CONCLUSION

In this book we made an effort to present the theoretical and practical significance of the new area of biophysics referred to as modern biomagnetism. A possible physiological role of biomagnetic fields appears to be the central idea of the whole description of this scientific branch.

There were proposed several hypotheses explaining electromagnetic communication in organism. Apart from the presented ideas we could also mention ephaptic transfer of information through the nervous system referred to by Lorente de No, Gerard and Libel, Ezrokhi and other researchers. These processes were mathematically described in publications by Chizmakhchev and Markov dealing exclusively with the electrical component of biological electromagnetic fields [61].

It should be also mentioned that the role of electromagnetic signals in the life of electric fishes is regarded as a proven fact. Today, many ichthyologists are busy studying the role of electromagnetic fields in the life of nonelectric fishes [43,44].

Keeping this in mind the hypothesis on a physiologic role of biomagnetic fields should not be treated as totally phantastic. However, both experimental and theoretical data on various ways of reception are required to verify the hypothesis. It is not ruled out that reception of biological EMFs is different from the classic reception of external physical factors, and that its analysis should accommodate a possibility of slow initial response detected in the course of studying reception of relatively strong external MFs [61].

The hypothesis on "mutual impact of fields" [61] was proposed, although without any substantiation, to explain the mechanism of biologic action of artificial external MF. This particular approach reminds of a purely physical problem of electromagnetic compatibility. Incidentally, conferences on this subject involved discussions of matters of biological impact of EMF. Superficially, the hypothesis endeavors to explain the biological mechanism of increased and attenuated MF although the explanation works to complicate solution of the problem. Therefore, the next stage of dealing with the problem will be evaluation of the mechanism of modifications resulting from collision of two EMFs, namely the own biological and external cosmogeophysical.

Another electromagnetic approach to evaluation of the biological mechanism of electromagnetic field impact lies in measurement of magnetic properties of biological objects, as discussed in Chapter 5.

We hold the opinion that those who make a sharp distinction between biomagnetism and magnetobiology actually impoverish these two biophysical areas destined to look into the dynamics of fundamental properties of biological systems.

However, the proof of kinship between these scientific areas is not at all obligatory for their individual progress. As is known, biomagnetism has many advantages of its own.

Judging by the ability to pick up data from a biological object locally biomagnetic techniques presently occupy an intermediate position between the use of superimposed electrodes and endoelectrodes applied for data acquisition and action monitoring.

It may be recalled that the ability to pick up data locally is primarily the function of ratio between volumes of the pick up probe and the monitored area of the biological object. Although today the area of SQUID probes is about 4-5 cm^ the technology for production of thin film SQUIDs may create a potential for manufacture of SQUID matrices by spray-coating having 20 or more probes on 1 cm. This technique will dramatically improve the ability for localized detection. Visualizing a possible combination of advanced magnetometry and computer technology one may predict the advent of a radically new technique for diagnosis.

Similarly to computer tomography based on X-ray absorption by tissues of biological objects with different density biomagnetic techniques are highly useful in evaluating the type of damage, for example, to brain, as well as in localizing it and estimating its shape and size. At the same time magnetometry possesses undisputable advantages over other known methods.

1. Featuring the advantage of noninvasive data detection this technique does not require exposure of biological objects to any field or use of contrast agents.

2. The technique is capable of qualitative evaluation of electrogenesis of genoplasms, for instance in the brain, and tracing the electrochemical relationships between various regions, neuron structures as well as corticocortical and cor-ticosubcortical relations, and to make the space-and-time and quantitative evaluation of the functional state without implantation of electrodes into the brain.

Relying on magnetometric hardware researchers engaged in the study of the brain will shift the emphasis from improvement of tumor localization to exploration of regularities controlling the development of pathologic state of the central nervous system, including phase shifts in macro- and microsystems of the brain reflecting the relationship between the pathological focus and the brain as a whole.

A possibility of during-life monitoring of tumor development in the brain will open new perspectives for tumor study, observation and treatment.

The outlined experimental areas of biomagnetism testify to high practical value of this branch of science as well as to its substantial theoretical importance.

The actual development of magnetocardiography and magne-toencephalography in particular must be based on wide application of mathematical methods to identify and analyze signals and simulate biologic systems. The need to apply these means stems out from the fact that hundreds meters of complex curves (in case of the regular recording mode) of EEGs, as well as of ECGs, are a rather typical result of just one test. Digital recording or further data transformation into digits involve millions of numbers. It is also known that analysis of these data targets at a large number of interrelated factors which may vary within limits that cannot be always checked experimentally. In case of registration of MF of biological objects the problem is rendered more complex by the fact that irrespective of the probes used the signal-to-noise ratio may be quite small, and even much less than the one dealt with in the field of bioelectric research where it may count 10^{-2}-10^{-3}.

Obviously enough, the analysis of such experimental data requires the use of mathematic approach borrowed from such areas as optimal filtration theory, statistical solutions theory, verification of hypothesis, evaluation theory, etc.

On the other hand it may be considered that the mechanisms producing MFs in various biologic objects remain practically unknown. At the same time the need to go beyond the simple accumulation of phenomenologic data and to improve the diagnostic value of MF registration of biological objects calls for solution of the reverse problem of magneto- and electrobiology i.e. estimation of EMF sources (localization, orientation, number) corresponding to a particular type of magnetic activity, relying on measurements of their characteristics. The structural and geometrical complexity of biological objects, inhomogeneity of electric and magnetic properties of the media where EMF proliferates from its source to the pick up probe are such that simulation and analysis of mathematical models of the likely physical and chemical processes as well as of organs' functioning seem to be the only realistic method for determining of source.

As simulation of these systems and analysis of experimental biomagnetic data are quite complex these problems can be effectively solved only with the use of powerful modern computers.

Proceeding from the experimental and theoretical data there may be identified the following advantages of the magnetometry of biological objects over many other methods.

1. Noninvasive pick up of data from biological objects.

2. Ability to detect certain sources of electromagnetic activity in man and animals which cannot be identified with measurement of the body surface potentials (such as the permanent field of the heart).

Physical simulation was performed with the view to identify the factors affecting the accuracy of neuromagnetic measurements. An artificial dipole was first placed in a plastic vessel filled with salt gel and then in a human corpse head. The maximal approximation between the computer simulated field and the field measured from the object resulted in the

1-3 mm accuracy of dipole localization. A few cases of crani-ectomy and implantation of an isolated vessel into model showed that such electrically inhomogeneous areas as eye sockets, zygomatic sutures and brain ventricles have little effect on electrical sources localization with MEG. Skull deviations from the spherical shape are responsible for bigger error in localization accuracy reducing the depth estimate by the order of several mm.

The measurements of MF and electrical field from 3 dipoles placed in the skull with conducting gel under X-ray control resulted in the 3.5 mm three-dimensional dipole localization accuracy with proper account of nonspherical shape of the head.

The need to take into account the actual geometry of the skull and brain to improve accuracy of MF source localization prompted mathematical simulation of the human head shape as well as the use of the nuclear-magnetic resonance tomography and the specifically designed craniometers for accommodation of individual features of the head.

Some publications are devoted to theoretical estimation and description of computer programs geared to determine the power and depth of current dipole in a sphere. The spherical computer model of the head produced the evidence on insignificant effect of cerebral suici geometry on MEG and EEG maps. The use of a mathematical model of the head with a mobile dipole source inside indicated that nonradial deviation (over 5°) of the MEG probe axis in relation to the head may cause considerable localization error.

It was theoretically proved that two identical tangential dipoles may be individually localized with the MEG method if there is at least a 1-2 cm gap between them [9]. There was also described the impact of multiplicity of sources on results of MEG based localization.

A number of mathematical models were made with the view to solve the reverse problem using MEG and EEG subject to spontaneous activity under brain pathology and with the use of EP and EMR methods for sources identification.

Magnetometry is not limited to the field of biology. As is known, electrochemical regularities lie in the foundation of a great number of fundamental biological processes. A lot of current research is focused at exploration of structural, functional and biochemical properties of cells, and at understanding mechanisms controlling transfer of charge in biological membranes and models thereof.

Magnetometers capable of measuring oriented transfer of charges i.e. the ion currents are presently built in the USA. The authors maintain that these instruments will be able to measure injury currents or the so-called currents in blood vessels which may allow to localize damage of cells as the first link of injury of the cellular vessel wall as well as to produce accurate quantitative characteristic of muscle elements of different types of vessels.

It may be assumed that eventually magnetometry techniques will be able to register any movement both in the stream of liquid, isolating laminary and turbulent currents, and in some biochemical reactions generating conditions for the oriented ion motion. It might beinteresting to consider in this context reports on magnetic effects in some biochemical reactions, in particular, on a possible impact of MF, of comparatively small induction, on biological processes under the condition that they involve radical chemical reactions.

It is our hope that this book will be helpful in attracting new enthusiasts who will be able to cope with many unsolved problems of biomagnetism.