enriched this field. Perhaps least known of the pioneers is Milton Zaret, a soft-spoken man who saw what he saw through his bimicroscope, wrote about it, and continued to write even though some found his reports displeasurable. It is the duty of the scientist to report on nature, and the duty of the citizen to contribute to the collective judgment of how the scientific facts are to be incorporated into the fabric of society. Perhaps the well-being of our society demands that we accept a specific prevalence of microwave-induced cataracts as the price for living in an affluent and militarily strong society. That is, however, an entirely different issue from whether microwave radiation causes cataracts.

Bioelectrical research in the Soviet Union antedates that done in the West but language and other difficulties have hindered widespread appreciation of the Soviet studies. Nevertheless, the work of Yu. Kholodov and A.S. Presman must be mentioned. Presman's book was one of the earliest systematic treatments of bioelectricity, and it had a profound influence on me and many others. Although I have never met the, I feel that they must have the same indomitable spirit as their American counterparts.

I have organized the chapters according to the general framework of bioelectricity. Chapters dealing with the biological significance of natural electrical signals are grouped following the introductory chapter. Part III deals with measurements and computations of electrical properties and characteristics of tissue. Laboratory studies of biological changes induced in living organisms are described in Part IV. The rationale for bioelectricity is what it tells us about life, health, and disease, and these topics are covered in the last two parts.

The King of Hearts advised "begin at the beginning, and go on till you come to the end: then stop." Practical considerations, alas, have necessitated a relatively arbitrary end to this book, and I cannot offer the reader a guarantee of completeness. But I can guarantee that it is an authoritative exposition of the major threads of modern bioelectricity.

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PART III. ELECTRICAL PROPERTIES OF TISSUE