

Contents

PREFACE	iii	
CONTRIBUTORS		vii
PART I. OVERVIEW		
1. ELECTROMAGNETISM AND LIFE	1	
Robert O. Becker		
References	13	
PART II. ELECTROMAGNETIC ENERGY AND REGULATION OF LIFE PROCESSES		
2. BACTERIAL BIOMAGNETISM AND GEOMAGNETIC FIELD DETECTION BY ORGANISMS	19	
Richard P. Blakemore, Nancy A. Blakemore, Richard B. Frankel		
Introduction	19	
Animal Orientation and Homing	20	
The Magnetosome	22	
Magnetotaxis	24	
Forms of Iron in Magnetic Bacteria	25	
Magnetite in Eukaryotes	27	
Magnetotactic Algae	27	
Acknowledgements	28	
References	29	
3. THE EARTH'S MAGNETIC FIELD AS A NAVIGATIONAL CUE	35	
William E. Southern		
Introduction	35	
Historical Perspective	38	

Geomagnetic Sensitivity and the Search for a Receptor	49
Magnetism and Other Vertebrates	52
Concluding Remarks and Summary	53
References	56
4. NMR CONDITIONS AND BIOLOGICAL SYSTEMS	75
E. Aarholt, J. Jaberansari, A.H. Jafary-Asl, P.N. Marsh, C. W. Smith	
Introduction	75
Basic Theory of Nuclear Magnetic Resonance	76
Measurements of Biological Systems Under NMR Conditions	80
Discussion	95
Acknowledgements	99
References	100
5. APOPLASTIC ELECTROPOTENTIALS IN PLANTS: MEASUREMENT AND USE	105
William Gensler	
Introduction	125
Basic Technique and Type of Potential Variations	105
Location of the Potential	110
Plant Acceptance	111
Origin of the Potential	112
Electrode Location and Plant Architecture	114
Reference Electrode	115
Applied Aspects of the Phytogram Technique	117
Active Bioelectrochemical Measurements	119
Summary	120
References	121
PART III. ELECTRICAL PROPERTIES OF TISSUE	
6. ELECTRICAL PROPERTIES OF BIOLOGICAL TISSUE	125
Ronald Pethig	
Introduction	125
Dielectric Theory: A Summary	127
Amino Acids, Proteins and DNA	133
Biologically Bound Water	144
Biological Electrolytes	146
Membranes and Cells	151
Tissues	156
References	168

7. ELECTRONIC PROPERTIES OF NATURAL AND MODELED BILAYER MEMBRANES	181
Jozef R. Zon, H. Ti Tien	
Introduction	181
Electronic Phenomena in Membranes	182
Electronic Properties of Biological Membranes	191
Electronic Phenomena in BLM Systems	207
Conclusions and Suggestions for Further Study	221
Acknowledgements	230
References	230
8. BIOELECTRIC PYROELECTRICITY	243
Sidney B. Lang	
Introduction	243
Fundamentals of Pyroelectricity	243
Studies of Biological Materials	256
Conclusions and Some Speculations	271
References	274
9. MATHEMATICAL MODELING OF ELECTROMAGNETIC INTERACTIONS WITH BIOLOGICAL SYSTEMS	281
Francis X. Hart	
Introduction	281
Static and Low Frequency Fields	293
Plane Waves	310
Near Fields	328
Discussion	330
Acknowledgements	334
References	334
10. RECENT DEVELOPMENTS IN THE THEORY OF ION FLOW ACROSS MEMBRANES UNDER IMPOSED ELECTRIC FIELDS	345
Martin Blank	
Introduction	345
Ion Flow in Excitable Membranes	346
Electrical Double Layers — The Surface	
Compartment Model (SCM)	349
A Kinetic Basis for Ion Selectivity in Channels	355
Alternating Electric Fields in the SCM	356
Ion-Pumping Processes	359
Summary	361
Acknowledgement	361
References	362

11. ELECTROFUSION OF CELLS	365
Hermann Berg	
Introduction	365
Theoretical and Experimental Principles	368
Results 372	
Discussion	375
References	382
PART IV. BIOLOGICAL EFFECTS OF ELECTRO MAGNETIC ENERGY	
12. ELECTROMAGNETIC ENERGY AND <i>PHYSARUM</i>	393
Eugene M. Goodman, Michael T. Marron, Ben Greenebaum	
Introduction	393
Exposure to Electromagnetic Fields	394
Search for a Mechanism	413
Summary	423
Acknowledgements	424
References	424
13. AN ELECTROCHEMICAL CONSIDERATION OF ELECTROMAGNETIC BIOEFFECTS	427
Arthur A. Pilla	
Introduction	427
Basic Electrochemical Kinetics Applied to the Cell Surface 427	
Generation of PEMIC Waveforms — Relation to Cell Impedance Studies	437
References	443
14. LYMPHOCYTES AND PULSING ELECTROMAGNETIC FIELDS	451
Ruggero Cadossi, Giovanni Emilia, Giovanni Ceccherelli, Guiseppe Torelli	
Introduction	451
The Lymphocyte-Lectin Model	452
The Lymphocyte	458
Preparation of Lymphocyte Cultures	463
The Effects of PEMFs on Lymphocytes	463
Assessment of Health Risk	480
Conclusions	480
References	484

15. EFFECTS OF ELECTROMAGNETIC FIELDS ON NERVE REGENERATION	497
Betty F. Sisken	
Introduction	497
<i>In Vitro</i> Studies	497
<i>In Vivo</i> Studies	505
Theories on the Mechanism of Action of Electric Fields on Nerve Regeneration	511
Future Studies	518
Acknowledgements	518
References	EA8
16. LIMB REGENERATION	529
Stephen D. Smith	
Introduction	529
Normal Limb Development	529
Epimorphic Regeneration and Its Control	530
Differences Between Regenerators and Non-Regenerators	534
Direct Current Stimulation	539
Pulsed Magnetic Field Stimulation	543
References	548
17. BEHAVIORAL MEASURES OF ELECTROMAGNETIC FIELD EFFECTS	557
Rochelle Medici	
Why Behavior?	557
Historical Perspectives	560
Present Status of Electromagnetic Behavioral Studies	562
Conclusions	574
References	574
PART V. THERAPEUTIC APPLICATIONS OF ELECTROMAGNETIC ENERGY	
18. THE MODERN MAGNETOTHERAPIES	589
Michael A. Persinger	
Introduction	589
Fundamental Strategies of Magnetotherapies	591
Supportive Evidence: Major Experimental and Clinical Studies	598
Placebo: A Phenomenon Without a Mechanism	610
Current Status, Critique and Suggestions	613
Conclusion	620
Acknowledgements	621
References	621

19. ELECTRICAL SILVER ANTISEPSIS	629
J. A. Spadaro	
Introduction	629
Background	629
Bacterial Inhibition by Silver Electrodes <i>In Vitro</i>	631
Electrochemical Studies of Silver Inhibition of Bacteria	634
Animal Studies of Biocompatibility and Bacterial Inhibition	641
Clinical Applications	644
Future Directions	646
References	647
20. DIRECT CURRENT AND BONE GROWTH	657
Andrew A. Marino	
Introduction	657
Bone Properties	658
Electricity and Bone: Foundations	662
Application of Electrical Energy	670
Discussion	684
A New Basis for the Clinical Use of DC Currents	693
References	697
21. PULSED ELECTROMAGNETIC FIELD THERAPY IN THE TREATMENT OF CONGENITAL AND ACQUIRED PSEUDARTHROSIS	711
A. Dal Monte, G. Fontanesi, R. Cadossi, G. Poli, F. Giancecchi	
Introduction	711
Clinical Experiences	714
The Double-Blind Problem	731
Comparison Between Treatments	737
Discussion	739
Acknowledgements	743
References	743
22. ELECTROACUPUNCTURE	757
Maria Reichmanis	
Introduction	757
Theories of Acupuncture	761
Anatomy of the Acupuncture System	762
Effects of Acupuncture	765
Auricular Acupuncture	769
Electroacupuncture	769
Complications of Acupuncture Treatment	771
Indications for Acupuncture Treatment	771
Conclusion	772
References	772

PART VI. HEALTH HAZARDS OF ELECTROMAGNETIC ENERGY

23. EVOLUTION AND RESULTS OF BIOLOGICAL RESEARCH WITH LOW-INTENSITY NONIONIZING RADIATION	785
Allan H. Frey	
Introduction	785
The Quiet Decade	786
The Lively Decade of the 1970's and Into the 1980's	792
Conclusions	814
References	816
24. ELECTROMAGNETIC ENERGY AND CATARACTS	839
Milton M. Zaret	
Introduction	839
Embryological and Anatomical Factors	839
Physiological Optics	843
Cataracts	844
Electromagnetic Energy and Cataractogenesis	847
Discussion	855
Conclusion	856
References and Endnotes	857
25. IMMUNOLOGIC AND CANCER-RELATED ASPECTS OF EXPOSURE TO LOW-LEVEL MICROWAVE AND RADIOFREQUENCY FIELDS	861
Stanislaw Szmigielski, Marian Bielec, Slawomir Lipski, Grazyna Sokolska	
Introduction	861
Immunologic Response to Low-Level Microwave and Radiofrequency Fields	864
Cancer-Related Aspects of Exposure to Low-Level Microwave Fields	890
References	915
26. THE BIOLOGICAL EFFECTS OF POWER-FREQUENCY ELECTRIC FIELDS IN THE ENVIRONMENT	927
MG. Shandala, Yu D. Dumanskiy, IS. Bezdol'naya	
Introduction	927
Physical Parameters of Powerline Fields	927
Biological Effects of Powerline Electric Fields	930
Possible Mechanisms of the Biological Action of Powerline Fields	942
Conclusions	943
References	945

27. ENVIRONMENTAL ELECTROMAGNETIC FIELDS AND PUBLIC HEALTH	965
Andrew A. Marino	
Introduction	965
EMFs in the Environment	966
Laboratory Studies of EMF Bioeffects	973
Environmental Factors and Disease	994
EMFs and Disease	1004
EMFs and Public Health	1015
Summary	1019
References	1019
INDEX	1045