BIOELECTROMAGNETICS

Current Concepts

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BIOELECTROMAGNETICS

Current Concepts

The Mechanisms of the Biological Effect of Extremely High Power Pulses

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PREFACE

This volume includes the lectures and selected posters on different aspects of biological effects of EMF, presented at the NATO ADVANCED RESEARCH WORKSHOP “The mechanisms of biological effect Extremely High Power Pulses (EHPP)” (3-5 March 2005) and the UNESCO/WHO/IUPAB Seminar “Molecular and Cellular Mechanisms of Biological Effects of EMF” (1-2 March 2005) that took place in Yerevan, Armenia. The gracious support of several international organizations made possible to bring together 47 scientists, engineers, physicians and policy makers from 21 countries from Europe, North and South America, Asia. The Capital of Armenia, Yerevan, provided an excellent opportunity for discussions of the experimental data and theoretical models of EMF effect on various levels, starting from cell aqua bathing medium to the whole organism, including the human, applying multidisciplinary approaches.

The continuous increase of the number of man made EMF sources leads to dramatic changes in the spectrum of EMF in the biosphere. During the last two decades the public concern about potential hazard of EMF generated by power and distribution lines, as well as mobile communications and base stations have initiated serious public concern and has triggered the attention of the WHO, which reflected in the EMF project of harmonization of standards. At the same time, contemporary medicine largely uses EMF diagnostic methods. The beneficial effects of EMF are complemented with a large scale of EMF therapeutic modalities used in a number of countries, helping millions of people.

The lack of knowledge on cellular and molecular mechanisms of the biological effect of EMF with different frequencies, however, is the main barrier for precise determination of the potential benefit or hazard of EMF. We hope that this book will stimulate the study of cellular and molecular mechanism of non thermal effects of EMF: namely, of Extremely High Power Pulses, and it will serve as a valuable source of information for modern concepts in non-thermal effect of EMF.

There were some controversial views on this subject, never the less authors agreed with one main conclusion from these meeting: that in the future worldwide harmonization of standards have to be based on biological responses, rather than computed values. The guidelines of International Commission on Non-Ionizing Radiation Protection (ICNIRP) specify the quantitative characteristics of EMF used to specify the basic restrictions are current density, specific absorption rate (SAR) and power density, i.e. the energetic characteristics of EMF. However, experimental data on energy-

dependency of biological effects by EMF have shown that the SAR approach, very often, neither adequately describes nor explains the real value of EMF-induced biological effects on cells and organisms for, at least, two reasons: a) the non-linear character of EMF-induced bio-effects due to the existence of amplitude, frequency, and exposure time “windows”) b) EMF-induced bioeffects significantly depends on physical and chemical composition of the surrounding medium. Consequently, it is important to determine the membrane/cellular targets responsible for detecting, amplifying and transferring the “message(s)” delivered by the exogenous EMF. These signals, indeed, could alter the functional state of the system.

The presentations and discussions during the NATO ADVANCED RESEARCH WORKSHOP and UNESCO/WHO/IUPAB SEMINAR brings the scientific community a step closer to the determination of the cellular parameter(s), which could serve as an adequate marker for estimation of the biological effect of EMF and further help in the search of adequate biological mechanisms of EMF interactions with living systems.

During UNESCO/WHO/IUPAB Seminar on “Molecular and Cellular Mechanisms of Biological Effects of EMF” that preceded to NATO ARW several important topic were discussed: molecular and cellular mechanism of static magnetic fields (SMF), and extremely low frequency (ELF) EMF effects, neurochemical mechanisms sensitive to EMF and EMF dosimetry and standards worldwide. It provided a possibility to discuss the role of non-thermal and thermal effects of EMF in deferent frequency ranges.

It is known that, in case of SMF and ELF EMF, non-thermal biological effect prevails over the thermal one, while in case of EHPP, the thermal effect is more pronounced than the specific non-thermal effects. It is technically difficult, perhaps impossible to separate the EHPP-induced non-thermal effect from the thermal one and it makes the data on non-thermal effect of EHPP an ambiguous interpretation by researchers. The NATO ARW was dedicated to establishing the scientific basis of multidisciplinary approach to the theoretical and experimental data obtained by different laboratories on EHPP effect on various experimental models (from water molecules to behavioral activity of mammals), to develop unique methods and criteria for determination of the possible biological effect of EHPP. The Workshop presentations covered a variety of topics such as theory of biological effect of extremely high power pulses; microwave induced pathologies (cancer, nervous and cardiovascular disorders); diagnostics and therapy with EMF; experimental evidence for biological effect of EHPP

We believe that this volume correctly represents the current trends and problems in Bioelectromagnetics. The large spectrum of topics represents the state of the art in Bioelectromagnetics and the book could be a guidebook for

young scientists and will represent interest for scientists, clinicians and policy makers involved in Magnetobiology and Magnetotherapy.

We believe that would be fair to summarize the main achievements of the meeting in the following way:

- ❖ The induced by EMF changes in water structure and in cells bathed by aqueous solutions are still underestimated and deserve careful investigation. As SMF, ELF EMF and EHPP have modulation effect on cell hydration in norm and pathology, the EMF-induced changes of cell hydration is recommended as a cellular marker for estimating the biological effects of EMF.
- ❖ The ICNIRP guidelines for radiofrequency electromagnetic fields exposure are based only on its thermal effects, and completely neglects the possibility of non-thermal effect.
- ❖ There is plenty of evidence from both basic science and clinical application that non-thermal effects of EMF might be the only way to execute EMF interactions. Therefore, it is necessary to create an international project to search for the mechanisms of interactions of EMF with various frequencies as well as EHPP.
- ❖ More efforts needs to be applied in the resolving the dilemma of “window effects” vs. SAR
- ❖ Non-thermal mechanisms could be a plausible explanation of therapeutic benefits received by millions of people worldwide.
- ❖ The WHO EMF project of harmonization of standards and precautionary principle are recognized as a plausible development in the integration of science, health and policy makers.
- ❖ Further improvement of dosimetry and protocol for studying the EHPP specific biological effect in different experimental models could help in distinguishing between thermal and non-thermal effects.
- ❖ Considering the promising future of the study of cellular and molecular mechanisms of non-thermal effect of EMF and EHPP as well as the effect of ultra short electrical pulses, a follow-up NATO ARW is planned for 2007 in Yerevan to stimulate the research in these relatively new avenues and for developing international projects.
- ❖ The possibility of publishing the presentation in NATO ARW Series would provide the scientific community with methodological handbook for current

trends and approaches in studying the cellular and molecular mechanisms of EMF and EHPP.

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The effectiveness of NATO Advanced Research Workshop was significantly determined by the fact that it followed to UNESCO/WHO/IUPAB Seminar during which the cellular and molecular mechanisms of non-thermal biological effect of EMF was the subject for multidisciplinary discussion.

We are also indebted the following sponsoring organizations: European Office of Aerospace Research and Development (EOARD), UNESCO, World Health Organization (WHO) and International Union for Pure and Applied Biophysics (IUPAB).

The organization of the both meetings would not be possible without the active efforts of the Members of International and Local Organizing Committees. We would like to emphasize the big personal contribution of the following members of Organizing Committee, Profs. Michael Rapacholi (Coordinator of Radiation & Environmental Health, WHO), Michael Murphy (Scientific director of Directed Energy Bioeffects USAF Research Laboratory) and Andrei Pakhomov (University of Texas Health Science Center, San Antonio).

The directors and the participants of this ARW are deeply indebted to the staff of UNESCO Chair - Life Sciences International Postgraduate Educational Center (Yerevan, Armenia) for their outstanding contributions that made the ARW such a success. The social events and tours through Armenian historical sights gave the participants the opportunity to meet the treasures of Armenian history, culture and religion.

The editors express their thanks to Ms. Hasmik Manukyan, Research Secretary of the meeting for her untiring work before, during and after the ARW, as well as for her organizational works during the compilation of the present book. Lastly, the careful and scholarly efforts of each of the participants is recognized, appreciated and clearly evidenced in the Proceedings.

A.S.N.
M.M.S.