WORKSHOP COST244BIS

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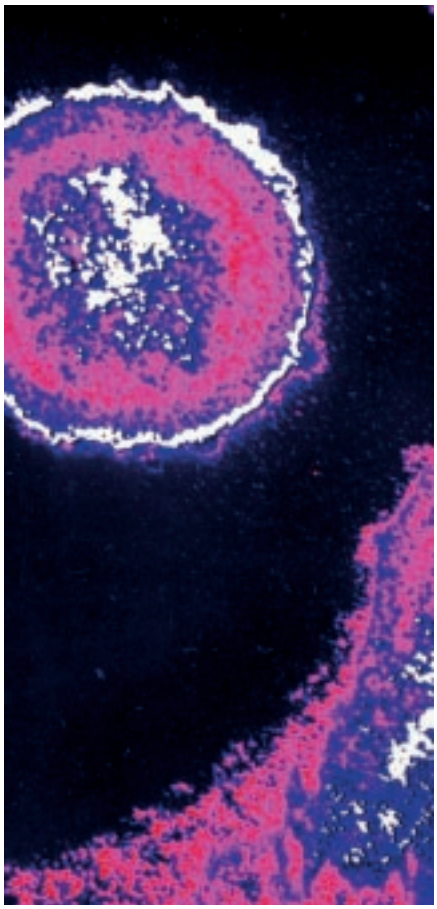
„Biological EMF-Interaction Mechanisms and their Relevance to Exposure Limits“

On July 10th 2000, at the start of the annual meeting of the Bioelectromagnetics Society, the 10th COST 244bis workshop „Biological EMF-Interaction Mechanisms“ took place in Munich. The workshop's aim was to achieve a deeper knowledge of physical and biological interaction mechanisms of electric, magnetic and electromagnetic fields and to discuss in detail possible mechanisms. Potential mechanisms may occur on the molecular level, causing effects which may have an impact on cells, tissue or whole organisms. Corresponding to the different types of interaction the event was divided into the following sessions:



I. Introduction and definitions
II. Primary biophysical and biochemical effects
III. Interaction on subcellular and metabolic level
IV. Interaction in cellular and tissue level
V. Interaction on organs and whole organism

During the first session it was established that there is still no conclusive definition of the term „mechanism“ in regard to biological effects of electric, magnetic and electromagnetic fields. Dr. Ulf Bergqvist presented the various approaches of different scientific disciplines to the problem reaching the conclusion that not least the different research methods are an obstacle for developing a generally valid definition.

Thus, mechanisms in a sense are a „black box“ containing individual observations, theories and insights. However, an increased knowledge of mechanisms might well contribute both to a better planning of future studies and an improved interpretation of results enhancing the credibility of scientific work. In addition, it would be useful in the process of assessing new technologies in their potential biological effects. Mechanisms can be seen as a sequence of events, triggered by physical quantities such as electromagnetic fields. Physical quantities do not accumulate in biological systems, in contrast to resulting alterations. Hence, we need greater knowledge of mechanisms for a better assessment of alterations.

Consequently, Dr. Bergqvist in his introductory paper stressed the importance of knowledge of physical and biological interaction mechanisms for setting appropriate and efficient exposure limits, in particular for selecting adequate exposure parameters and models for extrapolation accounting for multiple source exposure situations and chronic exposure duration. He also addressed the problem of reciprocity of time and amplitude in exposure assessment.

Prof. Dr. Jürgen Bernhardt presented the activities and future plans of the International Commission of Non-Ionizing Radiation Protection (ICNIRP) and explained ICNIRP's approach to EMF protection and future development of guidelines pointing out that our society needs different bodies dealing with different tasks: bodies like ICNIRP which set guidelines based on biological health related effects, governments which are responsible for considering social and economic impacts of limits, and scientific committees for developing product related standards. The guidelines set by ICNIRP, i.e. the limits for the general population and for occupational exposure, as well as basic restrictions and reference levels account for such factors as uncertainty of knowledge, different sensitivities and long term exposure.

Prof. Dr. Guglielmo d'Inzeo talked about theoretical models of interaction of electromagnetic fields and biological systems, such as the potential polarisation of ligand binding and functional alterations in ion channels. The primary site of such interactions, d'Inzeo concluded, might be cell membranes. As an approach to investigating effects he suggested step-by-step studies. Based on quantum mechanics there should be an examination of biophysical response at cell membranes on the level of biochemical processes. Cell biological alterations should be examined as a second step. With the „Integrated Membrane Model“ d'Inzeo presents an appropriate scientific approach for following up on possible interaction of electromagnetic fields and biological components.

In his lecture „Mechanisms of Interactions of RF-Fields with Biological Systems“ Dr. Kenneth Foster referred to effects with known mechanisms: membrane depolarization, electric charges, induced forces and thermal response. The extent of these forms of interaction is minimal because of the high energy turnover. In regard to other observed processes such as the heating of tissue or the electroporation, underlying mechanisms are purely speculative. As for the heating of tissue Foster mentioned a study of the U.S. Air Force registering a skin heating of up to 3 degrees K in a field exposure of 2.45 GHz. Foster suggested increased research activities on interaction mechanisms.

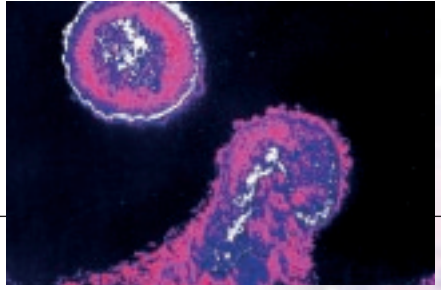
Following this paper Dr. Patrick Reilly talked about the choice of analysis parameters for defining standard limits which should not exclude any but adverse (unpleasant or painful) reactions. He favoured the electric field strength in situ for excitation metric and contrary to ICNIRP the concept of split limits for controlled and uncontrolled environment. Since all alterations at synaptic levels are considered adverse, EMF limits should be derived from the 1% level of the probability distribution of the general population's perception threshold and then reduced by an acceptance factor 3.

The topic of Dr. Rainer Meyer, from the University of Bonn, was the impact of electromagnetic fields on calcium homeostasis. Meyer's studies on cardiac muscle cells confirm the results obtained by Wolke et al. 1996. In other words, GSM signals show no influence on the calcium equilibrium of these cells.

In a short contribution Dr. René De Seze summarised that in his studies on hormones no effects could be found.

Dr. James C. Weaver pointed out that following an exposure there are alterations on the molecular level, though it must be confirmed that an exposure did occur. Molecular alterations must not per se be explained by a preceding exposure. Moreover, it is of importance to distinguish permanent from temporary alterations. In Weaver's opinion physical effects are not permanent, whereas chemical alterations may be irreversible.

Dr. Alexander Lerchl talked about the melatonin hypothesis. Melatonin is among other things known to be an antioxidant which is of importance regarding cancer. There might be a connection between low melatonin values and an increased occurence of tumors. Melatonin production



occurs in circadian rhythm; but low magnetic fields nonetheless could be responsible for alterations in this context, as they influence the pineal gland, where melatonin is produced. In his experiments with Djungarian hamsters, however, Lerchl could not detect effects of 900 MHz and 1800 MHz signals on melatonin production.

Dr. Jan Gimsa talked about mechanisms of energy absorption on the cellular level and described electrokinetic phenomena such as dielectrophoresis, electrorotation or deformation of small particles in the electromagnetic field.

Dr. Jiri Pokorny discussed short term EMF effects of electromagnetic fields on living cells. In his opinion there occur physical processes at the start of interactions of field and cell. Based on questions such as

- do cells emit EMF?
- which cellular structures generate EMF?
- how are such fields to be measured?
- can external fields alter intrinsic cellular EMF?

Pokorny investigated the role of mikrotubuli concerning the intracellular field of yeast saccharomyces cervisiae. His measurings show that yeast cells are surrounded by an electromagnetic field. The development of mikrotubuli (protein structures participating in cell stabilization and intracellular transport processes) is influenced by this field.

Prof. Dr. Alan Preece discussed the connection between electromagnetic fields and individual behaviour. The following areas of behavioural research were examined regarding the impact of electromagnetic fields:

- memory
- sleep
- learning
- avoidance
- driving.

An established effect of electromagnetic fields on ethological processes in humans is, according to Preece, the legthening of the reaction time of drivers after an exposure. In animals exposure resulted in altered perception of objects. Other parameters such as spatial memory remained unaltered.

During the COST 244bis workshop „Biological Interaction Mechanisms“ it was clarified that electromagnetic fields can lead to effects in biological systems on different levels, from molecules to complex organisms. Until now mechanisms on which these effects are based, at present are purely speculative. A survey of individual mechanisms is not available and may even be impossible. Conversations with participants showed that opinions differ widely regarding the question, wether studies on mechanisms make sense or wether a distinction between concepts such as „effect“ and „mechanism“ is of use. Sometimes „effect“ and „mechanism“ are distinguished, sometimes they have the same meaning. Some scientists deny the necessity to distinguish, as they ask, which one came first: Does an exposure lead to a certain effect which in turn has an impact on certain mechanisms? Or are certain mechanisms influenced by exposure leading to corresponding effects? Up to which level mechanisms can or must be explored? Up to the molecular, the nuclear or even the quantum mechanical level? These questions may be the subject of endless discussions, but it remains questionable, wether this approach contributes to solving problems. It is obvious, however, that effects and mechanisms of electric, magnetic or electromagnetic fields at present not only are a scientific, but also a language problem.

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