
Preface

We are honored to have been asked to follow the 2007 3rd Edition of the *Handbook* with this 4th Edition and to carry on the tradition established in the first two editions by Dr. Postow and the late Dr. Polk. In this edition of the *Handbook of Biological Effects of Electromagnetic Fields*, we have added new and newly relevant material on a number of aspects of basic science and on diagnostic and therapeutic applications. While we had to reduce or drop coverage of a few topics that now seem less immediately important, we refer the reader to the material on these in the previous editions. New additions include expanded coverage of brain stimulation, characterization and modeling of epithelial tissue wounds, theoretical models of proposed basic mechanisms giving rise to bioelectromagnetic effects, and dosimetric measurement methods and instrumentation. For the first time in this series we have added coverage of electromagnetic effects in the terahertz region, field effects on plants, and applying electrical engineering concepts of systems engineering and operational amplifiers with feedback to the analysis of biological electromagnetic effects. At the same time, all chapters have been updated in view of what has been learned in the past decade, some receiving relatively minor changes and others being completely revamped.

Research in bioelectromagnetics stems from three sources, all of which are important: Bioelectromagnetics first emerged as a separate scientific subject because of interest in studying possible hazards from exposure to electromagnetic fields and setting human exposure limits. A second interest is in the beneficial use of fields to advance health, both in diagnostics and in treatment, an interest that is as old as the discovery of electricity itself. Finally, the observed interactions between electromagnetic fields and biological systems raise some fundamental, unanswered scientific questions as to how they occur, the answers to which may lead to fields being used as tools to probe basic biology and biophysics. Various chapters treat both basic physical science and engineering aspects and biological and medical aspects of these three. Answering basic bioelectromagnetic questions will not only lead to answers about potential electromagnetic hazards and to better beneficial applications, but they should also contribute significantly to our basic understanding of biological processes. Both strong fields and those on the order of the fields spontaneously generated within biological systems may become tools to perturb the systems, either for experiments seeking to understand how the systems operate or simply to change the systems, such as by injecting a plasmid containing genes whose effects are to be investigated. These three threads are intertwined throughout bioelectromagnetics. Although any specific chapter in this work will emphasize one or another of these threads, the reader should be aware that each aspect of the research is relevant to a greater or lesser extent to all three.

As in previous editions, the authors of the individual chapters were charged with providing the reader, whom we imagine is moderately familiar with one or more of the sciences underlying bioelectromagnetics, though perhaps not in the others or in the interdisciplinary subject of bioelectromagnetics itself, with both an introduction to their topic and a basis for further reading. We asked the chapter authors to imagine and write what they would like to be the first thing they would ask a new graduate student in their laboratory to read. Like its predecessors, this edition is intended to be useful as a reference book but also as a text for introducing the reader to bioelectromagnetics or some of its aspects. For these students and other readers who are not familiar with the basic physical science

behind electromagnetic fields, the Introduction ("Chapter 0") and Chapters 5 and 6 are intended to be helpful.

As a "handbook" and not an encyclopedia, this work does not intend to cover all aspects of bioelectromagnetics. Nevertheless, considering the breadth of topics and growth of research, some ideas are unavoidably duplicated in various chapters, sometimes from different viewpoints that could be instructive to the reader and sometimes presenting different aspects or implications. While the amount of material has led to the publication of the handbook as two separate, but interrelated volumes: *Biological and Medical Aspects of Electromagnetic Fields (BMA)* and *Bioengineering and Biophysical Aspects of Electromagnetic Fields (BBA)*, there is no sharp dividing line, and some topics are dealt with in parts of both volumes. The reader is urged to go beyond a single chapter is researching a specific topic.

The reader should note that the chapter authors have a wide variety of interests and backgrounds. Their work and interests range from safety standards and possible health effects of low-level fields to therapy through applications in biology and medicine to the fundamental physics and chemistry underlying the biology and bioelectromagnetic interactions. It is therefore not surprising that the authors may have different and sometimes conflicting points of view on the significance of various results and their potential applications. Thus authors should only be held responsible for the viewpoints expressed in their chapters and not in others. We have tried to select the authors and topics so as to cover the scientific results to date that are likely to serve as a starting point for future work that will lead to the further development of the field. Each chapter's extensive reference section should be helpful for those needing to obtain a more extensive background than is possible from a book of this type.

Some of the material, as well as various authors' viewpoints, are controversial, and their importance is likely to change as the field develops and our understanding of the underlying science improves. We hope that this volume will serve as a starting point for both students and practitioners to understand the various parts of the field of bioelectromagnetics, as of mid-to-late 2017, when authors contributing to this volume finished their literature reviews.

The editors would like to express their appreciation to all the authors for the extensive time and effort they have put into preparing this edition. It is our wish that it will prove to be of value to the readers and lead to advancing our understanding of this challenging field.

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Frank Barnes