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**Biological Effects
of Nonionizing
Electromagnetic
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**Biological Effects
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Biological Effects of Nonionizing Electromagnetic Radiation

December, 1984 Volume IX, Number 1

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Preface

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by Information Ventures, Inc. under contract to the Office of Naval Research.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and other radio frequency radiation) is compiled, condensed, and disseminated on a regular basis. The effects of electric and magnetic fields (static and alternating) and research on medical applications of these nonionizing electromagnetic radiations are also included.

Biological Effects of Nonionizing Electromagnetic Radiation is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of the service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume VII and future volumes will include materials received during the preceding three months. Each issue contains abstracts of current English and foreign-language research literature, current research summaries, news items and announcements, and information on relevant meetings and conferences. Subject and author indices are provided for all literature abstracts to facilitate specific search and reference use. Journals, books and conference proceedings are used as sources for this publication. Materials for which full text is not available will be included as summary abstracts. Announcements and other materials submitted for publication should be addressed to: Dr. Bruce H. Kleinstein, Information Ventures, Inc., 1500 Locust Street, Philadelphia, PA 19102.

The digest was first published in 1974 under the title *Biological Effects of Electromagnetic Radiation*. It has been published under the present title since 1976. Previous issues can be obtained from the National Technical Information Service.

Abbreviations and Acronyms

A, amp - ampere
C - centigrade
cm - centimeter(s)
cps - cycles per second
dB - decibel(s)
EPA - Environmental Protection Agency
eV - electron volt
F - fahrenheit
FDA - Food and Drug Administration
g - gram(s)
G - gauss
GHz - gigahertz
HHS - Department of Health and Human Services
hr - hour(s)
Hz - hertz
ip - intraperitoneal
ISM - industrial, scientific, medical
IU - international unit(s)
iv - intravenous
J - joule(s)
k - kilo-
l - liter(s)
m - meter(s)
m - milli-
M - mega-
u - micro-
min - minute(s)

mo - month(s)
n - nano-
NIEHS - National Institute of Environmental Health Sciences
NIH - National Institutes of Health
NIOSH - National Institute for Occupational Safety and Health
NTIS - National Technical Information Service
Oe - oersted(s)
OSHA - Occupational Safety and Health Administration
rad - radiation absorbed dose(s)
R - roentgen(s)
rms - root-mean-square
rpm - revolutions per minute
sec - second(s)
sc - subcutaneous
USAF/SAM - U. S. Air Force School of Aerospace Medicine
V - volts
VA - Veterans Administration
W - watt(s)
WHO - World Health Organization
wk - week(s)
wt - weight
x - times
yr - year(s)

This issue is a complete translation of abstracts presented at the ALL-UNION SYMPOSIUM ON THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS, held in PUSHCHINO, U.S.S.R., in 1982.

Chapter I.

BIOLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC RADIATION.
Abstract No. 1449-1488

Chapter II.

BIOLOGICAL EFFECTS OF MILLIMETER-BAND ELECTROMAGNETIC RADIATION.
Abstract No. 1489-1502

Chapter III.

BIOLOGICAL EFFECTS OF LOW-FREQUENCY ELECTROMAGNETIC FIELDS.
Abstract No. 1503-1522

Chapter IV.

BIOLOGICAL EFFECTS OF CONSTANT MAGNETIC FIELDS.
Abstract No. 1523-1552

Chapter V.

BIOLOGICAL EFFECTS OF ELECTRIC FIELDS.
Abstract No. 1553-1563

Chapter VI.

CLINICAL AND HYGIENIC ASPECTS OF ELECTROMAGNETIC RADIATION.
Abstract No. 1564-1592

Chapter VII.

EFFECTS OF COMBINED EXPOSURES.
Abstract No. 1593-1602

Chapter VIII.

PHYSICAL FIELDS OF BIOLOGICAL OBJECTS.
Abstract No. 1603-1616

Of great interest are the reports on the effects of low-frequency EMR studied at different levels of biological organization (from molecular-biochemical changes to organism level). The materials on the effects of industrial frequency EMR are of special interest.

Evaluation of the responses of biological systems of various complexity to exposure to constant magnetic fields occupy a prominent position in the reports of the Symposium. Possible biophysical and physiological mechanisms of their action are considered.

Materials on electric fields include reports on continuous or alternating exposures at a given frequency. The possibility of producing different effects depending upon the frequency of the electric field is demonstrated.

For the first time, specialists in the clinical and public health aspects of exposure to EMR took part in this Symposium of the USSR Academy of Sciences. Reports presented at this Symposium cover various aspects of EMR effects on man, from methodological problems to analysis of specific reactions and techniques for their evaluation.

All reports on the effects of EMR in combination with various physical, chemical and other factors are assembled in a separate chapter. Of special interest are attempts at theoretical analysis of the combined effects.

Each report provides new data that contribute to a general knowledge of biological effects of EMR and electromagnetic fields (EMF) at different frequency bands. Analysis of the reports will be presented at the Symposium. It should be noted, however, that numerous aspects of the problem requiring study for improvement of environmental health standards and environmental protection did not receive sufficient attention. Data on the minimum threshold levels of exposure to radiation of different frequency bands for man and various animal and plant species are either insufficient or nonexistent. Theoretical analysis of the general mechanisms of action of EMR and EMF is completely inadequate. Questions concerning the reversibility of induced changes, the possibility of their combination, and of the adaptation of organisms remain unanswered. To resolve these problems, a transition from accumulation of qualitative data to exact quantitative analysis is necessary. Species differences in sensitivity and resistance to EMR and EMF, without which it is impossible to extrapolate experimental data to humans, are still unclear. Those are basic problems of current research in this field. The answer to these questions should take into account significant differences in the effectiveness of various types of EMR (constant, pulsed, frequency-modulated, etc.).

Due to the great interest in the inherent physical fields of biological objects, this problem was included in the reports of

MEETING ABSTRACTS

Chapter I. BIOLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC RADIATION.

1449 CONFORMAL REARRANGEMENTS INDUCED BY SUPERHIGH FREQUENCY RADIO-BAND RADIATION IN ERYTHROCYTE GHOST MEMBRANES (MEETING ABSTRACT). (Rus.) Zhadan, G. G. (Inst. of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Akoev, I. G.; Kim, Iu. A.; Shnyrov, V. L. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 6; 1982.

Transformations caused by heat in hemoglobin-free occluded human red cell ghosts in a 5 mM Na-phosphate buffer at a pH of 7.4 were studied by adiabatic scanning microcalorimetry. Six transitions, with peak positions of roughly 47, 52, 63, 77, and 82° were clearly distinguished on the thermogram obtained. Following irradiation of the membranes at 333 MHz (SAR = 15 W/kg), changes in both the intensity and location of the calorimetry peak associated with the fourth transition (63°) were clearly observed. Previous reports in the literature suggest that this peak reflects protein-lipid interactions in the membranes. In addition, a change in the original heat capacity was observed in the irradiated membranes. Both of these effects increased with irradiation time, reaching their maxima within 20 min of irradiation. These results cannot be explained by the direct action of heat on the membranes.

1450 INVESTIGATION OF THE EFFECT OF ELECTROMAGNETIC RADIATION ON VARIOUS STRUCTURAL LEVELS OF ERYTHROCYTE MEMBRANES (MEETING ABSTRACT). (Rus.) Kim, Iu. A. (Inst. of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Fomenko, B. S.; Akoev, I. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 6-7; 1982.

The effect of a superhigh-frequency (SHF) electromagnetic field (EMF) on various structural levels of an erythrocyte membrane from the blood of Wistar rats was investigated by fluorescent probes placed in different regions of the membrane. The probes used in this study [1-anilinonaphthalene-6-sulfonate (1,8-ANS), 2-toluidinonaphthalene-6-sulfonate (2,6-TNS), and 4-dimethylaminobenzyl (DMC)] are located at the boundary of the hydrophobic phospholipid hydrocarbon layer and the aqueous phase, while perylene is evenly distributed in the region of the glycerol residues and pyrene primarily in the hydrocarbon region. The kinetics of probe fluorescence quenching in this membrane during irradiation were recorded with the anisotropy of the polarization of the fluorescence. The temperature (an average value) of the specimen was simultaneously measured by an MMT-4 thermistor. Fluorescent measurements of the relative probe fluorescence yield at tempera-

tures ranging from room temperature to 40° were performed in a thermostat-equipped flask placed between the plates of a plane capacitor driven by a GZ-20 audio oscillator. At SARs of 35 W/kg and 100 W/kg and a frequency of 340 MHz, probe fluorescence quenching and lipid phase viscosity (from changes in the anisotropy of the perylene's polarized fluorescence within the SHF-EMF) did not deviate from changes observed as a function of specimen temperature. At all membrane levels studied, the processes were determined by the thermal action of the SHF EMF.

1451 CHANGES IN THE CONDUCTANCE OF MODIFIED PHOSPHOLIPID MEMBRANES CAUSED BY DECIMETER-BAND ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Rus.) Bol'shakov, M. A. (Institute of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Khizhniak, E. P.; Tiazhelov, V. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 7-8; 1982.

Changes in the conductance of artificial modified phospholipid membranes due to exposure to electromagnetic fields (EMF) at 0.8-0.9 GHz were reported previously. The authors of the earlier work explained the effect as arising from the local heating processes occurring in the specimen. This study presents results obtained from an investigation of this effect over a frequency band of 0.2-0.82 GHz. Unlike the previous studies, the specimen was irradiated in a strip line. It is shown that this effect exists over the entire frequency band under investigation. For fields of a constant amplitude in the electrolyte, the magnitude of the effect increases as frequency decreases, regardless of the modifying agents used, the current-carrying ions present, or any of the other parameters of either the membrane or the electrolyte employed. The behavior of the experimental 'magnitude-frequency' curves obtained agrees with theoretical estimates of local electrolyte heating occurring in the vicinity of a membrane. This agreement confirms the hypothesis that the results observed are related to a local thermal effect.

1452 SOME FEATURES OF THE ACTION OF A SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELD ON THE CONDUCTIVITY OF PHOSPHOLIPID MEMBRANES MODIFIED BY ALAMETHYICIN (MEETING ABSTRACT). (Rus.) Mirutenko, V. I. (T. G. Shevchenko State University, Kiev Inst. of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Alekseev, S. I.; Udovichenko, T. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 8; 1982.

Artificial phospholipid membranes (APM) modified by

localization is discussed.

1455 EFFECTS OF A HIGH FREQUENCY ELECTROMAGNETIC FIELD ON POSTSYNAPTIC MEMBRANE MODELS (MEETING ABSTRACT). (Rus.) Kolomytkin, O. V. (Inst. of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Akoev, I. G.; Kuznetsov, V. I.; Grigor'ev, P. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 10-11; 1982.

It is found that the conductance of a postsynaptic membrane model increases rapidly when electromagnetic radiation (EMR) is switched on and that this membrane exhibits increased conductance (1,400 pS) during the entire EMR exposure period. Following termination of the EMR exposure, the conductance returned to its original value. Repeated irradiation with EMR caused the same effect. The effects were rapid and entirely reversible. The rate of temperature increase in the cell used, measured by different methods, was as follows. Immediately after the EMR was switched on, the average rate of heating for the entire solution did not exceed $0.025^{\circ}\text{K/sec}$, while the rate of electrolyte heating in the vicinity of an opening in the Teflon diaphragm used was roughly 0.3°K/sec and the membrane's own temperature rise was 1.5°K/sec . When the molar concentration of the KCl was increased from 0.1 to 0.2 M, the conductance of the ion channel rose in a nonlinear manner, despite the fact that the amount of heat given off by the EMR and the temperature of the solution in the cell remained identical. Consequently, aside from thermal effects, the existence of other, as yet unstudied effects by EMR on membranes were suggested. An EMR with frequencies of 0.4 and 0.75 GHz (SAR = 0-300 W/kg) was employed in this work.

1456 BIOPHYSICAL BASES OF THE ACTION OF SUPERHIGH FREQUENCY RADIATION ON ERYTHROCYTE MEMBRANES (MEETING ABSTRACT). (Rus.) Ismailov, E. Sh. (Dagestan Polytechnic Institute, Makhachkala, USSR); Stepurina, L. E.; Mirzametov, R. M.; Ulukhanova, R. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 11; 1982.

The irradiation of human erythrocytes by electromagnetic waves (150-2,000 MHz with a power flux density greater than 5 mW/cm^2) increases the leakage of potassium, calcium, and hemoglobin as compared to intact cells. A superhigh-frequency (SHF) field also causes changes in various directions in the electrophoretic mobility (EM) of cells. At an exposure level of $1-10 \text{ mW/cm}^2$, a decrease in EM is observed, while EM increases when higher intensity values are used. Changes in EM are linked to the structural

impairment of an erythrocyte membrane's double electric layer. In the present study, the direct action of microwaves (MW) on the structure of erythrocyte membranes is detected by infrared spectroscopy and hydrogen exchange. This action is not linked to the temperature increase of the system as a whole. SHF irradiation at an intensity of $15 - 20 \text{ mW/cm}^2$ or higher impairs the normal kinetics of the hydrogen exchange process in corpuscle ghost films. An increase is observed in the proportion of readily exchangeable hydrogen atoms, and also the acceleration of slow H-D exchange, which suggests the impairment of the hydrophobic protein-lipid interaction occurring in the cell membrane. The present results indicate the possibility of the selective absorption of MW biological membranes. Changes in the structure and function of membranes are caused by the direct influence of MW on the molecular organization of cellular membranes. This organization arises from the nonuniform distribution of intermolecular interaction forces in the different membrane layers and in the area around a membrane; that is, from the nonuniformity of the electrical properties of membrane structures and their environs. The action of MW on membranes may be one of the chief ways in which SHF radiation affects biological objects.

1457 KINETIC CHARACTERISTICS OF THE INTRAMOLECULAR PROCESSES INVOLVED IN ELECTROMAGNETIC FIELD ENERGY TRANSFORMATION (MEETING ABSTRACT). (Rus.) Ivanov, S. F. (Institute of Biophysics, Soviet Ministry of Public Health, Moscow, USSR); Ostrovskii, A. V.; Pleshanov, P. G.; Pokin, V. S.; Sharov, V. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 12; 1982.

Studies on biomolecular solutions in the presence of an electromagnetic (EM) field with a frequency of less than 100 GHz have shown that a mechanism exists for the rotational relaxation of excitation energy. However, there is no direct evidence that the rotational movements of macromolecules or their individual components are the degrees of freedom primarily excited by such EM waves. It is known that a dipole-dipole interaction has a strong angular dependence, as well as being effectively 'neutralized' and attenuated. Thus, the rate of energy transfer between dipoles can be significantly reduced in the presence of an EM field if this field excites rotational degrees of freedom. An experiment to study the rotational relaxation process occurring in biological polymers and other related polymers through time resolution spectroscopy methods is discussed.

1458 ACTION OF A PULSED SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELD ON THE PARAMETERS

munal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Starodub, N. F. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 14-15; 1982.

The mechanism for changes observed in erythrocyte functioning during microwave (MW) irradiation of an intact organism (power flux density values of 0.05-50 mW/cm²) was studied. The ratio of different types of phosphates to hemoglobin in the red cells, the fractional composition of the hemoglobin present, the erythropoietic activity of the blood, and the level of mitoses in the erythroid components of the bone marrow were studied. The ratio of hemoglobin to individual phosphates in erythrocytes changes as a result of MW irradiation. The concentration of general organic phosphate is reduced and a related increase in inorganic phosphate is observed. Redistribution of organic non-nucleotide and nucleotide phosphates is also noted. Changes in the ratio of hemoglobin to individual phosphates in the blood can be caused by a number of factors. The appearance of immature cells in the blood during this process, which is expected on the basis of previous studies on the development of anoxia in organismic tissues during MW irradiation, was verified. These results and the changes detected in the level of phosphates and hemoglobin in the blood suggest that MW irradiation causes impairment of those structures involved in cellular energy metabolism. Changes (a reduction in the basal fraction and an increase in the minor fractions) are noted in the heterogeneous hemoglobin system. These changes persist for a quite prolonged period of time. Research has shown that the earliest changes to appear in fractional hemoglobin composition are a consequence of changes in the conformational state of the hemoglobin tetramer. The increase in the number of hemoglobin molecules that contain an oxidized iron atom in the heme-group contributes to this process. At the same time, the variations in the concentration of individual hemoglobins in the blood suggest that the processes which control the rate of synthesis of this or any other hemoprotein also change as a result of exposure to MW energy. The nature and extent to which the erythrocyte changes are manifested will depend substantially upon the intensity and duration of the MW exposure. The possible mechanisms of the biological action of MW exposure are discussed. Special attention is given to specific and nonspecific components of the general reaction of the red blood system during exposure of an organism to a superhigh-frequency electromagnetic field.

1462 EFFECT OF A LOW INTENSITY ELECTROMAGNETIC FIELD FROM THE SUPERHIGH FREQUENCY BAND ON THE COURSE OF DELAYED-TYPE HYPERSENSITIVITY (MEETING ABSTRACT). (Rus.) Belonozhko, N. G. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on

the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 15-16; 1982.

The rationale for this study was the existing claim that contact allergy to dinitrochlorobenzene (DNCB) can be used to assess the ability of an organism develop a delayed hypersensitivity reaction and can serve as one type of test for determining the functional activity of the T immune system. Experiments were carried out on 130 guinea pigs weighing 250-300 g, with identical care and feeding conditions. These animals were divided into 4 groups: Group I (control): animals that had been subjected to the influence of DNCB alone. Group II: guinea pigs treated with DNCB during irradiation and subsequently tested to determine the extent to which dermatitis was pronounced. Group III: animals treated with a 0.2% DNCB solution for 8 days then irradiated for 2 wk, and subsequently tested to determine the level of dermatitis present. Group IV: animals irradiated for 2 wk and subsequently smeared with a 0.2% DNCB solution for 8 days. Irradiation by a superhigh-frequency electromagnetic field (SHF EMF) with four energy flux density levels (1, 5, 50, and 500 uW/cm²) was employed in each series of experiments. Statistical tests included the Student's and the Chi-square criteria. It was established that SHF irradiation affects the functional state of T-lymphocytes, which are responsible for the delayed-type hypersensitivity (DTH) reaction. The extent of this effect depends upon both the magnitude of the SHF field levels studied and the times between irradiation and sensitization. Higher irradiation levels (50 and 500 uW/cm²) depress the DTH reaction, while the lower levels (1 and 5 uW/cm²) stimulate it.

1463 COMPARATIVE INVESTIGATION OF THE EFFECT OF A SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELD AND OF TEMPERATURE ON OXYGEN CONSUMPTION AND MEMBRANE PERMEABILITY IN AN ISOLATED RAT LIVER (MEETING ABSTRACT). (Rus.) Kakushkina, M. L. (Scientific Research Institute for the Biological Testing of Chemical Compounds, Soviet Ministry of Medical Industry, Kupavna, USSR); Khitrov, Iu. A.; Urazmanov, R. I.; Kutashov, V. N.; Shestiporov, V. A.; Shtemler, V. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 16-17; 1982.

A comparative investigation of temperature-related dependence (over a range of 18-45°) of tissue respiration and membrane permeability in isolated rat liver cells was performed both in the presence and in the absence of superhigh-frequency (SHF) exposure. An isolated rat liver was used in these experiments with the perfusion of an oxygenated nutritive medium through the vascular system and the simultaneous continuous recording of pO₂, pH, and pK values in the hepatic duct using selective electrodes. Organ temperature was monitored by measure-

1466 EVALUATION OF THE MECHANISM OF THE RESPONSE OF RAT BRAIN TISSUES TO A MICROWAVE EXPOSURE BASED ON AN ANALYSIS OF THE DYNAMICS OF TRANSFER ADENOSINE TRIPHOSPHATASE ACTIVITY (MEETING ABSTRACT). (Rus.) Artiukh, V. P. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Nazarenko, V. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 19-20; 1982.

It is generally accepted that the central nervous system of animals and man is most sensitive to microwave (MW) radiation exposures. Cerebral membrane structures which determine the functional activity of nerve tissues invite special interest. Proceeding on the basis that cation and mediator transport constitutes the groundwork of stimulation and inhibition processes, while transfer adenosine triphosphatases (ATPase) represent the main component in ion pumps, the changes observed in the activity of these substances in brain tissues of rats and cattle were investigated in vitro and in vivo. Previous reports which show that microwave irradiation, under specific conditions, causes an increase in the Na/K ratio of erythrocytes, as well as increasing the output of Ca^{2+} from the synaptosomes (in vitro) and cerebral cortex (in vivo), served as the basis of this research. It was shown that ATPase activity is altered in a number of tissues from different types of animals by exposure to electromagnetic radiation. MW irradiation of animals and brain enzyme preparations was carried out in anechoic chambers with constant temperature and air humidity and with continuous dose monitoring. Cerebral cortex membrane fractions, both in solutions and in lyophilized enzyme preparations, were irradiated in the in vitro experiments. During the in vivo experiments, test animals were subjected to whole body irradiation. To prevent posthumous changes, test animals were killed by freezing in liquid nitrogen. Na^+ , K^+ , and Ca^{2+} ATPase activity was determined in cerebral membrane preparations. This study showed that Na^+ and K^+ ATPase activity was not altered by exposure to nonthermal levels of MW radiation under in vitro conditions, and that K^+ acetylphosphatase activity (an analog of the K^+ phosphatase stage of the Na^+ and K^+ ATPase reaction) remained unchanged. A change in ATPase activity, primarily an increase, was noted in vivo, both during exposure to low power flux density (PFD) values and at PFD values exceeding 10 mW/cm². Comparison of results obtained from the experiments conducted in vitro and in vivo showed that the changes observed in the activity of the enzyme systems are most likely not a consequence of the direct influence of MW energy on the ATPase reaction, but result from an integrated reaction in the animal. From theoretical considerations, changes in ATPase activity can be interpreted as an adaptive reaction aimed at restoring and maintaining an optimum cation ratio within a cell.

1467 CYTOCHEMICAL INVESTIGATION OF NEUTROPHILS IN THE PERIPHERAL BLOOD OF RATS DURING EXPOSURE TO LOW-INTENSITY MICROWAVES (MEETING ABSTRACT). (Rus.) Gonchar, N. M. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Ahelezniak, A. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 20; 1982.

As is well-known, cell metabolism constitutes a sensitive indicator of the functional condition of a research subject and can indirectly demonstrate the extent of a given factor's deleterious effect. Glycogen level and alkaline phosphatase (APP) activity, which are expressed as the mean cytochemical coefficient (MCC), were studied during 30- and 90-day exposure to 2,375 MHz (wavelength = 12.6 cm) microwave irradiation at power flux densities (PFD) of 10, 50, and 500 uW/cm², and 1 and 5 uW/cm², respectively. Data were obtained prior to irradiation, several times during the irradiation period, and at monthly intervals during a 3-mo post-irradiation observation period. Microwaves with intensities of 1 and 5 uW/cm² caused small changes in indices during the 90-day irradiation period. However, following the termination of exposure, these indices immediately returned to their original levels and physical exertion did not change their magnitude. This made it possible to classify the effects of the fields as adaptive. During exposure to irradiation at 10 and 50 uW/cm², an increase in the level of glycogen was noted in the neutrophils of the irradiated animals, which was regarded as a positive effect. APP activity was altered in a phase-related manner: the stimulation observed during the first 3 wk of irradiation was replaced by a reduction in APP activity following 30 sessions. Microwaves with an intensity of 500 uW/cm² caused a reliable decrease in the MCC value of the glycogen in the blood cells from day 7 through day 30. During of the 90-day post-irradiation observation period, initial glycogen indices and neutrophil phosphatase activity (NPA) levels were not restored in animals exposed to microwaves with an intensity of 500 uW/cm². Both indicators remained reliably lower than their original levels. This indicates an injurious effect of microwaves with a 500 uW/cm² intensity.

1468 ELECTRICAL ACTIVITY OF VISUAL CORTX NEURONS IN THE CEREBRAL HEMISPHERES OF THE RABBIT DURING EXPOSURE TO A SUPERHIGH FREQUENCY FIELD (MEETING ABSTRACT). (Rus.) Chizhenkova, R. A. (Institute of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 21; 1982.

It was previously established that the electrical response (according to overall activity indices) of the cerebral cortex to a superhigh-frequency (SHF)

min with power flux density (PFD) values of 20, 50, 96, and 167 mW/cm². The blood levels of adrenocorticotropic hormone (ACTH), somatotrophic hormone (SH), hydrocortisone, thyroxin, triiodothyronine, and insulin were determined under dynamic conditions by radioimmunoassay. Single exposure to a centimeter-band SHF field at or below conventional thermal intensities (50-100 mW/cm²) stimulates the secretory capacity of the anterior pituitary gland, the adrenal cortex, the thyroid gland, and the pancreas, as indicated by increased content of ACTH, SH, hydrocortisone, thyroxin, and insulin in the blood plasma of test animals. Triiodothyronine content is reduced somewhat when a low-grade thermal dose is administered. The application of a non-thermal irradiation dose (20 mW/cm²) causes a decrease in ACTH, hydrocortisone, insulin, and thyroxin content, together with an insignificant increase in triiodothyronine content. High microwave (MW) intensities (167 mW/cm²) inhibit the secretory function of the anterior pituitary gland and the adrenal glands, which is expressed by a significant reduction in the amounts of hormones that these glands produce (ACTH, SH, and hydrocortisone). However, the changes observed in the hormonal activity of the pancreas and thyroid gland at the same exposure levels were opposite in nature: insulin and thyroxin content rose insignificantly, while triiodothyronine content remained unchanged as compared to its original value. A dynamic determination of the hormones present in the blood indicates that the changes seen in ACTH content occur more rapidly and persist for a longer period of time (up to 6 hr) than the changes observed in hydrocortisone and thyroxin concentration. When serial exposures (up to 10 procedures) were employed, the hormonal changes were of a similar nature, but the intensity of these changes depended on the number of exposures. By the 5th exposure, the changes had increased as a rule; however, these changes had abated considerably by the 10th exposure and approached their original levels in certain cases. Thus, the results suggest that active, yet far from identical, influences are exerted by centimeter-band SHF radiations on the functional state of endocrine gland activity, and that these influences must, in the author's opinion, be taken into consideration in the therapeutic use of MW, and in the interpretation of the peculiarities of the physiological effects produced by MW exposures.

changes occurring in the spleen in response to daily whole-body microwave (MW) irradiation (60 mW/cm² for 10 min) of test animals were investigated. These experiments were conducted on 30 mongrel white rats. The area ratio of the thymus-dependent and thymus-independent regions, as well as the reproduction center, was determined in 100 white pulp follicles on days 7, 14, and 28 of the experiment by light microscopy and an ocular grid in preparations that had been stained by conventional methods. In controls, the thymus-dependent region comprises 8.3% of the total area of a whole lymphatic follicle. The thymus-independent region is composed of small, medium, and large lymphocytes, reticular cells and macrophages. Reproduction centers that comprise 18.7% of the thymus-independent region's total area and which consist of large lymphoid and reticular cells, are noted in 26% of these follicle divisions. The interrelationships of these structures are altered by day 7 of the experiment. Aside from cell center alteration, the number of medium lymphocytes present in the thymus-independent region is noticeably increased. Large lymphocytes, as well as mature and immature plasmocytes, appear among these medium lymphocytes. The reproduction centers increase in size to comprise 27.4% of the thymus-independent region's total area and the number of mitoses present increases. No substantial changes were observed in the thymus-dependent follicle regions. By day 14 of irradiation, these cellular transformations are intensified. The number of germinal centers present in the thymus-independent regions increases, with centers detected in 64% of the follicles examined, and the dimensions of these centers are enlarged, reaching a level equal to 39.5% of the overall area value. The number of plasmocytes present among the medium and large lymphocytes increases. The percentage of medium lymphocytes residing in the thymus-dependent region increases by 6.8% of the overall area value. More perceptible changes were observed by day 28 of the test. The thymus-independent region's germinal centers were enlarged sharply, comprising an area of 48.9%. The number of plasmocytes present among the large lymphocytes and macrophages also increased. The thymus-dependent region is reduced in size to 5.4% of the overall follicle area, in which plasmocytes and fibroblasts are dominant. Thus, MW irradiation causes immunological changes in an organism, which are expressed by stimulation during the first days of the test and the depletion of immunocompetent cells during the latter stages of the experiment.

1471 EFFECTS OF A SUPERHIGH-FREQUENCY ELECTROMAGNETIC FIELD ON THE MORPHOLOGICAL STRUCTURE OF THE SPLEEN (MEETING ABSTRACT). (Rus.) Lazarovich, B. G. (Ivano-Frankovsk Medical Inst., USSR); Zbirak, N. P.; Vasilik, L. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 24; 1982.

1472 MORPHOLOGICAL CHANGES IN NERVE TISSUE DURING MICROWAVE IRRADIATION (MEETING ABSTRACT). (Rus.) Bashmanov, G. S. (Vladivostok Medical Institute, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 25; 1982.

The spleen, being a lymphoreticular organ, plays an important role in the immunological reactions of an organism. In the present study, morphological

A comprehensive histological investigation is re-

dence is noted between level of power and the exposure time needed to achieve identical effects), and the search for SHF modes that ensure the sterilization of microorganisms. The resolution of these questions is urgently dictated by the ongoing introduction of SHF devices into industry and everyday life. Work is under way both in the Soviet Union and abroad on SHF pretreatment of soils for weed suppression; however, considerations involved in the retardation of soil microflora, which can produce ecological consequences, are scarcely examined at all in these studies.

- 1475 BIOLOGICAL ACTION OF MICROWAVES ON CERTAIN MICROORGANISMS (MEETING ABSTRACT). (Rus.) Rybnikova, V. I. (Biology Dept., Dagestan Branch, Soviet Academy of Sciences, Makhachkala, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 27; 1982.

The effect of superhigh-frequency electromagnetic waves (microwaves) with intensities of 20-40 mW/cm² on microorganisms (such as salmonella and Staphylococcus aureus) was studied. Both growth and staining properties are altered in irradiated microorganisms. Morphological indicators are altered substantially; salmonella microorganisms acquire oval and circular shapes, while staphylococci become enlarged, the sizes of individual specimens exceeding their original dimensions by 1.5-3 times. The polymorphic cocci transmitted their altered properties to future generations; i.e., the microwaves acted as a mutagenic factor. Microwaves have an effect on the biochemical properties of microorganisms. Acid formation was reduced during carbohydrate fermentation in irradiated salmonella and staphylococcus cells, catalase activity was depressed, and redox potential was reduced.

- 1476 DEPENDENCE OF SUPERHIGH-FREQUENCY HEATING ON CONCENTRATION OF CELLS IN SUSPENSION (MEETING ABSTRACT). (Rus.) Berdnikova, I. P. (Scientific Research Inst. of Medical Radiology, Soviet Academy of Medical Sciences, Obninsk, USSR); Morozov, I. I.; Petin, V. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 27-28; 1982.

Nonuniform heating can occur as a result of the interaction of superhigh-frequency (SHF) radiation with the mass of an irradiated object, as well as the manner in which this mass is arranged. The increased heating observed in cells in suspension may be due to the selective absorption of microwave energy by the cells and/or their lower levels of heat conductivity. A temperature increase in the suspended cells should occur in either case, which

can determine the specific biological action of microwaves. Experiments were performed to study heating and cooling of *E. coli* bacteria irradiated by an SHF field as a function of bacterial concentration and of cooling conditions. Bacteria were suspended in a physiologic solution based on a Tris-buffer with a pH of 7.0 at a concentration of 4.2×10^{10} - 10^{12} cells/ml. The cell suspension and physiologic solution were irradiated in radiotransmissive test tubes with a volume of 5 ml using a Luch-58 electromagnetic field generator. These test tubes were uncovered and were placed in a glass rack, or, to achieve a high level of thermal insulation, in a plastic foam rack. Irradiation led to variable heating of both suspension and physiologic solution as a function of cell concentration. The rate of temperature increase depended on the cell concentration value. Heating differences in the more highly concentrated cell suspension and the physiologic solution in test tubes irradiated in the plastic foam rack increased with duration of irradiation, reaching a peak at 10-12° and subsequently remaining unchanged. When the test tubes were irradiated in the glass rack, the differences seen in temperature rises were not as pronounced, which is apparently due to the greater cooling in this case. Measurement of the cooling rate for cell suspension and physiologic solution heated to 52° showed that the respective heat loss rates of these samples differed. Here, the cooling rate was more pronounced when the cell suspension was less concentrated. The data obtained make it possible to reach a conclusion on the selective heating of bacterial cells suspended in a physiologic solution. Both the selective absorption of microwave energy by the cell mass and the lower heat conductivity of these cells as compared to the liquid in which they were suspended may constitute the basis of this heating effect.

- 1477 INFLUENCE OF CENTIMETER-BAND ELECTROMAGNETIC-FIELDS ON CANDIDA TROPICALIS D-2 CELLS DURING MUTAGENESIS (MEETING ABSTRACT). (Rus.) Danilenko, I. I. (Inst. of Microbiology, Virology, and Parasitology, Ukrainian Academy of Sciences, Kiev, USSR); Mirutenko, V. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 28-29; 1982.

The influence of centimeter wavelength electromagnetic fields (12.6 cm) on the mutagenic action of nitrosomethylurea in doses that induce a stimulative effect was studied. This research was conducted on the basis of a model which describes the induction of direct biochemical mutations accompanied by respiratory insufficiency. Nitrosomethylurea was used at a concentration of 70 µg/ml and at exposure times of 1-6 hr. A Luch-58 medical therapy generator operating in the continuous generation mode with output power measurement served as the superhigh-frequency (SHF) field source. Microbial cells were irradiated at an SHF field intensity

the gonadotropic activity of the pituitary gland is absent. Thus the adaptive metabolic changes observed in the reactions of an organism to SHF-band EMF irradiation are related to the endocrine status. Further study of this question can probably be aimed at the prospect of utilizing hormonal correction for formulating adaptive physiological reactions during exposure to an SHF-band EMF and, possibly, at an approach to the selection of a work force for job assignments subject to irradiation of this type.

1480 EFFECT OF DECIMETER-WAVE IRRADIATION OF THE RAT HEAD DURING CAROTID ARTERY CONstriction (MEETING ABSTRACT). (Rus.) Rutsai, S. V. (Central Scientific Research Institute of Health Resort Treatment and Physical Therapy, Soviet Ministry of Public Health, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 31-32; 1982.

The effect of decimeter wave (DMW) irradiation of the rat head (80 mW/cm²) following closure of the carotid arteries on the reproduction of a conditioned defense reflex and the content levels of DNA and RNA in the cerebral structures was studied. It was established, using 54 rats, that DMW irradiation reduces reflex reproduction by 79% ($p < 0.01$) on the day 1 after arterial constriction. A deterioration in the condition of animals in both the control and test groups is observed on day 2, expressed by disoriented running and sudden leaps that culminate in death. This worsened condition was manifested in a higher percentage of cases (63 $\pm$ 14.5%) than in the control (21.2 $\pm$ 7.1%) following repeated irradiation ($p < 0.01$). A significant improvement in reflex reproduction, on the order of 32% ($p < 0.01$), was noted in the rats which remained alive on day 2 after irradiation. RNA content was elevated in these animals, primarily in the tissues of the cerebral cortex. The increase ranged from 120.8 $\pm$ 1.5 to 126.0 $\pm$ 1.2 ($p < 0.05$), expressed in mg% of phosphorus per dry tissue weight, without any changes in the volume of DNA present. One peculiarity of the rats mentioned above was their slower rate of reflex development (after 5.2 $\pm$ 1.6 sec) as compared to that of the animals which succumbed during testing (3.2 $\pm$ 0.9 sec). Thus, DMW irradiation of the head causes an ambiguous effect during the first days after the impairment of cerebral blood circulation. The possible dependence of these effects on the initial condition of the test animals is apparent from the data. The mechanism of this positive action is viewed in terms of its effect on the assurance of flexible cerebral performance.

1481 FERTILITY IN MICE AND THE PHYSICAL DEVELOPMENT OF THEIR PROGENY AS A FUNCTION OF POWER-FLUX-DENSITY AND SUPERHIGH-FREQUENCY IRRADIATION DURATION (MEETING ABSTRACT). (Rus.) Orobel, V. V. (Leningrad Scientific Research Institute of Radiation Hygiene, Russian Soviet Federated Socialist Republic Ministry of Public Health, USSR); Bronshtein, I. E.; Sakevskaya, M. S. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 32; 1982.

The effect of the power flux density (PFD) and irradiation duration associated with intermittent (every other day) exposure to a superhigh-frequency (SHF) field on the fertility of female mice (the number of females giving birth in each group, the average number of baby mice per litter, and the reproduction ratio) and on the physical development of their progeny (the average weight of month-old mice) was studied. This research was carried out on 309 test animals which were divided into 12 groups according to SHF irradiation exposure conditions (wavelength = 12.6 cm) in an anechoic chamber. These conditions were as follows: the groups 1, 2, and 3: a PFD of 20 mW/cm² and times of 10, 15, and 22.5 min, respectively; groups 4, 5, and 6: a PFD of 10 mW/cm² and times of 15, 22.5, and 32 min, respectively; groups 7, 8, 9, and 10: a PFD of 5 mW/cm² and times of 22.5, 32, 48, and 71 min, respectively; group 11: a PFD of 2.5 mW/cm² and a time of 45 min, and group 12: nonirradiated, serving as control. Following 26 irradiation sessions, the females were mated by nonirradiated males (in a ratio, respectively, of 1 to 3), after which another 5 irradiation sessions were performed. Dispersion analysis and the phi criterion demonstrated that a reliable increase (stimulation) of the indices under investigation as compared to the control group ($p > 0.95$) took place in animals from groups 7 and 11. As exposure duration was increased to 15, 22.5, and 48 min (groups 2, 5, and 9, respectively), this stimulative effect was replaced by depression. The effective dose (D_{eff}) that produced this effect is determined by the equation $D_{eff} = t \times PFD^{1.5}$. In previous works (1972, 1975), A. G. Subbota and coauthors observed a similar dependence using other physiological indices. Subsequently increasing exposure times to 22.5, 32, and 71 min results in the indices returning to control levels. The results pertain to the development of adaptive reactions which will be dependent upon PFD magnitude and SHF exposure duration.

1482 MECHANISM OF FUNCTIONAL SHIFTS IN THE CENTRAL NERVOUS SYSTEM, CARDIOVASCULAR SYSTEM, AND DIGESTIVE SYSTEM DURING EXPOSURE TO SUPERHIGH-FREQUENCY ELECTROMAGNETIC RADIATION (MEETING ABSTRACT). (Rus.) Samokhina, A. A. (Karaganda Medical Institute, USSR); Baigutanov, Zh. B.; Zheksenbiyev, N. Zh. Mindubaeva, F. A. Pospelov, N. I. Proshin, V. V. Smailov, B. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 33-34; 1982.

ary due to fluctuations in neuroendocrinal regulation. The changes occurring in thyroid gland activity are of special interest, since thyroxin is capable of altering chromosome integrity under certain conditions. Changes in the neuroendocrinal system, particularly in thyroid gland performance, are also observed as a result of exposure to microwaves (MW). The present study examined the possibility that an EMF influences chromosome stability in intact mammals, the effect of MW on the resistance of chromosomes to the influence of ionizing radiation, and the relationship between the anticipated genetic effects of an EMF and the function of the thyroid gland. Parenchymal cells were taken from the livers of male white rats which had been irradiated by an EMF at a frequency of 2,375 MHz and energy flux density (EFD) of 500 $\mu\text{W}/\text{cm}^2$ for 1 day, 10 $\mu\text{W}/\text{cm}^2$ for 45 days, and 50 $\mu\text{W}/\text{cm}^2$ for 10 and 20 days. Daily irradiation duration was 7 hr. The number of cells containing chromosomal aberrations in the anaphase were counted in histological sections of the liver. Following exposure to an EMF at EFDs of 500 and 50 $\mu\text{W}/\text{cm}^2$ for 10 days, the fraction of cells exhibiting chromosomal aberrations remained unchanged. After irradiation at an EFD of 10 $\mu\text{W}/\text{cm}^2$, a reliable decrease (by as much as 2 times) was detected. However, this exposure also produced a twofold increase in the sensitivity of chromosomes to the injurious effect of x-radiation. The curve which described variant distribution became double-peaked for animals irradiated at 50 $\mu\text{W}/\text{cm}^2$ for 20 days. An antimutagenic effect was noted in one portion of the test rats, while a mutagenic effect was exhibited in another portion. Judging from the results obtained as a whole, the genetic action of an EMF is linked to thyroid gland activity, since the antimutagenic effect did not appear in animals that had received thyroidectomies and since the mutagenic effect was eliminated by injection of thyroxin during irradiation.

1485 REACTIVE-ADAPTIVE AND COMPENSATORY MECHANISMS AT THE CELLULAR AND SUBCELLULAR LEVELS OF THE BRAIN DURING THE EXPOSURE OF AN ORGANISM TO MICROWAVE RADIATION (MEETING ABSTRACT). (Rus.) Belokrinskii, V. S. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 36-37; 1982.

Test animals were irradiated in special cages housed within a shielded chamber. The cages were situated in the region formed by an electromagnetic field (EMF) of variable intensity (from 5 to 1,000 $\mu\text{W}/\text{cm}^2$) centimeter waves (wavelength = 12.6 cm). The indices were determined both immediately after a single exposure and under dynamic conditions some 5-10 days after repeated exposures (10, 20, 30, and 60 days). It was learned that a cell, being the basic structural unit of both the brain and the organism as a

whole, reacts by increasing the activity levels of individual enzymes (succinic dehydrogenase [SDH] and glucose-6-phosphate dehydrogenase [G-6PDH]) when the organism is exposed to an EMF with an intensity of 5-10 $\mu\text{W}/\text{cm}^2$ for 3-7 hr, and the rate at which oxygen is absorbed by the mitochondria, moderately reducing the content of glycogen within the cell, and altering both the shapes and the electron densities of the organelles present. As the intensity and duration of irradiation were accelerated during these tests, a disproportionate increase was observed in the activity levels of the redox enzymes, accompanied by disruption of the oxidative and phosphorylating functions of the mitochondria, a more pronounced reduction in the content of glycogen and nucleic acids, and structural impairment in the mitochondria, the endoplasmic reticulum, and other organelles. Redistribution of activity of the enzymes which catalyze individual metabolic nodes and types of metabolism took place over the course of the irradiation, as did a fluctuating change in both the catecholamine content and the activity and thermal stability of the acetylcholinesterase present in the grey matter of the brain's frontal pole and subcortical formations. These changes differ in nature from those encountered in cerebral hypoxia. During the long-term (2-mo) exposure of the rat to microwave radiation (MWR) with intensities of 10, 25, 50, and 1,000 $\mu\text{W}/\text{cm}^2$, or exposure to MWR with an increased intensity, a wide range of changes was observed in the histochemical processes and ultrastructures that constitute a morphological base for the reactive, adaptive, and compensatory processes under investigation, including the appearance of cells with a clearly marked pathology. The results suggest that impairments in the ultrastructures and functions of the cell organelles occur as a result of exposure to low levels of MWR. The changes in the mechanisms of metabolic regulation and in the mechanisms governing the self-regulation of repair in these structures, which are probably caused by alteration of molecular conformation and the accumulation of metabolites, comprise the foundation of such impairments. The extent of these impairments depends on the frequency, duration, and intensity of the exposure to a stimulus, which is MWR in the present study.

1486 ULTRASTRUCTURAL CHANGES IN BRAIN CELLS DURING EXPOSURE TO A CENTIMETER-WAVE ELECTROMAGNETIC-FIELD (MEETING ABSTRACT). (Rus.) Belokrinskii, V. S. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 37-38; 1982.

Tests are performed on male white rats which had undergone exposure to a superhigh-frequency (SHF) field daily, 3x/day, for 2 mo for 40 min each and

parallel to each test group. The concentration of creatinine in the blood and urine was determined according to Jaffe, using the modification proposed by Berkhin and Ivanov, while inulin content was determined by the Antronov method. The electrolyte content was studied on an FPL-1 flame photometer. The indices used to judge the natriuretic performance of the kidneys were calculated by generally accepted formulae (Iu. V. Natchin). Statistical analysis of the data was carried out according to Student. The results demonstrated that a 10-day irradiation at an EFD of 50 uW/cm² does not alter glomerular filtration, but slightly reduces diuresis (from 4.2±0.3 to 3.6±0.2 ul/min/100 g) and the elimination of sodium by the kidneys. In this instance, the sodium fraction excreted was decreased from 0.85±0.08 to 0.82±0.09%, which indicates an increase in sodium reabsorption in the tubules. During single irradiation at an EFD of 500 uW/cm², glomerular filtration was altered in an irregular manner. Diuresis was retarded considerably (from 4.2±0.3 to 3.2±0.4 ul/min/100 g), as was the renal excretion of sodium (from 0.62±0.08 to 0.52±0.08 ueq/min/100 g). Irradiations that are administered one time at an EFD of 500 uW/cm² against a background of a previous 10-day irradiation at an EFD of 500 uW/cm² cause less pronounced changes (as if they had been smoothed out) in the transport of sodium through the tubules of the rat kidney. The author suggests that this phenomenon is an adaptation on the part of the organism to a repeated microwave irradiation exposure.

Chapter II. BIOLOGICAL EFFECTS OF MILLIMETER BAND
ELECTROMAGNETIC RADIATION.

1439 ANALYSIS OF MILLIMETER AND SUBMILLIMETER
WATER ABSORPTION FROM THE VIEWPOINT OF A
TWO-STRUCTURE WATER MODEL (MEETING ABSTRACT).
(Rus.) Gaiduk, V. I. (Inst. of Radio-Engineering
and Electronics, Soviet Academy of Sciences, Moscow,
USSR); Kalmykov, Iu. P. In: All-Union Symposium on
the Biological Effects of Electromagnetic Fields,
Pushchino, USSR, p. 40; 1982.

The molecule movement in polar fluids, including water and aqueous solutions, is studied by analyzing and interpreting the spectra of submillimeter (SMM) and millimeter (mm) wave absorption, or Pauli absorption. It is shown that so-called Debye absorption is identical in nature to Pauli absorption. The phenomenon of resonance interaction with the field of molecules engaged in thermal rotational oscillations and the frequencies of these oscillations that have a distribution of the Boltzmann type constitutes a basis for the microwave and SMM absorption of polar fluids. Attempts at independently examining the two mechanisms involved (mechanisms of the Debye and libration types) are not very promising. Only a single molecule oscillation

takes place on the average in a configuration of the short-range order over an interaction time frame of tau; therefore, Frenkel's concept concerning the existence of many librations in the time-related equilibrium position over the course of the tau time frame can not be correlated to SMM fluid absorption data. An analysis of the water absorption spectrum in the far infrared (IR) region is made. The water absorption band situated at 190 cm⁻¹ can be analyzed both within the framework of a constrained rotator model and within the framework of a model that describes almost free rotation. Over the course of the tau time frame, H₂O molecules succeed in being turned by an angle of 120°. Here, tau is 0.3 ps. A second absorption band in the far IR region (at 680 cm⁻¹) is explained, as is already known, by hydrogen-bonded H₂O molecule librations. Thus, the water absorption spectrum analysis agrees with the hypothesis of a mixed water structure model, wherein a small portion of the H₂O molecules that have a high level of rotational mobility govern water absorption with a peak at 190 cm⁻¹, while an ice-like water fraction governs absorption at 680 cm⁻¹.

1490 INVESTIGATION INTO FORCED PARTICLE DIS-
PLACEMENTS IN SOLUTIONS DURING EXPOSURE
TO NONUNIFORM SUPERHIGH-FREQUENCY-FIELDS (MEETING
ABSTRACT). (Rus.) Guliaiev, Iu. V. (Saratov
Branch, Inst. of Radio-Engineering and Electronics,
Soviet Academy of Sciences, USSR); Veselov, A. G.;
Zborovskii, A. V. In: All-Union Symposium on the
Biological Effects of Electromagnetic Fields, Push-
chino, USSR, p. 41; 1982.

Results obtained from research conducted on the effect of nonuniform millimeter wavelength-band superhigh-frequency (SHF) fields on the forced displacements of charged particles in solutions composed of organic and inorganic compounds are presented. SHF field nonuniformity was created by using electrodes with different configurations, positioned along the plane perpendicular to the direction of electromagnetic wave propagation. It is shown that any fluctuations in solution conduction will be dependent upon the shapes and positions of the electrodes positioned in the electromagnetic radiation field. The effect of SHF fields is compared to the effect of thermal solution heating. The possibilities of using nonuniform SHF fields for electrophoresis are discussed.

1491 STUDY OF THE CONFORMATIONAL CHANGES OF A
HEMOGLOBIN MOLECULE DURING INTERACTION
WITH ELECTROMAGNETIC RADIATION (MEETING ABSTRACT).
(Rus.) Deviatkov, N. D. (Tomsk Polytechnical Inst.,
USSR); Didenko, N. P.; Zhankov, V. I.; Zelentsov, V. I.; Krechmer, A. M.; Cha, V. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 41; 1982.

following the cessation of irradiation and corresponded to the elevation of the SCC value. The dependence of phi increase upon irradiation intensity had two characteristic points, the first at 1 mW/cm², the threshold intensity where the influence of the mm radiation begins to be exerted, and the second at 4-6 mW/cm² where the curvature of the characteristics under investigation is heightened. The outer skin layer, which contains the epithelial cells that transport Na⁺, proved to be sensitive to the mm radiation. The changes in the membrane permeability of the epithelial cells associated with mm irradiation increased or decreased when transport activating or inhibiting agents were employed. Since the rate of transepithelial transfer of Na⁺ by frog skin is determined by the passive transfer of ions through the membranes, which must in turn be limited when the flow that carries the ions through the aqueous layers near the membrane is of a high order, the results of this work can be explained by convection in the diffuse aqueous layers near the membrane due to the formation of temperature gradients as a result of a high level of water absorption (alpha, approx = 20 dB/mm). This assumption is confirmed by measuring convection in the water by the polarographic method. The increase observed in polarographic current with mm radiation power levels was similar to that observed during the frog skin tests. It is assumed that the convective transfer of ions and other substrates in the aqueous phase is one of the chief mechanisms of the reaction of living cells to SHF radiation.

1495 ACTION OF MILLIMETER RADIATION ON BIOLOGICAL MEMBRANES (MEETING ABSTRACT). (Rus.) Deviatkov, N. D. (Institute of Radio-Engineering and Electronics, Soviet Academy of Sciences, Moscow, USSR); Chernov, Z. S.; Bettskii, O. V.; Putvinskii, A. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 44; 1982.

The results obtained from a study carried out over the past 2 yr on the problem of the nonthermal influence of millimeter radiation on different biological objects are discussed. Various sources of electromagnetic radiation of low average intensities are analyzed, ranging from continuous radiation with a power density that is expressed in terms of mW/cm² to pulsed radiation with nanosecond duration and high peak power level. Primary attention is given to the role of the layers near membranes in radiation reception, as well as to the capillary effect.

1496 CHANGES IN THE AFFINITY OF HEMAGGLUTININIZING IMMUNOGLOBULINS DURING EXPOSURE TO ELECTROMAGNETIC RADIATION (MEETING ABSTRACT). (Rus.) Didenko, N. P. (Tomsk Polytechnical Inst.,

USSR); Gurevich, M. E.; Zelentsov, V. I.; Perel'muter, V. M.; Cha, V. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 44; 1982.

The after-effects of electromagnetic radiation on the hemagglutinating activity of immunoglobulins is studied. It is generally known that the antigen-antibody reaction is developed under conditions of a rigid epitope and paratope complement. Thus, any exposure that alters the conformation of immunoglobulin must be reflected in the force of antigen-to-antibody bonding. The change occurring in antibody affinity is demonstrated by the equilibrium sedimentation method. The possible mechanisms of this phenomenon are discussed.

1497 POSSIBILITY OF REGULATING THE VITAL ACTIVITY OF MICROORGANISMS DURING EXPOSURE TO MILLIMETER-BAND ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Rus.) Briukhova, A. K. (Institute of Radio-Engineering and Electronics, Soviet Academy of Sciences, Moscow, USSR); Dvadtsatova, E. A. Golant, M. B.; Landau, N. S.; Rebrova, T. B.; Okhokhonina, G. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 45; 1982.

A procedure is developed and optimum conditions are selected for exposing microorganisms used in alcohol production and in medicine to millimeter-band electromagnetic fields. Such irradiation enables slightly raising the fermentative activity of enzyme producers and elevating the reduced level fermentative activity inherent in a given producer; isolating altered microorganismic life forms which have useful properties that are improved in the practical sense; and bringing about changes in the complement of enzymes synthesized by microorganisms so that an essential component will be dominant by varying the irradiation parameters.

1498 EFFECT OF MILLIMETER BAND SUPERHIGH-FREQUENCY-ENERGY ON THE PHENOTYPICAL DEVELOPMENT OF THE P-386 PLASMID AND ON CERTAIN PROPERTIES OF E. COLI (MEETING ABSTRACT). (Rus.) Luneva, I. O. (Saratov Medical Institute, USSR); Shub, G. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 45-46; 1982.

The use of microorganisms to study the biological effects produced by millimeter (mm) band superhigh-frequency (SHF) energy is a convenient model due to the absence of intermediate regulation of physiological processes on the part of the nervous system, the endocrine system, etc. Study of microorganism-

detected when animals carrying transplanted tumors are subjected to similar combined exposures. Such an omnidirectional effect by mm waves on normal and tumor cells when combined with antitumoral preparations or x-radiation is of great practical importance. Both classical approaches and those based on quantum mechanics, which demonstrate the existence of mm-band fields in a number of biological systems, as well as the presence of proton generators (of the superhigh-frequency mm-band type) in membrane cells, provide theoretical substantiation for the results obtained.

- 1502 MECHANISM OF ACTION OF LOW-POWER ELECTROMAGNETIC RADIATION FROM THE MILLIMETER BAND ON LIVING ORGANISMS AND PROSPECTS FOR ITS USE (MEETING ABSTRACT). (Rus.) Deviatkov, N. D. (Inst. of Radio-Engineering & Electronics, Soviet Academy of Sciences, Moscow, USSR); Golant, M. B.; Rebrova, T. B. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 48; 1982.

Low-power millimeter-band electromagnetic radiation (mm EMR) does not cause tissue heating, cannot lead to the rupture of intermolecular bonds, and does not penetrate to any great depth. The action of such radiation on an organism is informational in nature and is determined by the frequencies employed. A determination of the frequencies over which mm EMR affect vital activity can be carried out by radio-physical methods only when instrumentation with a sufficiently high level of sensitivity is available. The most effective method at the present time is the one that detects the irradiation frequencies which produce an action-related biological effect. The possibility of an effect of low power EMR on a living organism is ensured when active losses are compensated by metabolic energy. The irradiation time needed for a mm EMR exposure effect to be remembered is roughly 1 hr. In a number of cases, several irradiation cycles or several sessions are needed to produce a significant effect. Perception of an mm EMR occurs at the cellular level. The mechanism of the direct perception by an organism of the effect of an mm EMR is apparently linked to the synchronization of a great many oscillators. These oscillations also exist in an organism not subject to external EMR, but are not synchronized under normal conditions. The effect of an EMR on an organism is reduced to the regulation of the organism's physiological activity and to mobilizing its reserve capabilities in a certain direction, thus determining the manner in which mm EMR is employed in biology and medicine.

Chapter III. BIOLOGICAL EFFECTS OF LOW FREQUENCY ELECTROMAGNETIC FIELDS.

- 1503 LIPID PEROXIDATION IN THE MECHANISM OF BIOLOGICAL ACTION OF A LOW FREQUENCY MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Udintsev, N. A. (Tomsk Polytechnical Institute, USSR); Ivanov, V. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 49; 1982.

Spontaneous chemiluminescence and the content of peroxidation products, the status of certain factors which regulate lipid peroxidation, (such as the antioxidative and antiradical activity of lipids, the level of reduced glutathione, the content of the common thiol and dithiol groups), and the activity of glutathione peroxidase and glutathione reductase in liver mitochondria and homogenates during exposure to an alternating magnetic field with a flux density of 20 mT and a frequency of 50 Hz in the presence of different exposure times and an arbitrary number of exposures per se, are investigated in experiments conducted on male white rats. It is established that a short-term magnetic field exposure which is carried out for therapeutic purposes causes no significant change in the content of lipid peroxidation products in the liver. Here, the antioxidative activity of the lipids is increased, as is the level of reduced glutathione present, which is apparently of some importance to the mechanism of the therapeutic action. Repeated long-term exposure to a magnetic field activates the substantial free-radical oxidation of the lipids contained in biological membranes due to a decrease in both the antioxidative activity of the lipids themselves and in the activity of the enzymes that provide antiperoxide protection. The accumulation of lipid peroxidation products leads to the oxidation of the thiol groups, changes in the activity of the membrane-bound enzymes, and a reduction in mitochondrial respiration. The introduction of the antioxidants tocopherol and ionol before field exposure begins impedes the accumulation of the toxic products derived from the peroxidation process and inhibits metabolic changes. The results suggest that peroxidation reactions play a substantial role in the mechanism of the biological action of a magnetic field.

- 1504 ABSENCE OF AN EFFECT BY WEAK LOW FREQUENCY MAGNETIC FIELDS ON THE BELOUSOV-ZHABOTINSKII REACTION (MEETING ABSTRACT). (Rus.) Begar, V. A. (Inst. of Chemical Physics, Soviet Academy of Sciences, Moscow); Livshits, V. A. In: All Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 50; 1982 (1 ref).

mov. E. V.; Plekhanov, G. F. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 52; 1982.

The goal of the present study was an examination of the effect of a weak industrial-frequency alternating magnetic field (AMF) on populations of *D. melanogaster* consisting of 39 inbred lines. The development of this fruit fly population was carried out under optimal growth conditions at a temperature of 25°. Exposure to an AMF (160 A/m and 50 Hz) was continued over the course of this population's entire life cycle. Aggregate fertility and the dynamics of the fly breeding process were determined for each line studied over the course of these experiments. The magnitude of the effect on various individual lines examined was determined from the difference between control and experimental fruit fly population density values. The overall response of the population as a whole was determined from the sum of the responses of the individual lines. Eight series of experiments were carried out. It was shown that the population in toto only exhibited a slight reaction to the AMF exposure. Fly fertility was altered insignificantly on the average; however, a change was observed in the dynamics of the fly breeding process, which was expressed by an increase in the number of females during the first (+20 +/-18%, p=0.05) and fifth (+10 +/-8%, p=0.05) days of the breeding period. An analysis of each of the 39 lines for their sensitivity to the AMF exposure showed that there were two groups of lines in the population which differed as a function of both fertility and sensitivity to the AMF. The first group was affected during the first day of breeding, while the second was affected on the fifth day of breeding. Thus, the reaction of a fruit fly population to an AMF with the stated parameters is determined by the heterogeneity in the sensitivities of individual specimens.

1508 SEROTONINOGENIC EFFECT OF A PULSED ELECTROMAGNETIC FIELD AS A FACTOR WHICH INITIATES TISSUE REACTIONS IN AN ORGANISM (MEETING ABSTRACT). (Rus.) Merkulovs, L. M. (Chuvash State University, Cheboksary, USSR); Amosova, V. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 53; 1982.

Long-term research by the authors has resulted in voluminous data on the morphohistochemical effects in the organs and tissues of white rats during prolonged exposure to a pulsed electromagnetic field (PEMF) with a flux density of 100 mT (a current discharge frequency of 2.5 kHz, single unipolar sinusoidal pulses, a pulse duration of 0.2×10^{-3} sec, and a repetition frequency of 16 per min). From the authors' viewpoint, a study of tissue serotonin, which has a considerable and multi-

faceted effect on the performance of the nervous and cardiovascular systems as well as the functions involved in the intercellular exchange of substances and the condition of the cell membranes, constitutes a matter of paramount interest. Serotonin content, monoamine oxidase activity, and the condition of the mast cells residing in the skeletal and cardiac muscles, the internal organs, the peripheral nerves, and the skin were studied using the histochemical methods proposed by Masson and Fontana, Glenner, Unna, and Spicer. An initial PEMF exposure leads to a statistically reliable increase in the level of tissue serotonin in all organs, which depends on the morphological and functional state of the organs themselves. The similar unidirectional nature of these changes shows that a PEMF exposure exerts a serotoninogetic influence. The authors found that the increase in tissue serotonin concentration is linked to the increased rate of its synthesis in the organs themselves (the heart) and in the skin, as well as to the influx of serotonin with the blood arriving from the organs that produce and store it. Shortening and intensification of the mast cell life cycle is noted during this period. All of this can be regarded as a biological protection reaction in the organism, since serotonin is an active antioxidant and a cell membrane stabilizer. However, the prolonged inundation of tissues by large amounts of serotonin during repeated exposure to a PEMF and the ultimate stress which appears in a mast cell system initiate the development of numerous pathomorphological changes in vessels and tissues, as the authors have already noted. The injurious effect of a PEMF on the biological polymers in the connective tissues of the skin and the heart valves, as well as on the complicated protein-lipid carbohydrate complexes present in other structures (as exemplified by the myelin tunic of the nerve fibers), can be viewed as being mediated by micromolecular compounds, particularly by the monoamine-serotonin complex. Possessing the ability to be bonded to a nuclear genome (Csaba and Surjan, 1970), serotonin can repress old and initiate new processes for the synthesis of macromolecular substances (as exemplified by heparin), playing a vital role in the formulation of a biological reaction to PEMF exposures.

1509 SOME REGULARITIES OF THE EFFECT OF A SINGLE MAGNETIC FIELD PULSE ON THE ELECTRICAL ACTIVITY OF NEURONS (MEETING ABSTRACT). (Rus.) Danilov, V. I. (Joint Inst. for Nuclear Research, Dubna, USSR); Parshintsev, V. V.; Turkin, V. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 54; 1982.

Changes in the electrical activity (EA) of neurons from the *L. Stagnalis* mollusk in response to triangular magnetic field (MF) pulses with variable amplitudes (1, 10, and 100 G) and different time rates of change of the field (dB/dt; 5×10^{-2} , 10^{-1} ,

1982.

The possibility of applying the Deriagin-Landau-Vervey-Overbeck lyophobic colloid stability theory to a description of the energy-related interaction between erythrocytes in the blood system is based on an analysis of the physical and chemical parameters of blood constituents. Curves are plotted which describe the energy values of the paired and collective interaction processes occurring between spherical erythrocyte models with electrokinetic parameters of different magnitudes. The possibility of the formation of stable erythrocyte aggregates with bonding energies on the order of 10^{-19} J per erythrocyte, which is in good agreement with experimental data, is demonstrated in this study. From calculations of the energy of collective erythrocyte interaction processes, which were carried out as proposed by I. P. Yefremov (1971), the conceptual possibility is shown for the existence of structural transitions in erythrocytes with small energy expenditures (on the order of 10^{-20} J per erythrocyte) during exposure to external low-frequency electromagnetic fields and other factors. The electromagnetic field energy absorbed by a volume unit of biological tissue over a unit of time was calculated using formulae proposed by V. M. Shtemler and S. V. Kolesnikov (1978).

- 1513 CHANGES IN IODINE CONTENT IN THE RAT ORGANISM DURING EXPOSURE TO AN ALTERNATING MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Marsakova, N. V. (I. N. Ul'ianov State Teachers' Institute, Ul'ianovsk, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 57; 1982.

Research is conducted on 248 rats weighing 180-240 g. The flux density of the uniform alternating magnetic field (AMF) employed was 0.11 mT, the frequency was 50 Hz, and the exposure time was 3 hr. The animals were maintained on an artificial nutritionally balanced ration. The iodine content in the salt mixture used was 0.005 mg per rat per day, and the level of iodine present in the dietary components was 0.002 mg per rat per day. Some 10 groups of rats were employed in this experiment; the first 5 served as controls, with the remaining groups subjected to AMF exposures for 10, 20, 30, 40, and 50 days, respectively. Using the full-value ration, the general and organic iodine levels in the organs and tissues of the control animals were constant over the entire test. The 10-day AMF exposure did not alter the content of general iodine or the level of SBI in the thyroid gland, the spleen, the cardiac muscle, the kidneys, and the fur, or the nature of ^{131}I proliferation. The 20-, 30-, and 40-day AMF exposures reduced the content of general iodine in the thyroid gland ($p < 0.001$), while an increase in its content was observed in the remainder of the organs studied ($p < 0.001$); moreover, ^{131}I prolifera-

tion was retarded. Greatest changes were noted during the 30-day AMF exposure ($p < 0.001$). A reduction in the level of SBI in the skeletal muscles, heart, spleen, kidneys, and blood was noted. An increase was also observed in the level of SBI in the liver; this increase was reduced during the 40-day exposure to a magnetic field (MF). A 60-day MF exposure normalized the content of iodine and SBI in the organs studied, and normalized the weight of the thyroid gland and ^{131}I proliferation. The data suggest the suppression of thyroid gland activity during exposure to a weak AMF for periods of 20 or 30 days. Prolonged exposures, covering a period of 60 days, diminish this effect.

- 1514 MODELING HOMEOSTATIC DISTURBANCES WHEN STUDYING THE BIOLOGICAL EFFECTS OF A WEAK LOW-FREQUENCY MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Sokolovskii, V. V. (Medical Inst. of Health and Hygiene, Leningrad, USSR); Pavlova, R. N.; Muzalevskaya, N. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 57-58; 1982.

The sensitivity of patients to the effects of magnetic storms is shown in a number of publications, the effect being aggravation of different types of chronic disorders. An infirm organism is in unstable equilibrium that is easily removed from its state of instability, even by such weak factors as superlow-frequency magnetic fields (SLF MF), which are classified as risk factors. However, the majority of biological experiments with magnetic fields are carried out on healthy animals or intact cells. Such an inadequate approach leads to negative results in many instances. The present study is an investigation into the effect of a uniform magnetic field that contains a square pulse (τ pulse = 1 sec, rise time = 0.01 sec, a frequency of 0.5 Hz, and an intensity of 4.5×10^{-5} T) during a 6-hr exposure on general adenosine triphosphatase (ATPase) and alanine aminotransferase (ALT) activity, as well as on the erythrocyte sedimentation rate (ESR) of donor blood. No statistically reliable changes were noted. The disruption of redox equilibrium in a cell, induced by an oxidizer (in the series of tests involving ATPase), and the use of blood from liver patients in the test series involving ALT, as well as blood from myocardial infarct patients in a test series involving the ESR value, made it possible to obtain statistically significant results during exposure to an SLF MF with the given parameters. All of these tests were done in vitro.

- 1515 CHANGES IN THE BACKGROUND ACTIVITY OF NEURONS DURING EXPOSURE TO A LOW-FREQUENCY MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Sadauskas, K. K. (Inst. of Higher Nervous Activity and Neurophysiology, Soviet Academy of Sciences,

reaction triads (training, activation, and stress) used in this study, which are separated by a zone of reactivity, were applied repeatedly at different reactivity levels. In the opinion of the authors, any magnetic field (MF), even if it differs insignificantly from a geomagnetic field, can be biologically active, since a living organism reacts to change in a subtle manner. By inducing a stable activation reaction by means of a low-intensity AMF (0.2, 0.7, 1.4, and 3.2 mT), an antitumoral effect was obtained that achieved complete remission of malignant tumors in 60-80% of all cases under experimental conditions. Resistance to toxic chemical preparations and ionizing radiation was also maximally increased during the development of activation and training reactions induced by a low intensity MF. As intensity was increased, the changes observed in the resistance value were also nonlinear. The authors suggest that a quantitative-qualitative regularity of this same type, expressed by the development of local nonspecific adaptive reactions at different reactivity levels, also exists at other hierarchical levels of an organism (for example, at the tissue and cell levels). Other studies, carried out on both tumorous and normal tissue cultures and homogenates, have demonstrated the existence of an identical nonlinear dependence between the magnitude of an influencing factor (hormonal preparations, chemical preparations, and AMFs) and the response elicited by such factors.

- 1518 STUDYING THE EFFECT OF AN ALTERNATING MAGNETIC FIELD ON THE FUNCTIONAL CONDITION OF A TISSUE CULTURE (MEETING ABSTRACT). (Rus.) Poliakova, L. A. (Scientific Research Institute of Biology & Biophysics, Tomsk State University, USSR); Kartashev, A. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 61; 1982.

The action of an alternating magnetic field (AMF) on normal cells in a transplanted human amnion-Wisch culture was studied. The cell culture was grown on cover glasses in penicillin vials. The effect of an AMF (at 50 Hz and 60 Oe, with an exposure time of 72 hr and a nonuniformity of 20%) on the logarithmic phase of the culture's growth, starting at the moment of cell seeding, was investigated. Tests were employed with a paired format. The current was fed along a bifilar winding to a control test tube. The temperature difference in each test tube pair did not exceed 0.12°. The magnetic field (MF) was switched on in a random order to eliminate any subjective influence when evaluating the changes observed. A total of 10 test series was carried out, using 5 test tube pairs in each series. The results were processed using Wilcoxon's pairing criterion. After some 72 hr, cover glasses containing a cell monolayer were fixed in a Karnaukh fluid, stained by hematoxylin-eosin, and encased in Canada balsam, after which the mitotic index and

the nucleus-nucleole ratios in the tissue culture were determined. An analysis of the results shows that an MF with the above parameters has virtually no effect on the mitotic index and the nucleus-nucleole ratios.

- 1519 INVESTIGATION ON THE EFFECT OF A PULSED MAGNETIC FIELD ON THE GROWTH OF STREPTOCOCCUS CREMORIS (MEETING ABSTRACT). (Rus.) Pecherkin, M. P. (Scientific Research Institute of Biology and Biophysics, Tomsk State University, USSR); Evdokimov, E. V.; Plekhanov, G. F. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 61-62; 1982.

The biological effectiveness of strong pulsed magnetic fields (PMF) on certain microorganisms has been noted frequently by a number of authors. Changes in the specific growth rate (μ) of *Streptococcus cremoris* 224 in a PMF were studied to determine the effect of PMFs on other types of bacteria. Culturing was accomplished in a turbidostat (using a synthetic medium that contained 10 g/l of glucose at 30°). The μ value measurement error came to 1.5%. Field nonuniformity within the effective area of a Helmholtz coil did not exceed 0.1%. The duration of the exponential current pulse, measured at half-width, was 0.5 msec (with a leading edge of less than 0.1 msec). The bacterial strain was cultured for 200 hr. Some 26 PMF exposures were carried out at random intervals. The duration of each of these exposures was 1 hr. During the first 14 exposures, field intensity amplitude was 1.04×10^5 A/m, reduced to 0.5×10^5 A/m for the remaining exposures. The pulse repetition period was 15 and 5, respectively. In all cases, the time required for the population density to double did not exceed 0.9 hr. The statistical analysis of data was carried out by computing the correlation coefficient between the μ value and the presence of the PMF. No reliable effect was seen on the growth of *S. cremoris* bacteria.

- 1520 AGE-RELATED RESISTANCE OF WHITE MICE TO AN INDUSTRIAL FREQUENCY ALTERNATING MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Baskurian, A. K. (Scientific Research Institute of Biology and Biophysics, Tomsk State University, USSR); Kartashev, A. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 62-63; 1982.

Research was carried out on mongrel white mice in three age groups, young (14 days), sexually mature (1.5 mo), and aged (7 mo), to detect any changes in age-related resistance to the effects of an alternating magnetic field (AMF) with values of 40 kV/m and 50 Hz. The test animals were exposed to

production among lysogenic staphylococci by a medium-intensity CMF.

Chapter IV. BIOLOGICAL EFFECTS OF CONSTANT MAGNETIC FIELDS.

1523 INVESTIGATION INTO THE POSSIBLE EFFECT OF A CONSTANT MAGNETIC FIELD ON THE EQUILIBRIUM-RELATED DYNAMIC STRUCTURE OF GLOBULAR PROTEINS USING THE PROTEIN HYDROLYSIS METHOD (MEETING ABSTRACT). (Rus.) Nazarova, N. M. (Scientific Research Institute for the Biological Testing of Chemical Compounds, Soviet Ministry of the Medical Industry, Kupavna, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 65-66; 1982 (2 refs).

A previous hypothesis (1) concerned the effect of a magnetic field (MF) on the structure and dynamic properties of proteins. The most probable mechanism of the effect is an influence on the equilibrium-related dynamic structure (EDS) of the protein molecule due to the action of the Lorentz forces present. The EDS of a protein molecule consists of a complement of oscillations from different sections of the molecule, in particular, from the charged atom groups most subject to the influence of the Lorentz forces present in an MF. The possible displacement of atom groups of this type in a field of 1 T can reach a magnitude of $1 \cdot 10^{-4}$ Å; that is, such displacements can be of an order that is significant with respect to the EDS. One test which is sensitive to the EDS of a protein is its rate proteolysis (2). Therefore the author investigated the effect of strong MFs (with values up to 10 T) on the hydrolysis of human serum albumin (HSA) and human methemoglobin by trypsin. Results showed that the kinetics of a proteolysis process which occurs in a field of 1.4 T do not differ reliably from those which occur in the absence of the field. The HSA proteolysis product yields observed with and without a field of 10 T over the course of an intermediate conversion time frame agreed within 3%. Taking into account that the rotation of a 'trypsin-hydrolyzed protein' complex can reduce the possible effect of an MF, the hydrolysis of HSA in a field of 10 T was also studied using immobilized trypsin. No effect was seen on the rate of proteolysis, to an accuracy of 6%. Thus, the results suggest the absence of any noticeable effect of strong MFs on the equilibrium-related dynamics of proteins and therefore do not suggest as a possible mechanism of the effect of an MF on biological structures. References: 1. V. M. Aristarkhov, L. A. Piruzian, V. P. Tsybyshev. In: Reactions of Biological Systems to Magnetic Fields. Science Publishing House, Moscow, 1978, p. 6. 2. L. V. Abaturon, T. P. Molchanova. In: Equilibrium-Related Dynamics of a Protein's Native Structure. Office of Sci-

entific and Technical Information, Scientific Center for Biological Research, Soviet Academy of Sciences, Pushchino, 1977, p. 5.

1524 CONVERSION OF LOW-FREQUENCY ELECTROMAGNETIC ENERGY IN MEMBRANE SYSTEMS (MEETING ABSTRACT). (Rus.) Zhgenti, T. G. (Tiflis State University, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 66; 1982 (2 refs).

A spherical model of a cell encircled by an elastic membrane is examined. Using an approximation that does not make allowance for the viscosity of external and intracellular media, analytical expressions are derived that describe the rate at which a cell membrane is displaced during exposure to a periodic magnetic field. In the calculation, both the intracellular and extracellular media were regarded as neutral; that is, the cellular 'magnetostriction' linked to differences in the respective magnetic susceptibilities of these two media was analyzed. Expressions are also derived for approximate natural cell resonance frequencies. In addition, estimates of these frequencies are made. On the basis of these estimates, an audio-range electromagnetic field apparatus is created. The biological objects studied in this work (rats) were irradiated by an alternating magnetic field over a band of frequencies ranging from 1 to 20 kHz, with an intensity ranging from 1 to 10 G. Exposure time varied from 5 to 20 min. These experiments, conducted in collaboration with E. Z. Gak, demonstrated that the alternating magnetic fields under investigation contribute to the actual breakdown of tumor cells which have been grafted into experimental animals.

1525 STUDY OF DEGRADATION REACTIONS OF PEROXIDE BY CATALASE AND CERTAIN METALLOORGANIC COMPLEXES IN A CONSTANT MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Afonin, V. V. (Institute of Chemical Physics, Soviet Academy of Sciences, Moscow, USSR); Vanag, V. K. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 66-67; 1982 (2 refs).

It was reported in a previous work (1) that the reaction rate (RR) of peroxide decomposition by catalase, as well as by an $(Fe^{3+} EDTA)_2$ dimer complex, is increased 20% in the presence of a constant magnetic field (CMF) with a flux density of 6T. The purpose of this study is to explain the mechanism of action of this CMF. It is shown by gas-volumetric and spectrophotometric methods that when catalase is present in conjunction with <0.01 M of peroxide, a classic catalase mechanism is observed, while those processes which involve both the reversible and irreversible inhibition of catalase by

ova, N. M.; Raikhman, L. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 69; 1982 (2 refs).

In view of the data obtained in references (1) and (2) on the effect of a constant magnetic field (CMF) on the active transport occurring in tissue preparations, and the dependence of this effect upon the presence of ouabain, sodium ions, and potassium ions, a question has arisen about the possible influence of a CMF on isolated sodium, potassium-adenosine triphosphatase (Na, K-ATPase) preparations. The influence of a CMF on Na, K-ATPase preparations from the brains of cattle was investigated over a wide range of magnetic induction values (0.08-10 T) and at temperatures of 15, 25, and 37°. No effect was found, either on the enzymatic activity of the Na, K-ATPase preparation or on its cooperative properties. Regarding a possible effect of a CMF on the liquid-crystal state of lipids, the absence of any effects on an isolated system might be linked to the rapid growth of the Na, K-ATPase particles (10^4 - 10^5 sec⁻¹), preventing a CMF from exerting any orienting influence on the lipid in the enzyme particles. Immobilized Na, K-ATPase preparations were also tested. The tests also failed to detect any effect of the CMF (0.08-1 T) on enzymes at temperatures of 15, 25, 37°. Since the effect of a CMF on tissue preparations may be caused by the effect on the rates of radical reactions, a CMF can be expected to influence a vanadate-ascorbic acid system, in which an intermediate complex of two interacting paramagnetic particles is formed during the reduction of the vanadate by the ascorbic acid. Even when different schemes are used to set up these experiments on the effect of a CMF on Na, K-ATPase in the presence of vanadate and ascorbic acid, it was still impossible to detect any influence by the CMF (0.08-1 T) on the enzyme activity present in this system at 37°. References: 1. S. E. Bresler, V. M. Bresler. Reports From the Soviet Academy of Sciences 214:936-939, 1974. 2. S. E. Bresler, V. M. Bresler, N. I. Vasil'ev, E. N. Kazbekov. Reports From the Soviet Academy of Sciences 242:465-468, 1978.

1529 EFFECT OF A MAGNETIC-FIELD ON THE RADICAL REACTIONS OF A LIPID-PEROXIDATION PROCESS CATALYZED BY Fe^{2+} (MEETING ABSTRACT). (Rus.) Aristarkhov, V. M. (Institute of Chemical Physics, Soviet Academy of Sciences, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 70; 1982.

Lipid peroxidation (LP) initiated by Fe^{2+} -ascorbate can serve as a kinetic model when studying the various mechanisms of heterogeneous catalysis. A constant magnetic field (CMF) can also be used as a tool when investigating the radical stages and mechanisms of catalytic and autocatalytic reactions. In the present study, phospholipid liposomes, the

oxidation of which was catalyzed by Fe^{2+} -ascorbate, were used as a model system. The Fe^{2+} ions in this system catalyze RH oxidation over a concentration range of $(2-6) \times 10^{-6}$ M, whereas the same ions act as oxidation inhibitors when concentrations greater than 10^{-5} M are used. The effect of a CMF with an intensity of 200 Oe on the kinetics of malonic dialdehyde (MDA) accumulation is discussed. Any magnetic effect observed in this instance (magnitude and sign) will depend on the temperature and lipid concentration of the liposomes present. The temperature-dependent structural changes occurring in phospholipids are caused by the alteration of spatial packing in fatty-acid chains and polar groups, which probably plays a substantial role with respect to $RO_2^{\cdot}$, $R^{\cdot}$ mobility and lifetime fluctuations. When attempting to explain the action of a CMF, the hyperfine interaction (HFI) mechanism that manifests itself in competing reactions of the $R^{\cdot} + O_2 \rightarrow RO_2^{\cdot}$ and $RO_2^{\cdot} + RO_2^{\cdot} \rightarrow R^{\cdot} + K^{\cdot}$ hnu types can be employed as a base. The regularities of magnetic effects dependent upon the presence of Fe^{2+} , O_2 can help to elucidate the mechanisms of catalytic reactions involving Fe^{2+} in the oxidation-related chain-rupture and chain-branching stages.

1530 EFFECT OF STATIC MAGNETIC FIELDS ON THE LIQUID-CRYSTAL STRUCTURE OF LIPID BILAYER MEMBRANES (MEETING ABSTRACT). (Rus.) Bresler, S. E. (B. P. Konstantinov Institute of Nuclear Physics, Soviet Academy of Sciences, Leningrad, USSR); Kazbekov, E. N.; Sumbaev, I. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 70-71; 1982.

According to existing concepts, the lipids in biological membranes form liquid-crystal structures. Experimental data suggest that a lipid organization of this type exerts a substantial influence on the conformation and functioning of membrane-bound proteins (enzymes and ion carriers). However, a direct investigation into the liquid-crystal properties of biological membranes is complicated by the fact that, as opposed to classical multilayer liquid crystals, membranes actually constitute a two-dimensional structure. For this reason, the electro-optical and magneto-optical effects that are characteristic of liquid crystals have extremely low values in biological membranes. In the present study, the authors designed and constructed a high-sensitivity apparatus for measuring birefringence of artificial and natural biological membranes. This apparatus makes it possible to measure the difference in the phases of light beams, $\Delta\phi$ above or equal to 10^{-5} radians. Using this apparatus, the effect of a magnetic field on the birefringence of bilayer lecithin-cholesterol lipid membranes is studied. It is established that a magnetic field with a value of 8 kOe at 30°, directed tangentially with respect to the membrane plane, causes a change on the order of $\Delta\phi$ of approximately 10^{-4} radians, which corresponds to the value anticipated on the

110 A/cm² through the mitochondria suspension, no reduction in the CL of the MC was observed. The mechanisms of the influences exerted on a membrane are apparently identical, both when induced electrical currents are present in the MF in association with mixing and when an electrical current is passed through the suspension. A study of the effect of an electrical current (7 kHz and 110 A/cm²) on the extraction of peripheral MC membrane proteins demonstrated that it is apparently the lipid portion of the membrane which is subjected to the influence of the electrical current.

- 1534 POSSIBILITY OF ERYTHROCYTE MEMBRANE DAMAGE DURING EXPOSURE TO A HIGH-INTENSITY MAGNETIC FIELD (MEETING ABSTRACT). (Rus.) Cherkasov, G. V. (Institute of Medical and Biological Problems, Soviet Ministry of Public Health, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 73-74; 1982.

Erythrocyte hemolysis represents one possible mechanism of the effect of magnetic fields on erythropoiesis. The goal of this investigation was to determine the possibility of the development of erythrodierosis in response to the influence of a constant magnetic field (CMF) with a flux density of 1.6 T. The shifting of the erythrocytometric curves into the macrocyte region was noted among mice residing within a CMF, with no changes in curve shape. These shifts were observed just 3 hr after the test animals had been placed in the field and reached their peak by day 4. The shifts were retained for up to 10 days; however, despite an ongoing exposure, these changes subsequently leveled off and full curve normalization ensued. One day after the termination of a 30-day exposure, the Price-Jones curve was shifted toward the microcyte region, while this curve was shifted into the macrocyte region on day 3 after the cessation of the exposure. By day 6, no differences were observed as compared to the control group. An increase in the number of reticulocytes in the peripheral blood was noted after 1 day of residence in the field, as well as on day 10. Reticulocytopenia was developed following the termination of both 1-day and 30-day exposures. During and following the 30-day exposure, insignificant changes occurred in hemoglobin and erythrocyte content. The absence of a correlation between the changes observed in erythrocyte size and the number of reticulocytes present makes it possible to assume that cell swelling occurs as the result of disturbances in metabolic processes, which leads to deterioration in the condition of an erythrocyte membrane. Damage of this magnitude is apparently not meaningful relative to the development of a systemic erythron reaction.

- 1535 EFFECT OF A MAGNETIC FIELD ON PRIMARY PHOTOSYNTHESIS PROCESSES (MEETING ABSTRACT). (Rus.) Vozniak, V. M. (Institute of Soil Science and Photosynthesis, Soviet Academy of Sciences, Pushchino, USSR); Elfimov, E. I.; Proskuriakov, I. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 74-75; 1982.

The mechanism of the effect of a constant magnetic field (MF) on the charge separation and recombination processes occurring in the reaction centers (RC) of photosystems I and II in both higher plants and photosynthesizing bacteria is investigated in the present study. During the excitation of an RC of less than 10 picosec, a chain of electron transfer reactions is triggered, which ultimately leads to the accumulation of light energy in the form of chemical bond energy. An intermediate link in this chain is a radical pair (RP). The lifetime of an RP is 100-200 picosec when active photosynthesis occurs. The RP lifetime can be increased to the nanosecond range by special exposures, which is sufficient for the occurrence of intercombinative conversion. In this instance, there is a possibility that magnetic effects in the RP will appear. An MF alters RP distribution along triplet and singlet recombination channels, thereby influencing the quantum yields associated with triplet states and the recombinative fluorescence of the primary donor of the P electron. In all of the systems investigated, a magnetic effect of fluorescence is observed; its maximal value (1-8%) together with the half-field values, $B_{1/2}$ (4-60 mT), constitute an intrinsic identifier for each of the systems studied. At the temperature of liquid helium, recombinative fluorescence is absent due to the presence of an activation barrier with a magnitude on the order of 0.1 eV. However, even in this case, an MF alters the fluorescence yield (of the 'fast' fluorescence of a photo-detector antenna) due to its influence on the steady-state concentration of the RC triplet states. This effect can be achieved by two mechanisms: by mixing the P_T molecules' triplet sublevels and by the effect on S-T conversion in the RP. In both cases, in contrast to room temperature conditions, the presence of the MF causes a reduction in the fluorescence yield. A pigment-protein antenna complex absorbs light and rapidly transmits excitation to the RC; in addition to the primary pigment (chlorophyll), it also contains accessory pigments called carotenoids. The primary function of the latter is to absorb and transmit excitation energy to the antenna's chlorophyll component. A process that involves the division of singlet carotenoid excitation into two triplets, and which competes with the excitation energy transmission process, is detected. By influencing the singlet excitation division process, an MF alters not only the triplet carotenoid yield, but also the antenna chlorophyll fluorescence yield. Thus studying the effect of an MF on the photochemical processes occurring in an RC, as well as on the photophysical processes in an antenna, makes it possible to obtain new and important information on

over the flux density range studied (0.03 to 0.08 T) is proportional to field magnitude. The rate at which electrophysiological parameters are restored to their original levels following exposure to a CMF is inversely proportional to the field's flux density value. CMF exposure of a smooth-muscle cell membrane that has been previously depolarized is accompanied by a further reduction in membrane resting potential, as well as by a significant increase in the membrane's level of ionic conduction and an increase in both the amplitude and frequency of its spontaneous action potentials. The results of these experiments suggest that CMFs with flux density values of 0.03 and 0.06 T have quite an effective influence on the synaptic transmission of inhibition in the smooth-muscle cells, as well as on the transmission of stimulation in the skeletal muscles, which is expressed by an increase in the amplitudes of inhibitory postsynaptic potentials (IPSP) and EPSPs. The favorable influence of a CMF on neuromuscular transmission is primarily due to its effect on the presynaptic membrane and is not dependent upon the type of mediator present. Judging from the changes in micropotential frequency, the spontaneous release of acetylcholine from the nerve terminals is decreased under field exposure. When the CMF is switched off, IPSP and EPSP amplitudes remain elevated for some time, after which they gradually return to their original levels.

1539 EFFECT OF A CONSTANT-MAGNETIC-FIELD ON IN VITRO SYNTHESIS OF DNA IN HUMAN GLIOMAS (MEETING ABSTRACT). (Rus.) Apshkalne, D. L. (Riga Medical Institute, USSR); Liepa, M. E.; Kikut, R. P. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 77-78; 1982.

There are a number of reports on the cytostatic effect of magnetic fields (MF) on tumor cells; however, many authors explain the retardation of tumor growth by a general effect of an MF on the organism as a whole, and by changes in adaptive reactions and in both the endocrine and immune systems. In the present study, the authors developed a methodology to determine the individual sensitivity of human gliomas to constant MF exposures at different flux densities to demonstrate the existence of a direct cytostatic effect on tumor cells. Autoradiography in vitro was used according to a standard procedure generally applied to short-term cultures. A 30-min exposure to constant MFs with specific flux density values (0.025, 0.05, 0.1, and 0.25 T) was carried out during hour 2 and 23 of the incubation process. The labeling index (LI) was determined on histoautoradiographs under control conditions and following the CMF exposure; i.e., the number of labeled cells (those cells in which the synthesis of DNA takes place and by means of which subsequent tumor growth occurs) was calculated. The data were analyzed using the method of Fischer and Student. An analysis of the results obtained

from a study of 14 malignant gliomas demonstrated that constant MFs with flux density values of 0.025-0.25 T exert a direct influence on DNA synthesis in short-term cultures. During exposure to a constant MF with a flux density of 0.25 T, DNA synthesis in gliomas was reduced by an average of 46.5% (over a range of 11 to 66%). An increase in DNA synthesis was noted in two cases. During exposure to a constant MF with a flux density of 0.1 T, in vitro tumor growth was suppressed by an average of 48.1% (over a range of 11 to 97%). In vitro tumor growth was increased in three cases. Exposure to a constant MF with a flux density of 0.05 T resulted in reduction of DNA synthesis by an average of 28.8% in short-term human glioma cultures (over a range of 17 to 40%). An increase in DNA synthesis was noted in four cases. During exposure to a constant MF with a flux density of 0.025 T, tumor growth was suppressed by an average of 37.6% (over a range of 3 to 93%). An increase in DNA synthesis was observed in two cases. In every case investigated in this study, DNA synthesis in human glial tumors was most effectively suppressed when one or two of the constant MF flux density values were employed. Of the 14 gliomas studied, there was not a single instance where at least one of the constant MF flux densities did not reduce DNA synthesis. It was not possible, however, to isolate any one flux density that affected all of the gliomas investigated. Two of the glioma cases studied should be singled out: the case in which synthesis was suppressed by 97% during exposure to a constant MF with a flux density of 0.1 T and the case in which exposure to a constant MF with a flux density of 0.025 T reduced synthesis by 93%; that is, in vitro tumor growth was suppressed almost entirely. The present results indicate that the sensitivity of human gliomas in vitro to different constant MF flux densities is individual in nature. These results also permit the future use of this constant MF effect in conjunction with other treatment methods already employed in neurooncology.

1540 INVESTIGATION OF THE EFFECT OF THE CONSTANT MAGNETIC FIELDS GENERATED BY MAGNETOPHORE APPLICATORS ON HEALING AND DESTRUCTIVE PROCESSES IN HUMAN SKIN (MEETING ABSTRACT). (Rus.) Taran, Iu. P. (Scientific Research Institute for the Biological Testing of Chemical Compounds, Soviet Ministry of the Medical Industry, Kupavna, USSR); Shilov, V. N.; Usacheva, M. D.; Rabinovich, E. Z. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 79; 1982.

The effects of constant magnetic fields generated by ALM-2 magnetophore applicators (CMFMA), with a surface magnetic flux density, B, of some 30 mT and a gradient of B = 5 mT/mm, on healing of cutaneous surgical wounds in vivo and the destructive processes occurring in surviving skin in vitro were investigated. The functional condition of the tis-

special interest. The present study examines BBB permeability in rats during exposure to a CMF with a flux density of 0.4 T. Anesthetized animals were subjected to 10-min and 3-hr CMF exposures. For the 10-min exposure, sodium fluorescein (FCN) was introduced before the test animals were placed into the magnetic field; for the 3-hr exposure, FCN was introduced about 10 min before termination of the exposure. At the end of the exposure period, the brain was flushed with a physiologic solution, using a cannula inserted into the left ventricle of the heart. FCN levels were determined in extracts obtained from four regions of the brain: the cerebral cortex, the medulla oblongata, the cerebellum, and the hypothalamus. The data from these tests demonstrated that exposure to a CMF with a flux density of 0.4 T for 10 min does not lead to the impairment of BBB permeability. Following the 3-hr exposure, a statistically reliable decrease was noted in FCN in the cerebral cortex and the hypothalamus. FCN content in the medulla oblongata and cerebellum was also lower in this instance; however, the differences vs. control values were not significant. Thus, a CMF exposure exerts an influence on BBB permeability. The time factor is essential in this effect. According to present results, the most sensitive regions of the brain under the given exposure conditions are the cerebral cortex and the hypothalamus.

1543 CERTAIN REGULARITIES IN THE REACTION OF THE SPERMATOGENIC EPITHELIUM TO HIGH-INTENSITY CONSTANT MAGNETIC FIELD EXPOSURES (MEETING ABSTRACT). (Rus.) Matriukova, V. M. (Institute of Biological and Medical Problems, Soviet Ministry of Public Health, Moscow, USSR); Strzhizhovskii, A. D. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 82; 1982.

The spermatogenic cell population and the range of distribution for such cells in their stages of maturation are reported in mice which had undergone exposure to constant magnetic fields (CMF) with flux density values of 0.4-1.6 T and exposure durations of 3 hr to 30 days. The results confirm that short-term exposure to a CMF causes reversible inhibition of spermatogonium proliferation and destruction of the spermatozoa, followed by a sharp increase in the rate of spermatogenesis. The magnitude and persistence of this effect increase with the CMF flux density. When exposure duration is increased, the rate of the spermatozoon destruction process is also increased. No indications of adaptation to the CMF are detected. At the same time, compensatory reactions of the spermatogonia are fairly evident and spermatogonium proliferative activity is virtually unchanged when long-term exposures are employed. Compensation of a CMF's harmful effect is possible during long-term exposures (15 and 30 days); after termination of long-term exposure, the testes readapt to a normal geomag-

netic field. The readaptation process involves a sharp decrease in spermatozoa count, followed by an abortive recovery, a second spermatozoa population drop, and a subsequent final recovery. Of the mammalian tissues studied, the spermatogenic epithelium is the most sensitive to the magnetic field.

1544 SOME CHANGES IN THE BLOOD DURING EXPOSURE TO CONSTANT MAGNETIC FIELDS (MEETING ABSTRACT). (Rus.) Ivanova, S. N. (Saratov Institute of Animal Husbandry and Veterinary Medicine, Soviet Ministry of Agriculture, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 82-83; 1982.

The effect of the fields generated by permanent magnets with varying intensities (ranging from 1 to 3,500 Oe in 100-Oe increments) on bovine blood in vitro as a function of the degree of field nonuniformity (in gradients of 1.5 to 500 Oe/cm) and exposure time (ranging from 20 sec to 4 days) was investigated. The following patterns were established. Hemolysis is inhibited and the concentration of hemin pigments in the blood serum and plasma is decreased in freshly drawn blood during exposure to uniform constant magnetic fields (CMF). Here, erythrocyte resistance is altered, viscosity is reduced, the pH values rise, and the number of SH groups present in the blood serum changes. The time interval between blood sample collection and the onset of the exposure plays an essential role, as does the degree of field nonuniformity. An increase in exposure time leads to the intensification of the effect observed, ultimately reaching a 'saturation' level. In 80% of the test animals exposed for 4-hr periods to CMF, changes were seen in membrane-related activity of the erythrocytes with respect to potassium and sodium ions which were accompanied by changes in adenosine triphosphate content. The changes observed in the optical density of the blood serum and plasma, the redistribution of the individual protein fractions (the gamma globulin content increased while alpha, beta globulin and albumin content decreased), and the reduction in the spread of the concentrations can be explained in terms of conformational transformation and complexing of the protein molecules of low molecular weight. The electrophoretic mobility of the purified albumins was reliably reduced, whereas the globulins present were inhibited in an insignificant manner. The formation of protein molecule complexes and types of crystallization of these complexes were verified by electron microscopy of serum, plasma, purified gamma globulin, and albumin solutions. The results support the liquid-crystal hypothesis of a CMF's action.

1545 EFFECT OF A HIGH-INTENSITY CONSTANT MAG-

citability. The importance of the field intensity gradient values remained unclear during these experiments.

1548 KINETICS OF THE CHANGES IN A TRANSFORMED L-LINE CELL POPULATION DURING EXPOSURE TO A CONSTANT MAGNETIC FIELD AT VARYING TEMPERATURES (MEETING ABSTRACT). (Rus.) Liu, B. N. (Kazakh Polytechnical Inst., Kazakh Ministry of Advanced Learning Institutions, Alma-Ata, USSR); Krasnoshtanov, V. K. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 85-86; 1982.

Transformed mouse fibroblasts (in the cells of mice from the L line) at temperatures of 34 and 42° were studied. The cells, in an initial concentration of 200 thousand/ml, were placed in Correl vials. A nutritive medium was prepared using 80% agent 199 and 20% bovine serum. The test vials (with the exception of the control samples) were positioned on annular permanent magnets with average field intensity along the magnet faces of 450 Oe (type 1) and 1,100 Oe (type 2). A cell count was made under dynamic conditions by using an inverted microscope in regions that had been determined beforehand and which are limited in area. The cell count was made at 34° before the cells began forming a continuous monolayer. The reliability of the difference seen in the average cell population values was set at $p < 0.01$ by a t-test. At 34°, the cell population increase in the vials that had been positioned on magnets of type 1 was retarded vs. control values. This inhibitory effect was especially marked when magnets of type 2 were used. A statistically significant difference vs. control values was reached in 2.0-2.5 days in this instance. The magnitude of this difference amounted to 60%. At 42°, the number of living cells was reduced due to heat-related injuries and fatalities, regardless of whether the cells were exposed to a constant magnetic field (CMF). However, the fields employed were seen to offer protection against heat. This protective influence was quite substantial when magnets of type 2 were used. Over the 24-48-hr time span that corresponded to the most active period of upward movement of the kinetic curves plotted (at 34°), and over the 36-84-hr time span that corresponded to the most intensive period of downward movement (at 42°), the inhibition of cell population growth by the CMFs (at 34°) and the retardation of cell fatalities (at 42°) were roughly proportional to the intensity of the CMFs used. It was assumed that the antimutagenic and thermoprotective influences of these CMFs, the latter apparently detected for the first time, were the result of the antioxidative properties of the fields employed.

1549 EFFECT OF LONG-TERM EXPOSURE TO HIGH-IN-

TENSITY CONSTANT MAGNETIC FIELDS ON THE MITOTIC ACTIVITY OF MAMMALIAN TISSUES (MEETING ABSTRACT). (Rus.) Galaktionova, G. V. (Institute of Biological and Medical Problems, Soviet Ministry of Public Health, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 86-87; 1982.

The mitotic activity (MA) of the corneal and medullary epithelia in mice during prolonged exposure to a constant magnetic field (CMF) with a flux density of 1.6 T was studied. Short-term exposure to a CMF (0.1 to 0.4 T) causes suppression of the corneal epithelium's MA, which is rapidly restored following the termination of the exposure. During prolonged exposure to a CMF (0.1 T), the level of MA suppression in the corneal epithelium was offset by activation on the part of the cornea itself, despite any ongoing exposure. It seemed of interest to study the MA-related reactions of these tissues during even longer exposures to CMFs with higher flux density. Mice were confined within the active area of an SP-57 electromagnet for 30 days. Samples were taken from the corneal and the medullary epithelia of both test and control mice after they had resided in the CMF for different periods of time (1, 4, 7, 10, 15, 22, and 30 days), and after exposure termination (0.25, 1, 2, 3, and 6 days later). Mitotic index values and the frequency of chromosomal aberrations during anaphase were determined. Results suggest a high level of resistance on the part of the tissues studied to long-term exposure to a powerful magnetic field. The CMF employed caused no degenerative changes in the cells of the corneal and medullary epithelia of the mice, nor was the frequency of the chromosomal aberrations increased. The changes in mitotic index values after the animals had resided in the CMF for different periods of time were insignificant and were not statistically reliable at a number of points. The data obtained suggest that the tissues studied possess a high level of compensatory activity.

1550 EFFECT OF A MAGNETIC-FIELD ON THE PROLIFERATION AND SIZE OF RENAL STRUCTURES (MEETING ABSTRACT). (Rus.) Iuldashev, S. D. (Tashkent Medical Inst., USSR); Gontmakher, V. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 87-88; 1982.

A study is reported of the growth-stimulating influence exerted by a magnetic field (MF). The kidneys of 100-120 g male white rats which were divided into groups for several series of tests served as the subject of this research. In four of the test series, the animals were exposed to a variable MF that had different flux density values (ranging from 5 to 50 mT) to determine the parameters of the field's highest level of biological ef-

exposure are ambiguous. The functional shifts in individual systems, particularly in the red blood system, are normalized over the course of the exposure process. In other systems, these changes remain present as long as the exposure continues. Persistent leukocytosis, and increases in the content of catecholamines and corticosterone in the blood and adrenal glands, are regarded as changes of the latter type. Changes such as a reduction in the proliferative activity of immature formations and the destruction of mature formations in the spermatogenic epithelium, which are characteristic of short-term exposures, were not detected during long-term residence in a CMF; however, changes of this type did develop following cessation of the exposure. The return to normal of individual indices while test animals still reside within a magnetic field suggests the ongoing adaptation of certain functional systems to a CMF exposure. The increase in the activity of the sympathoadrenal and adrenocortical systems, and the reduction in the weight of the thyroid gland, indicate the presence of nonspecific adaptive mechanisms. However, total adaptation to a CMF exposure does not occur, as suggested by lingering signs of stress. The after-effects detected following termination of an exposure, reticulocytopenia and the disruption of spermatogenesis, merit an independent examination.

Chapter V. BIOLOGICAL EFFECTS OF ELECTRIC FIELDS.

1553 INFLUENCE OF AN ELECTROSTATIC FIELD ON BASIC OXYGEN-DEPENDENT PROCESSES (MEETING ABSTRACT). (Rus.) Artseruni, G. G. (Erevan State Medical Inst., Armenian Ministry of Public Health, Erevan, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 91; 1982.

The author previously demonstrated that exposure to an electrostatic field (ESF) leads to an increase in the supply of oxygen to the tissues. This must, in turn, lead to changes in the oxygen-dependent processes occurring in the cells. The present study investigates mitochondrial oxidation and peroxidation processes in the livers of mongrel white rats immediately and 1, 4, 7, and 14 days after exposure to an ESF with an intensity of 2,000 V/cm for 24 hr. Electron-microscopic, polarographic, and electron paramagnetic resonance (EPR) studies, and measurements of the intramitochondrial Ca^{2+} content and the activity of certain respiratory chain mediators and enzymes (succinate dehydrogenase, succinate cytochrome-C reductase, and cytochrome oxidase) show that an ESF exposure leads to structural and functional changes in the mitochondria. The changes suggest the suppression of mitochondrial oxidation. Studies on the concentration of lipid peroxides in

liver homogenates and the investigation of certain factors which regulate lipid peroxide content levels (the content of alpha-tocopherol and the activity of superoxide dismutase, glutathione peroxidase, and glutathione reductase) show that exposure to an ESF leads to the intensification of lipid peroxidation processes. The extent of the changes in the parameters under investigation is dependent upon the ESF after-effect period. The greatest changes take place immediately after the termination of an exposure, as well as some 7 days later; however, the majority of these parameters have returned to normal by day 15 of the after-effect period. The present results, together with analysis of previous results in the literature, provide a basis for concluding that an ESF can serve as a modulator of basic oxygen-dependent processes.

1554 EFFECT OF AN ELECTROSTATIC-FIELD ON CYTOCHROME-OXIDASE ACTIVITY IN A MITOCHONDRIAL FRACTION OF RAT LIVER (MEETING ABSTRACT). (Rus.) Portnov, F. G. (All-Scientific Research Institute of Cable Industry, Planning, Design, and Technologies, Moscow, USSR); Marchenkova, I. A.; Terusalimskii, A. P. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 92; 1982.

It is known that an electrostatic field (ESF), when it acts upon living organisms, causes the impairment of metabolic processes and respiration, and alters both gas exchange and redox processes. However, the effect of an ESF on redox enzymes remains insufficiently studied. An investigation of these enzymes is also of interest because of their involvement in processes that generate the energy needed to maintain and optimize the vital activity of a cell. In this instance, an important role is played by cytochrome oxidase, which acts upon the terminal portion of the respiratory chain, the transfer of electrons along which is closely linked to phosphorylation. During experiments conducted on white rats the authors established that the cytochrome oxidase in rat liver mitochondria is sensitive to the influence exerted by an ESF. The magnitude of the effect on enzyme activity depends both on field exposure time and field intensity. During a daily 4-hr exposure at a field intensity of 60 kV/m for 3 days, cytochrome oxidase activity differed very little from control values, but was increased by 1.5 and 2 times, respectively, during 14-day and 30-day exposures.

1555 RESONANCE EFFECT OF LOW-FREQUENCY ELECTRIC FIELDS ON THE PERMEABILITY OF BIOLOGICAL MEMBRANES (MEETING ABSTRACT). (Rus.) Markevich, N. I. (Institute of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR); Sel'kov, E. E. In: All-Union Symposium on the Biolog-

posure duration of 30 days or less were characterized by the development of reversible shifts that changed into shifts of the degenerative type (vacuolization and fraying of the neurofibrillar apparatus and appearance of varicose swelling) as the exposure time and field intensity values were increased. The nonmedullary nerve fibers proved to be more resistant structures. The changes arising in these fibers during a prolonged field exposure were reactive (hyperimpregnation and swelling of the axons). At the same time that these morphofunctional shifts were originating in the dermatome, destructive shifts were also developing (pyknosis and vacuolization of both the nuclei and the cytoplasm, edema, hyperkeratosis, and development of stasis). Thus, the results suggest that complex and diverse reactions originate in the dermatome during exposure to an ESF, the nature and directional effect of these reactions being dependent upon the field's E value and the duration of the exposure.

- 1558 EFFECT OF AN ELECTROSTATIC FIELD ON PROTEIN AND LIPID METABOLISM INDICES IN RATS (MEETING ABSTRACT). (Rus.) Portnov, F. G. (Scientific Research Institute of Cable Industry Planning, Design, and Technology, Moscow, USSR); Vorob'eva, L. F.; Ierusalimskii, A. P. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 95; 1982.

In working out the problems associated with the biological effects of electric fields, experimental research occupies an important position. Such research affords the opportunity of studying the isolated influence of a field in the presence of predetermined exposure parameters. It has been ascertained that most 'conductive' components of an organism are the blood and the nervous system. The effect of an electrostatic field (ESF) with a variable intensity (60-90 kV/m) on the most important and functionally significant components of the blood proteins and lipids was studied using 220 male Wistar rats. The state of the lipid metabolism was determined by the common lipid and phospholipid content values, as well as the fractional composition of these substances. The composition of the blood serum proteins, the fractional composition of the seromucoid fluid and its content, and the activity and isozymatic spectrum of the ceruloplasmin were studied to ascertain the characteristics of the protein metabolism. The fractional compositions of the proteins were investigated by disk electrophoresis in a polyacrylamide gel and thin-layer chromatography. These experiments demonstrated the dependence of an ESF's biological effects upon exposure time. The exposure of the protein system components to an ESF is primarily limited by a zone of adaptive perception. During a long-term exposure, changes in the lipoprotein spectrum suggested the conformational alteration of high-density lipoproteids (either due to distur-

bances in the synthesis of the protein component or to secondary changes in the composition of the lipid components).

- 1559 CHANGES IN CERTAIN INDICATORS OF IMMUNOLOGICAL REACTIVITY DURING EXPOSURE TO AN ELECTROSTATIC FIELD (MEETING ABSTRACT). (Rus.) Tovmasian, V. S. (Erevan State Medical Institute, Armenian Ministry of Public Health, Erevan, USSR); Shekorian, V. A.; Artsruni, G. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 96; 1982.

Indicators of immunological reactivity in mongrel white mice following exposure to an electrostatic field (ESF) with an intensity of 2,000 V/cm for 24 hr were investigated before and after immunization of the test animals with ram erythrocytes. It was shown that ESF exposures lead to a reduction in the number of antibody-forming cells in the spleen, to a decrease in the hemolysin titer in the peripheral blood, and a reduction in the immune rosette-forming cell population. The highest level of immune response suppression was observed when immunization preceded the ESF exposure. The results suggest that ESFs produce an immunodepressive effect. Over the course of this research, the exposure of individual immunogenetic components to an ESF was studied to explain the mechanisms behind the effect detected. Special attention was given to macrophages, since these cells play a significant role in inducing the initial stages of the antibody formation process. The increase observed in phagocytic activity suggests alterations in the functions of macrophages. Thus, an ESF exerts a modulating influence on immunogenesis, during which an important role is played by the changes produced in macrophage functions. The object of future research will be to study the roles of T and B lymphocytes in bringing on an immune response following exposure to an ESF, since cooperation between macrophages, T cells, and B cells is needed in order to produce such a response.

- 1560 EFFECT OF ELECTROSTATIC FIELDS ON THE GROWTH OF POLLEN TUBES IN CORN (MEETING ABSTRACT). (Rus.) Dukhovnii, A. I. (Department of Plant Genetics, Moldavian Academy of Sciences, Kishinev, USSR); Lysikov, V. N. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 96-97; 1982.

The influence of electrostatic fields (ESF) with intensities of up to 170 V/m on pollen germination and pollen tube (PT) growth in inbred and hybrid corn was investigated in vitro and in vivo. The tests were performed under laboratory conditions at temperatures of 22-23°. No effect of the ESF em-

cal changes were detected in the testes of BALB and CBA mice, as well as of Wistar rats; the nature of these changes depended on IF EMF intensity. Neither disturbances in spermatogenesis nor changes in the frequency of mitosis and meiosis were detected. However, electron microscopy study showed the expansion of the smooth endoplasmic reticulum's tubules in the sustentocytes that produce the nutritive medium which nourishes developing gametes. Male BALB mice which had undergone a daily 5-hr exposure to an IF EMF with an intensity of 15 kV/m proved to be sterile, despite a high level of activity. After the exposure of male BALB mice to an EMF with an intensity of 10 kV/m, and of male CBA mice to EMFs with intensities of 15-25 kV/m, progeny were produced; however, these offspring were more poorly developed than those born within the control group (an increase in the frequency of congenital defects and fetal deaths, together with a decrease in the rate of body development). Aside from these phenomena, poorer fur development was noted among the offspring of females which had undergone exposure to IF EMFs with intensities of 10 and 15 kV/m. Genetic analysis showed that the reproductive impairments resulting from IF EMF exposures were not related to mutagenesis. When a female was subjected to an IF EMF exposure at intensities of 15 and 25 kV/m during pregnancy (from the day of conception until birth), the offspring were in excellent condition and continued to develop normally over the next three generations. Consequently, an IF EMF does not possess marked gonadotropic or embryotropic effects; however, long-term exposure of a sexually mature organism causes functional deficiencies in the gametes. The effect of an IF EMF is dependent upon field intensity and exposure time, as well as upon the sex and genotype of the exposed organism.

1563 ECOLOGICAL EVALUATION OF THE ALTERNATING ELECTROMAGNETIC FIELDS OF ELECTRIC POWER TRANSMISSION LINES (MEETING ABSTRACT). (Rus.) Kartashev, A. G. (Scientific Research Institute of Biology and Biophysics, Tomsk State University, USSR); Plekhanov, G. F. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 99-100; 1982.

Experiments were conducted according to a plan for the ecological standardization of electric fields (EF) generated by superhigh-voltage (SHV) electric-power transmission lines (EPTL) to elucidate the biological effect of an alternating electromagnetic field (AEMF) (with an intensity of 40 kV/m and a frequency of 50 Hz) on biosystems with different levels of organization. The red-blood indices of 2-wk-old white mice, the development of the preimaginal stage in the China oak silkworm, the larval developmental of mosquitoes, and the characteristics of dry hawk's-beard seeds were examined. The exposure of white mice to an AEMF (exposure times of 5, 10, and 20 days) resulted in the devel-

opment of anemia (30%) on day 10, which was subsequently offset by reticulocytosis by day 20. In the development of the preimaginal stage in the China oak silkworm, inhibition of growth rates was observed, together with retardation of development in young caterpillars, which had been offset by the time these caterpillars reached the third developmental stage. In studies on mosquito larva, it was shown that an AEMF can constitute a selection factor, increasing the mortality rate among 1st-stage and 2nd-stage larvae by 2-3 times vs. the control group, whereas the exposure of 3rd-stage and 4th-stage larvae only led to an increase in the time required for the larvae to develop into pupae. The adverse effects of the AEMF were probably determined by the ecologic features of the respiration biology of mosquito larvae. The exposure of dry hawk's-beard seeds to an AEMF for 10-30 days led to their accelerated germination and growth. Thus, it was demonstrated that an AEMF as used in this study elicits adaptive reactions by the biosystems examined. However, the biotropic effect of such a field depends substantially on stage of ontogenesis of the subject, its organizational level, and the ecological features of the exposed subjects, which must be considered when setting ecological standards for AEMFs. It should also be noted that 2-yr field observations carried out using live EPTLs of the LEP-500 type (10-14 kV/m) confirm the present conclusion that such lines inflict a considerable level of damage on individual types of ecosystems. In this instance, no changes were noted in the level of biota present, which indicates the increased resistance of higher organisms to the effects produced by AEMF.

Chapter VI. CLINICAL AND HYGIENIC ASPECTS OF ELECTROMAGNETIC RADIATION.

1564 ADAPTATION TO NONIONIZING RADIATION AS A HYGIENIC PROBLEM (MEETING ABSTRACT). (Rus.) Shandala, M. G. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 101-102; 1982.

The features and significance of adaptive and compensatory reactions of an organism during exposure to physical factors under environmental conditions, especially reactions with small orders of magnitude, remain one of the least studied areas in hygiene. The problem of an organism's adaptation to physical environmental factors encompasses a wide range of questions. These problems include physiological methods for controlling adaptation, potential effects of an exposure on the adaptive process, reactions aimed at countering homeostatic

Soviet researchers have primarily studied the effects of low-intensity MW (with power flux densities ranging from 1 to 1,000 $\mu\text{W}/\text{cm}^2$). Research related to the hygienic evaluation of nonionizing radiation has been carried out in a number of countries around the world since the early 1950's; however, several nonionizing radiation spectra have yet to be standardized at this time. Just as with other environmental factors, the correct approach to resolving the problem of standardizing the effects of MW radiation must include the biological substantiation of standards based on experimental research, together with a study of health of persons living in population centers where this factor exists to a known extent. In order to answer these questions, it is necessary to accumulate the maximum amount of information on the magnitude and biological significance of the effects. This is done by experiments on animals and observations of humans. In this instance, the data must extend over the entire range of the effect, from its total absence to high levels that are incompatible with living organisms. Based on bibliographic data and fundamental research, it is possible to demonstrate the unfavorable influence of high MW levels which are capable of causing pronounced changes in an organism (increased body temperature, irreversible morphological changes in organs, birth defects, impairment in function of the central nervous system, a reduction in redox enzyme activity, and disturbances in organismic functions that are vital to life). Much controversy has arisen about the existence and significance of the nonthermal effects of MW radiation. The chief problem here is that, to date, there are no uniform methods for studying the biological action of low MW intensities on living organisms and organismic systems, since different hygienic standards are in force in the principal countries of the world, covering a wide range of energy flux density values, from 10 $\mu\text{W}/\text{cm}^2$ to 10 mW/cm^2 (the 10 mW/cm^2 value was first proposed by H. P. Schwan in 1953 as a standard for use by the U.S. Navy for protection against MW radiation). For many years now, research associates at the A. N. Marzeev Scientific Research Institute of General and Communal Hygiene in Kiev have been engaged in intense work to establish uniformity in the manner in which hygienic investigations are set up and carried out, and to formulate adequate methods for assessing the functional condition of an organism during exposure to nonionizing MW radiation. A scheme developed by M. G. Shandala (1976) is the basis for assessment of the significance to an organism of the changes produced by MW radiation. New regulations have been established pertaining to the biological effects of low levels of MW radiation, and recommended procedures have been developed for the evaluation of low-intensity SHF energy. In addition, curves which describe the adaptive changes in a number of organ systems have been plotted, the sensitivity and information-content of indices which describe the condition of organismic systems have been determined, and the significance of these indices to the development of compensatory adaptive reactions during exposure to MW has been defined. Based on the many results

presently available, it is concluded that methods for investigating the protective and adaptive reactions of an organism must first be employed when studying the biological effects of low intensity irradiations, while methods for investigating reactions that reflect greater functional changes in an organism must be employed when studying the effects of high-intensity exposures. Aside from the intensity of exposure, the duration of any exposure must be taken into account in the hygienic standard-setting process, which involves the problem of a dose-related approach to standard setting. To resolve such questions, scientific research should be aimed in the appropriate direction, and research efforts coordinated so that a high level of uniformity is ensured in the methods employed, and comparable and mutually complementary data are generated.

1566 PROBLEMS OF HYGIENIC REGULATION OF ELECTROMAGNETIC FIELDS IN RESIDENTIAL AREAS (MEETING ABSTRACT). (Rus.) Dumanskii, Iu. D. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 105; 1982.

The biological action of electromagnetic fields (EMF) from the low-frequency, high-frequency, ultrahigh-frequency, and superhigh-frequency bands is studied. The results showed that EMFs generated by radio-engineering equipment and electric-power transmission lines (EPTL) are a biologically active environmental factor, which depends on the frequency range, level and duration of the EMF exposure. In this instance, it was established that the nervous system exhibits the highest level of sensitivity to the effects produced by an EMF. During exposure to an EMF, specific changes also occur in the cardiovascular system, metabolic processes, immunological reactivity, and reproductive function in animals. This research demonstrated that high EMF levels can cause morphological changes in the tissues of the brain, heart, liver, spleen, and testes. The data made it possible to develop procedures for regulation of EMFs in residential areas and to formulate measures and methods to protect the populace against EMF exposure. These data also made it possible to identify the basic trends of research on the hygienic study of EMFs of man-made origin.

1567 SIMULATION OF IRRADIATION CONDITIONS IN ANECHOIC CHAMBERS AND THE ESTIMATION OF ABSORBED ENERGY DURING BIOLOGICAL AND HYGIENIC RESEARCH (MEETING ABSTRACT). (Rus.) D'iachenko, V. N. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Varetskii, V. V.; Galich, L. N.; Rudnev, M. I. In: All-Union Symposium

The autoallergic processes which develop in an organism during exposure to different levels of superhigh-frequency (SHF) energy, possible mechanisms for the microwave (MW) effect on the immune system, and the manner in which allergic processes occur both in an ambient environment and as a result of MW irradiation were studied to substantiate an immunological health hazard criterion. The effects of SHF electromagnetic fields with an energy flux density (EFD) of 50 $\mu\text{W}/\text{cm}^2$ on the development of immediate and delayed forms of hypersensitivity were investigated. The results demonstrated that MW irradiation leads to a reduction in the formation of antibodies against horse serum and suppresses the allergic reaction (bronchospasm) of an isolated lung. These data suggest the impairment of the B immune system's performance; that is, disturbance of the humoral link in the immune response chain. The data also suggest that impairment of the T immune system occurs during MW exposure, on the basis of suppression of blast transformation in peripheral blood lymphocytes, and decreased manifestation of contact dermatitis from dinitrochlorobenzene. The generalization of the data enables the immunological health hazard criterion to be singled out as an independent indicator. In order to ascertain the characteristics of this indicator, it is important to establish, aside from immunological reactivity indices, the quantitative dependence of the effect on the level of exposure, and the limits of the adaptive reactions of the immune system of an organism when increased demands are placed upon it in the presence of functional loads. This last fact is especially vital in the field of environmental hygiene. Here, the task of distinguishing the phenomena normally associated with an adverse exposure from adaptive changes in organismic functions takes top priority.

1570 USE OF MATHEMATICAL MODELING METHODS TO STUDY MICROWAVES DURING BIOLOGICAL AND HYGIENIC EXPERIMENTATION (MEETING ABSTRACT). (Rus.) Antomonov, M. Iu. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 109; 1982.

Since different mathematical operations are employed to describe processes and phenomena that are being investigated, the adequacy of the models must be verified. The selection of the mathematical operation that best applies to a given situation depends both on the nature of the phenomenon being studied (static or dynamic) and the type of model (functional, structural, or structurally functional). At present, the view that the greatest benefit is derived by using mathematics to investigate the structures and mechanisms of phenomena rather than a simple description of these phenomena through the use of different functions is becoming

more widespread. The most effective means for making a detailed examination of such phenomena has proved to be the use of the theory of differential equations. Here, it is most efficient to employ the following algorithm: statistical processing of experimental data and plotting of experimental curves; selection of functions that most accurately describe these curves; presentation of these functions as superpositions of solutions of a specific class of differential equations; determination of the parameters of the mathematical model employed (a system of differential equations) using experimental data; and compiling a block diagram for the process as a whole and then interpreting it. During a biological and hygienic investigation on the effect of different levels of superhigh-frequency (SHF) energy on laboratory animals, the data reflected the rereactions of the various organismic systems. Quantitative assessments were made of the complexity and organization of the reactions to an SHF field and a mathematical operation which adequately described these reactions was selected in compliance with existing criteria. Mathematical models were then constructed using this algorithm which described the effect of an SHF field on immunological, morphological, physiological, and genetic indicators. A comparative analysis of these models was carried out and block diagrams that characterized the associated processes were compiled.

1571 HYGIENIC CHARACTERISTICS OF ENVIRONMENTAL EXPOSURE TO THE ELECTROMAGNETIC FIELDS GENERATED BY CIVIL AVIATION RADAR STATIONS (MEETING ABSTRACT). (Rus.) Soldatchenkov, V. N. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 110-111; 1982.

Navigational radar systems are currently employed to ensure air traffic safety in civil aviation. These systems radiate electromagnetic (EM) energy into the environment. As this author previously demonstrated, the main sources of EM energy in the area of an airport are flight route and airport surveillance radar sets which operate over wavelength bands of 10, 23, and 35 cm. The author examined 22 airports in the Soviet Union to make a hygienic evaluation of the EM conditions present. The extent of effects on the environment by the fields varies noticeably with energy flux density (EFD), depending upon the types of radar stations, the respective positions of the source and the irradiation points, the relief of the surrounding terrain, and the climatic and geographic features of a given region. Biological and medical research was conducted using experimental animals under conditions which simulated those actually created by exposure to the field to study the biological effects of pulsed EM fields in the 10-cm range. 620

ities. The experience gained from such treatments in a number of localities throughout the Ukraine (the Kiev, Vinnitsa, Donetsk, Somy, Crimean, and Cherkassy administrative regions, etc.) indicate that favorable results can be obtained by them.

- 1574 USE OF THE THERMOGRAPHY METHOD TO STUDY THE EFFECTS OF MICROWAVE DIATHERMY (MEETING ABSTRACT). (Rus.) Burenkov, M. S. (Institute of Biophysics, Soviet Ministry of Public Health, Moscow, USSR); Varetskii, V. V.; D'iachenko, V. N.; Mytarev, M. A.; Stolian, E. F.; Flora, T. S.; Engovatov, V. V.; Klimenko, E. F. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 113; 1982.

Microwave radiation (MWR), which is generally used in the deep heating of tissues, is currently enjoying extensive use in the treatment of a number of disorders. Since MWR can adversely affect both animal and human organisms, the authors carried out research to identify nontherapeutic effects of MW diathermy. During initial stages of this research, the authors studied the distribution of MW energy that strikes the surface of a patient's body. Here, skin surface temperature increases were used to isolate those organs and tissues which are initially affected by MWR exposures under such conditions. The extent of the effects produced by such exposures was also evaluated. An investigation was made of the skin temperature changes that occur at different points along the ventral body surface of 23 patients of both sexes from 7 to 14 yr of age who had undergone a MWR exposure for treating chronic disorders in the respiratory organs. An AGA-780 thermovisor unit (Swedish) was employed. The patients were irradiated using a Luch-2 physiotherapy generator. Here, the applicators were placed on the dorsal body surface in the approximate vicinity of the apex pulmonis. It was shown that different types of skin temperature changes take place in different sections of the skin during exposure, which occurred on the side of the body opposite the irradiated region. These changes may be the result of both the direct and indirect effects of MWR; therefore the data can contribute to the resolution of the problem of the mechanism of the effects produced by MWR.

- 1575 EFFECT OF MICROWAVES ON THE APPEARANCE OF LONG-TERM AFTER-EFFECTS (MEETING ABSTRACT). (Rus.) Shemetun, A. M. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Leonskaia, G. I. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 114; 1982.

Few data exist on the long-term effects of exposure to superhigh-frequency (SHF) energy at nonthermal levels in the centimeter wave band. The authors previously showed that nonthermal SHF electromagnetic energy is capable of causing a significant increase in the overall rate of embryo mortality, and disrupting the development of intrauterine rat fetuses, these effects being manifested by the onset of hemorrhaging and changes in the relative mass of certain internal organs. This research, together with the results obtained from cytogenetic studies that the authors had conducted earlier on rat bone marrow cells, suggest that the embryotoxic effects of microwaves (MW) may be due to the genetic damage to developing embryos. The ability of nonthermal levels of MW irradiation to inflict genetic damage was studied using a peripheral human blood lymphocyte culture. It was established that the exposure of short-term cultured human lymphocytes to an SHF field for 15 and 30 min at energy flux density (EFD) of 0.5, 1, and 7 mW/cm² produces a cytogenetic effect which increases with EFD and exposure duration. The authors also detected genetic effects from MW in examining persons residing in regions that were bombarded by an SHF field source. During a genetic examination of a random cross-section of individuals who lived in both a control region and a region that had been exposed to an SHF electromagnetic field, it was shown for the first time that the percentage of chromosome aberrations in the inhabitants of the exposed region was twice that of persons who resided in the control region.

- 1576 ADAPTIVE REACTIONS IN TISSUE AND CELL STRUCTURES DURING EXPOSURE TO MICROWAVES AND THEIR HYGIENIC SIGNIFICANCE (MEETING ABSTRACT). (Rus.) Obukhan, E. I. (A. N. Marzeev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Starchenko, S. N.; Chernenkii, N. N. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 114-115; 1982.

Structural changes constitute the physical basis of the adaptive reactions which take place during exposure to microwaves. Experiments on animals which have undergone different periods of exposure to superhigh-frequency (SHF) energy reveal the presence of specific morphological changes in the parenchymatous organs and the tissues of the mesenchyme. A comparison of the extent of these changes as a function of energy flux density (EFD) values (individual and aggregate) makes it possible to establish a definite pattern that characterizes the adaptation of an organism to nonionizing radiation. Rats which had been irradiated by an SHF field (2,375 MHz) at EFD values of 15, 30, and 50 uW/cm², for 10 exposures or for a 1-mo period, and at an EFD of 500 uW/cm² for single, 7, or 10 exposures, or for a 1-mo period, were investigated. The brain,

of an electric field is reduced noticeably as the distance between a bottom line's projected path and the ground is increased. The manner in which a field is distributed depends largely upon the relief of the terrain and the presence of objects along the route followed by high-voltage lines. These objects may be trees, high shrubbery, wooden buildings, and other types of structures. Such objects provide a good screening effect. An analysis of the conditions present in residential regions has shown that the various segments of a given population can be divided into three categories who undergo electric field exposures, depending upon place of residence and type of occupation. These categories, determined by the amount of time spent in the fields, are: around-the-clock; short-term (daily, for about 2 hr/day); and occasional, over the course of field work. The field levels and population exposure times observed under actual conditions provided a basis for setting up the present biological and medical studies. The biological effects of a low-frequency EMF on white rats and rabbits in the presence of different field intensity values (ranging from 0.1 to 20 kV/m) and different exposure times (ranging from 5 min to 22 hr a day for 4 mo) were studied under experimental conditions. The index values determined in this study characterized the overall condition of the organism as a whole, the nervous system, the cardiovascular system, the endocrine system, certain aspects of the metabolic processes, nonspecific immunity levels, and reproductive functions in the test animals. The results made it possible to determine the dose-time relationship of the biological effects of a 50-Hz electric field, and which field levels were active or inactive with respect to the animal organism. These studies were augmented by observations made on individuals residing in a low-frequency electric field (with a frequency of 50 Hz). In order to facilitate these observations, a laboratory apparatus was developed which simulated the electric fields generated by high-voltage EPTLs. The functional condition of human subjects was assessed using electrophysiological, psychophysiological, physiological, immunological, and hematological indices. As a result, data were obtained which made it possible to resolve a number of practical problems related to regulatory control of 50-Hz EMFs in the environment.

1579 INDUSTRIAL FREQUENCY ELECTROMAGNETIC FIELDS AS A FACTOR IN THE WORK ENVIRONMENT (MEETING ABSTRACT). (Rus.) Shestakov, V. G. (Kharkov Scientific Research Institute of Labor Hygiene and Occupational Diseases, Ukrainian Ministry of Public Health, USSR); Skorikov, L. N.; Dolgikh, A. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 118-119; 1982.

The problem was to investigate the industrial-frequency (IF) alternating electromagnetic fields (AE-

MF) generated by a given piece of equipment (more precisely, by the spot-welding machines used during resistance-type electric welding operations), to study their effect on the functional condition of certain physiological systems in the bodies of welders, and to formulate a procedure for the mathematical prediction of a particular system's condition at the job site. In order to more precisely evaluate both the IF AEMFs generated by welding equipment and the biological activity of these fields, and to ensure this field's hygienic standardization, a hygienic scheme for the classification of IF magnetic fields (MF) was developed, no such scheme being available until this time. The following results were obtained: the IF MFs generated by various types of equipment can be classified as continuous, intermittent, and pulsed categories as a function of their (time) parameters; the machines used in resistance-type electric spot welding generate IF pulsed MFs at the job site; the main sources of IF AEMFs are electrodes with different sizes and shapes; pulsed IF AEMFs have an effect on the functional condition of the central and autonomous nervous systems, which is expressed by increases in the latent and motor periods associated with auditory and visual motor reactions, temperature increases, and reductions in the electrical resistance of the skin (these changes were reliable in nature; however, they did not exceed the bounds of physiological norms); and a procedure is developed for the simplified determination of the maximum possible magnitudes and distributions of the IF AEMFs generated by different types of electric spot-welding machines. The results will be taken into consideration when setting hygienic standards for IF MFs and when formulating recommendations for improving the health-related labor conditions of workers.

1580 CONSTANT MAGNETIC FIELDS IN COMBINED TREATMENT OF OPEN INTRA-ARTICULAR INJURIES (MEETING ABSTRACT). (Rus.) Khabirova, G. F. (Kazan Scientific Research Inst. of Traumatology and Orthopedics, Russian Soviet Federated Socialist Republic Ministry of Public Health, USSR); Spektor, I. M. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 119-120; 1982.

The authors observed 55 patients suffering from open intra-articular fractures of the extremities. Treatment of these patients was begun by surgical repositioning of breaks and reduction of dislocations. Thirty-three of the 55 patients were treated by generally accepted procedures, including ultrahigh-frequency (UHF) therapy and decimeter-band (DB) therapy. The remaining 22 patients underwent comprehensive treatment that included the use of constant magnetic fields (CMF). The fields were provided by permanent magnets attached to metal frames in a parallel manner and 200 mm apart. The intensities of the fields ranged from 10 to 50 mT.

importance in setting hygienic standards for the EM factors present in the environment.

1583 CLINICAL AND PHYSIOLOGICAL EFFECTS OF SUPERHIGH-FREQUENCY ELECTROMAGNETIC RADIATION IN HYPERTENSION (MEETING ABSTRACT). (Rus.) Orzheshkovskii, V. V. (Kiev Institute for the Advanced Training of Physicians, USSR); Chopchik, D. I.; Fastyskovskii, A. D.; Kovalenko, V. P. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 121-122; 1982.

Clinical and physiological effects of superhigh-frequency (SHF) radiation were studied in 171 patients with the first and second stages of hypertension. Centimeter-band radiation was used on 95 patients, and the remaining 76 patients were exposed to decimeter-band radiation. The collar area was irradiated using oblong-shaped radiating elements. Centimeter-wave (CMW) therapy was performed using a Luch-58 electromagnetic field generator with a power of 20-45 W. Decimeter-wave (DMW) therapy was performed using a Voyna-2 medical therapy generator with a power of 15-45 W. The radiation exposures were administered for 10-min/day for 12-15 sessions. No other treatment measures were prescribed for the patients. The irradiation was carried out in a shielded booth, and all pertinent safety regulations were observed. Clinical examinations of all the patients were performed under dynamic conditions, and arterial pressure measurements, electrocardiography, polycardiography, and rheography procedures, etc., were performed both before and after the treatment course. The primary symptoms associated with hypertension, in particular, headaches, dizziness, chest pains, palpitations, dyspnea, and general weakness, etc., either disappeared altogether or were diminished significantly as a result of SHF therapy. Both SHF treatment methods had a hypotensive effect. During the DMW treatment course, maximum pressure was reduced by 27.3 +/- 2.7 mmHg, and minimum pressure was reduced by 13.0 +/- 1.7 mmHg. When CMW therapy was employed, maximum and minimum pressure were reduced by 28.7 +/- 2.3 mmHg and 8.3 +/- 0.9 mmHg, respectively. Electrocardiograms revealed signs of hypertrophy in the left ventricle, changes in intraventricular conduction, and impairment of coronary blood circulation; a tendency toward normalization was seen over the course of the treatment. According to polycardiographic data, a favorable influence was exerted on the contractive function of the myocardium. This positive effect occurred most often with DMW therapy. An improvement was also observed according to data obtained by rheography, etc. A significant level of improvement was noted in 42% of the patients undergoing DMW treatment. Some improvement was observed in 54% of these patients, and no change in 4%. Considerable improvement was noted in 30% of the patients completing CMW treatment, some improvement in 66%

of these patients, and no change in 4%. Thus, SHF electromagnetic waves exert a positive therapeutic effect on the first and second stages of hypertension. This effect is slightly more pronounced with DMW irradiation.

1584 USE OF REGRESSION ANALYSIS IN THE EVALUATION OF THE FUNCTIONAL STATE OF AN ORGANISM DURING EXPOSURE TO SUPERHIGH-FREQUENCY ENERGY (MEETING ABSTRACT). (Rus.) Soldatchenkov, V. N. (A. N. Marzhev Scientific Research Institute of General and Communal Hygiene, Ukrainian Ministry of Public Health, Kiev, USSR); Los', I. P. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 122-123; 1982.

Based on a study of the biological effects of intermittent pulsed electromagnetic energy with a frequency of 2,750 MHz, regression analysis was approved for evaluating the functional state of an exposed organism. The orthogonal central composite experiment planning process was employed, making it possible to derive second-order regression equations for each of the criteria studied. A similar equation was also obtained for the so-called D parameter, which made it possible to present the condition of the organism as a whole in a formalized and quantitative manner in the form of a system of interrelated subsystems, using the results obtained from all of the criteria examined. The equations derived in this text take the form: $y = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2$, where x_1 and x_2 are the factors studied (x_1 denotes the level of the electromagnetic field used and x_2 designates exposure time), while b_0 , b_1 , b_2 , b_{12} , b_{11} , and b_{22} are coefficients that indicate factor significance. From the two tests conducted (the experiment was duplicated), the criteria that were most informative, exhibited the best reproducibility, and made it possible to achieve good resolution were isolated. The data derived from this research demonstrated that regression analysis can be recommended for use in the hygienic evaluation of the electromagnetic factors present in the environment.

1585 ELECTRIC AND MAGNETIC FIELDS ON THE OPEN BUS-AND-SWITCH STRUCTURES OF NUCLEAR ELECTRIC POWER PLANTS (MEETING ABSTRACT). (Rus.) Fomin, G. V. (Inst. of Biophysics, Soviet Ministry of Public Health, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 123-124; 1982.

Open bus-and-switch devices (OBSD) with voltages of 110, 220, 330, and 500 kV or more are essential to the transmission of high-power electricity within a

control conditioned reflex activity and electrophysiological reactions, and were expressed as the dominance of stimulatory over inhibitory processes. The results obtained by psychophysiological, conditioned reflex, and electrophysiological methods showed that the responses evoked in an organism during an IFEF exposure of an intensity of 15 kV/m with exposure times of 90 and 60 min are normal adaptive reactions.

1588 PROBLEMS ASSOCIATED WITH SPECTRAL ANALYSIS DURING THE HYGIENIC ASSESSMENT OF PULSED ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). (Rus.) Teslenko, A. S. (Kharkov Scientific Research Institute of Labor Hygiene and Occupational Diseases, Ukrainian Ministry of Public Health, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 126; 1982.

The principles and standards (All-Union State Standard document number 12.1.006-76, etc.) pertaining to the hygienic assessment of electromagnetic fields (EMF) offer no unified procedure for the comprehensive evaluation of a pulsed EMF (PEMF), but rather provide for the measurement of the field amplitude alone. The recommendations made in literature concerning the practical calculation of spectral characteristics can only be applied to idealized pulses. The results obtained from an analysis of oscillograms depicting the currents and EMFs in different types of industrial equipment suggest that the shapes of the signals differ dramatically from those of idealized signals. For this reason, the following parameters are proposed for use in setting hygienic standards with respect to a PEMF: (1) the PEMF's intensity amplitude value; (2) the spectral function modulus of the PEMF; (3) the PEMF's energy spectrum; and (4) the energy of the PEMF (90-95%). A special set of programs is developed for calculating the pulse parameters through the direct use of oscillograms, tabular functions, or analytical functions. These programs are written for electronic computers from the MIR series and for microcomputers of the D2-28 type, and are used in studying the PEMFs generated by industrial equipment, conducting experiments on animals, designing protective screens, and constructing measurement instruments.

1589 EFFECT OF A CONSTANT MAGNETIC FIELD ON MICROCIRCULATION AND TRANSCAPILLARY EXCHANGE IN CLINICAL AND EXPERIMENTAL CONDITIONS (MEETING ABSTRACT). (Rus.) Zhukov, B. N. (D. I. Ulianov Medical Institute, Kubyshchev, USSR); Ragimov, E. M.; Vashurina, S. A.; Musienko, S. M.; Myshentsev, P. N.; Kostiaev, V. E.; Petrov, E. S. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 126-

127; 1982.

Research on the effect of a constant magnetic field (CMF) on microcirculation and transcapillary exchange in rats and in clinical treatment of phlebological disorders in the lower extremities is discussed. The state of microcirculation in various organs of rats was studied using light and electron microscopy. The content of histamine and serotonin in the mast cells, the adrenaline and noradrenaline levels present in the substantia medullaris of the adrenal glands, and the state of hypothalamic neurosecretion were also investigated. In vivo biomicroscopy was performed on the mesenteric vessels. The questions involved in the transcapillary transfer of proteins, electrolytes, and oxygen were examined under clinical conditions in the presence of phlebological disorders through the use of venous gradient, polarography and redoxometry methods, as well as by the biological determination of oxidation-reduction potential values. The state of lymph drainage was studied by indirect dynamic lymphography. A patient's individual sensitivity to a CMF was mapped by quantitative photopigmentometry. The treatment process was monitored by thermovision data recordings. The dominant effects of a CMF on biological objects were viewed as a chain of nascent adaptive reactions. In this case, the resultant adaptive processes were optimal during exposure to weak magnetic fields with values ranging from 2 to 10 mT. The appearance of marked hyperemia in the microvessels was caused by the opening up of the reserve capillaries and the expansion of the capillary system as a whole. Here, the absence of diapedetic hemorrhaging along the routes followed by the microvessels suggested a reduction in capillary permeability. The mast cell population was sharply increased, these cells releasing an enormous amount of histamine as a result of degranulation. The manufacture of adrenaline and noradrenaline having a vasoconstrictive action occurred in the adrenal glands. The microvascular system retained and stabilized proteins; a normal colloidal-osmotic pressure was created, which facilitated the elimination of edema. The activation of the 'sodium pump' increased the osmotic pressure, resulting in the elimination of extracellular fluids. The improvement observed in lymph drainage was linked to active performance on the part of the capillaries themselves. Tissue metabolism was altered dramatically due to the optimum intake and utilization of oxygen by the tissues. Capillary permeability was reduced by the 6th to 9th min of the exposure session; subsequently, it increased and dystrophic changes developed in the microvascular system. Since the changes in the microvascular system during single exposure to a CMF with a flux density of 10 mT were normalized by the 5th to 7th day after this exposure, there was no need to continue the daily use of the CMF. The author suggests that magnetic therapy sessions are needed once every 5 to 7 days, with exposure times of 6 to 9 min. The number of these sessions varies according to the extent of the pathological process. Thus, a CMF with a weak flux density ranging from 2

in the functional properties of the leukocytes. The functional properties of the skin were not simultaneously activated under the present test conditions: the content of lipids on the skin surface was increased first, after which the skin surface pH value rose. A CMF with a flux density of 0.03 T has an antiinflammatory and antiallergic effect on the clinical and experimental forms of allergic contact dermatosis, reduces the extent to which vascular and tissue-related alterations are expressed, and restores the nonspecific indicators of organismic resistivity (humoral, cellular, and tissue-related) that have been transformed by pathological processes. The best effect obtained by exposure to a CMF is observed when treatment is administered during the initial onset of dermatitis. The advantage of employing CMSs during the treatment of dermatoses as opposed to combined treatment methods that do not include CMF exposures is confirmed by the reduction in treatment time and by the stimulation and normalization of nonspecific organismic reactivity indicators.

1592 THREE DEGREES OF MANIFESTATION ASSOCIATED WITH THE NONSPECIFIC CHANGES OCCURRING IN AN ORGANISM DURING CHRONIC MICROWAVE IRRADIATION (MEETING ABSTRACT). (Rus.) Tiazhelova, V. G. (Institute of Biological Physics, Soviet Academy of Sciences, Pushchino, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 130; 1982.

Past studies of the effects in mammals of exposure to chronic microwave irradiation have demonstrated nonspecific changes in numerous organismic systems. The criteria that are employed most frequently are: blood pressure indices, analysis of electrocardiograms and encephalograms, metabolic indices, and changes in the circulatory, reproductive, and endocrine systems. A more thorough analysis has allowed detection of three degrees of manifestations, which the author suggests be viewed as the three stages of chronic microwave sickness. Due to the unclear manifestation of many symptoms of this disorder, it is recommended that all changes occurring in any of the above organismic systems be scrutinized. The criteria developed in this study can serve as a basis for comparing chronic electromagnetic exposures with different frequencies, intensities, and durations, as well as for working out a hypothesis regarding the equivalence of these exposure parameters.

Chapter VII. EFFECTS OF COMBINED EXPOSURES.

1593 REACTIONS OF THE HEMATOPOIETIC SYSTEM IN

TEST ANIMALS DURING COMBINED EXPOSURE TO MILLIMETER WAVES, ANTINEOPLASTIC AGENTS AND X-RADIATION (MEETING ABSTRACT). (Rus.) Sevast'ianova, L. A. (All-Union Oncology Science Center, Soviet Acad. of the Medical Sciences, USSR); Zubenkova, E. S.; Borodkina, A. G.; Golant, M. B.; Rebrova, T. B. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 131-132; 1982.

A study on the effect of omnidirectional exposures to superhigh-frequency (SHF) waves from the millimeter (mm) band in conjunction with x-radiation or chemical preparations on myelopoiesis in intact animals and animals into which multiple tumors have been transplanted is presented. The biological effect of such exposures was assessed by calculating leukocyte, erythrocyte, and reticulocyte populations, determining bone-marrow volume values, analyzing hemograms and myelograms, computing osmotic resistance, and estimating exocolony and endocolony populations in the spleen. It is shown that combined use of mm-band SHF waves and the above agents enables reduced hemopoietic tissue damage (the criteria for which are irregularities in white and red blood cells, erythrocyte devitalization processes, giant cells, etc.), and the preservation of no less than 70% of the active bone marrow present (the criteria for which are karyocyte and blast cell populations, the mitotic index, etc.). A study of the clonogenic activity of the bone marrow as concerns its ability to form visible hemopoietic colonies in the spleen demonstrated that the nature of the hematoietic system's protection, as well as its restoration or depression, is dependent upon the reaction of stem cells to the presence of combined exposures. Consequently, mm-band SHF radiation, which is a protective agent, reduces the extent to which actively proliferative hemopoietic tissue is affected and stimulates cell division processes. A possible hypothesis for describing the protection of the hematoietic system may envision an increase in the radioresistance of an organism's individual cell systems under the influence of mm waves. Preliminary data derived from a determination of osmotic stability in leukocytes using a 0.2% hypotonic NaCl solution have revealed a stability increase in the cells of animals undergoing combined exposures as compared to the cells of animals that have been subjected to x-ray therapy alone.

1594 MODIFICATION OF THE EFFECT OF X-RADIATION AND ANTITUMORAL PREPARATIONS ON TRANSPLANTED TUMORS BY MILLIMETER WAVES (MEETING ABSTRACT). (Rus.) Sevast'ianova, L. A. (All-Union Oncology Science Center, Soviet Academy of the Medical Sciences, USSR); Borodkina, A. G.; Zubenkova, E. S.; Golant, M. B.; Rebrova, T. B. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 132-133; 1982.

lead vapors and superhigh-frequency (SHF) electromagnetic energy) is of vital importance to the considerable number of workers currently employed in the field of instrument manufacture. Workers examined (nearly 1,000 individuals) were divided into three test groups and one control group on the basis of working conditions. Group 1 was comprised of individuals working under conditions of exposure to SHF electromagnetic energy (EME) with an energy flux density that generally stayed within the confines of the maximum permissible level, but who periodically exerted enough physical effort over the course of the work day so as to exceed this safe level. Group 2 was comprised of individuals who underwent exposure to lead in concentrations of 0.02-0.08 mg/m³ in addition to undergoing an SHF EME exposure at the same intensity for 50% of their work day. Individuals in group 3 were exposed to lead alone in concentrations of 0.01-0.05 mg/m³. The control group comprised workers from the same facilities who were not exposed to either the factors being investigated or to any other damage-inducing agent. All of the workers were examined to evaluate the condition of the nervous system, the cardiovascular system, the respiratory organs, and the gastrointestinal tract. An increase in pressure in the central artery of the retina (CAR) is one of the early signs of exposure to lead alone, or to lead in conjunction with SHF EME. This pressure increase reflects the development of arterial hypertension in the internal carotid artery system. In this instance, hypotension in the CAR itself was more typical of exposure to SHF EME alone. Functional changes observed in the myocardia of persons who worked under conditions involving combined exposure to both lead and SHF EME were basically more unidirectional than those detected during exposure to one factor alone. Here, the earliest changes detected included impairments in the performance of functions related to automatism. A weakening of the interdependence between the individual indices of hemodynamics and mineral exchange was noted during this research, indicating the disruption of physiological interrelationships in the central vasomotor system, as well as in other regulatory mechanisms. Vascular hyperemia was detected in the brain, lungs, and liver among the group of persons subject to combined exposure to both SHF EME and lead. This was apparently related to certain early changes in the performance of external respiration (a reduction in vital capacity and in the ratio of vital capacity to its established value), as well as to disturbances in the functioning of the liver, which were detected through the use of biochemical and radioisotope research methods.

1597 BIOLOGICAL EFFECTS PRODUCED BY EXPOSURE TO A CONSTANT ELECTRIC FIELD IN CONJUNCTION WITH AEROLIONS (MEETING ABSTRACT). (Rus.) Shepeleva, M. V. (Scientific Research Institute of Labor Hygiene and Occupational Diseases, Russian Soviet Federated Socialist Republican Ministry of

Public Health, Leningrad, USSR); Kalitad, T. V.; Krivova, T. I.; Nikitina, V. N.; Shaposhnik, G. G. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 135-136; 1982.

Maintenance personnel can undergo exposure to a high-intensity electrostatic field (ESF) in conjunction with exposure to air ions at elevated concentrations when they are operating superhigh-voltage direct-current electrical equipment and working with electrifiable materials associated with various production processes. Reactions in the central nervous system (CNS), cardiovascular system, and apparatus that regulates body temperature were studied under experimental conditions using volunteers (10 human subjects) who were exposed to ESFs with intensities of 30 and 15 kV/m in the presence of positive air ion concentrations of $3-4 \times 10^5$ and $8-9 \times 10^4$ electrical charges per cubic meter, respectively. The exposure process was carried out for 20 days for 2 hr/day. This research was performed by applying a physical load to an ergograph. It was found that exposure to an ESF with an intensity of 30 kV/m caused a slight reduction in the excitability of the CNS; however, an increase was observed in CNS excitability over the course of the entire exposure period. Following the irradiation period, an increase was noted in arterial pressure, and in systolic and minute volume values. Both under the dynamic conditions involved in the experimental process and over the course of the exposure period itself, increases occurred in the hyperemia of the peripheral vessels, in skin temperature, and in heat release due to radiation. During combined exposure to an ESF with an intensity of 15 kV/m and to air ions in a concentration of $8-9 \times 10^4-10^5$ electrical charges per cubic meter, a number of indices were altered in a unidirectional manner in all of the test subjects examined, while certain indices exhibited individual traits. In this vein, exposure to the above factors caused fluctuations in CNS excitability among three of four test subjects. Variations were noted in the critical flicker frequency (CFF) under the dynamic conditions associated with the experiments, over the course of the true exposure period as a whole, and during the after-effect period. A reliable increase in arterial pressure was observed in the cardiovascular system in two of the test subjects, both under the dynamic conditions associated with the experiments and over the course of the irradiation period as a whole. The pulse rate was elevated during all of the recording periods. The minute volume of the blood and the peripheral resistance value were altered in a similar manner. The volume circulation rate was increased in all of the test subjects under the dynamic conditions associated with the experiments. The volume pulse level in the peripheral vessels grew following the true exposure period and did not return to its original control period level over the course of the after-effect period.

The effect of an alternating magnetic field (AMF) with a frequency of 8 Hz and an intensity of 4.1 A/m on two experimental pathological models, acute radiation sickness and the hypokinetic syndrome, was studied. Sexually mature male mongrel white rats and mice were used in these tests. The AMF exposure was carried out in a shielded chamber, making it possible to reduce geomagnetic field intensity 12-fold, using a Helmholtz coil and sinusoidal current. The precision of the AMF's intensity and uniformity in the exposure region was no worse than 5%. Acute radiation sickness was produced by irradiating the test animals using a RUM-17 medical x-ray unit at a dose level of 7.5 Gy. The hypokinetic syndrome was induced by placing the animals into organic glass cages that restricted their movements. During the experiments conducted with the acute radiation sickness model, animals from the test group underwent a single 3-hr exposure to an AMF both before and immediately after the radiation exposure. During the experiments that involved the use of the hypokinetic syndrome model, the test animals were subjected to a daily 3-hr AMF exposure. The observation of the animals in both the test and control groups was continued for 30 days. In experiments dealing with acute radiation sickness, a one-time pre-irradiation AMF exposure caused a 15 +/- 20% decrease in the percentage of animal deaths and a 13 +/- 15-day increase in average life span, and produced variations in the time-related distribution of animal deaths. A one-time post-radiation magnetic field exposure did not lead to any significant changes. Based on measurement of the indicators that characterize lipid metabolism, the coagulation and anticoagulation systems, together with certain indicators of nonspecific resistance, and blood picture, it was ascertained that the integral index describing the development of the hypokinetic syndrome decreased to 130 +/- 0.3% in animals from the test group as compared to those from the control group. This index approached normal levels in terms of different parameters. The dynamics of development of the syndrome were also altered, and the adaptive manifestations of hypokinesia appeared 5 +/- 1 days earlier in the test group than in the control group. Thus, the results obtained using two different pathological conditions that occur within an organism suggest that a weak AMF exerts a modifying influence on such processes.

1602 EFFECT OF MICROWAVES AND PREPARATIONS DERIVED FROM RHODOMELA LARIX ALGAE ON THE ACID RESISTANCE OF MOUSE ERYTHROCYTES (MEETING ABSTRACT). (Rus.) Belozero, A. V. (Vladivostok Medical Institute, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 139-140; 1982.

An attempt was made to assess the effect of preparations derived from *Rhodomela larix* algae, a biological storehouse for bromine (up to 3.36%), on the

acid resistance of erythrocytes in mice that have been exposed to a superhigh-frequency (SHF) electromagnetic field. The combined effect of algae preparations and SHF fields on the acid resistance of erythrocytes was determined by means of acid erythrograms. The classic procedure of I. I. Gitel'zon and I. A. Terakov was employed in obtaining these erythrograms, with appropriate changes to permit automatic recording of the hemolysis process. The data obtained demonstrate that the introduction of the algae preparation into mice produces no change in erythrocyte acid resistance of these animals. The irradiation of test animals by microwaves leads to a 1.24-fold decrease in erythrocyte resistance as compared to unirradiated animals. The preliminary introduction of *Rhodomela larix* preparation before irradiation curtails this decrease by 20%. Thus, substances contained in the algae enhance (protect) erythrocyte resistance during microwave irradiation. The results can be used when developing measures for the prevention of microwave damage.

Chapter VIII. PHYSICAL FIELDS OF BIOLOGICAL OBJECTS.

1603 MAGNETIC FIELDS OF BIOLOGICAL OBJECTS (MEETING ABSTRACT). (Rus.) Kholodov, Iu. A. (Institute of Higher Nervous Activity and Neurophysiology, Soviet Academy of Sciences, Moscow, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 141-142; 1982.

The recording of weak magnetic fields (MF) generated by biological objects has been done since the early 1960s. At first, such recordings were performed using sensors made up of multiturn coils, then later using superconducting quantum interference sensors and optical-pumping magnetometers (OPM). Special magnetically-shielded rooms are sometimes used when conducting biomagnetic research of this type; however, a gradientometric circuit made up of two sensors is most often employed, making it possible to perform this research under conventional experimental conditions. Most studies recorded human MFs, although individual reports touch upon the MFs in fish, frogs, and dogs. The most powerful MF generator in the human body is the heart; therefore, it is the magnetocardiogram (MKG) that receives the most study, even though the study of magnetoencephalograms (MEG) is viewed as the most promising, since contactless magnetography permits the more local determination of the brain's individual bio-current sources. Research on human MFs has been under way in the Soviet Academy of Sciences, Institute of Higher Nervous Activity and Neurophysiology since 1976. This research is performed using a gradientometric OPM circuit developed in the So-

surface from the surrounding air, which is linked both to electrical phenomena of an external origin and those within the body itself. It has been established that the static charges produced by external factors generate electric fields in the air around the human body. The high amplitudes of these fields reflect the dynamics of the respiratory movements and displacements in the body surface arising from the pulse. Such displacements result from the mechanical contraction and relaxation of the heart muscle, and the resultant hydrodynamic surging of the blood through the arteries and veins. These periodic high-amplitude signals, which have complex configurations and coincide with the frequency of the heart's operating cycle, correspond to the signals present on a contact-recorded seismocardiogram. An analysis of the electric signals associated with respiratory movements allows measurement of the frequency, depth, and rhythm of respiration. Here, it is also possible to indirectly estimate the volume of air contained in the lungs. The recording of the electric fields above different regions of the body surface through the use of field sensor displacement affords the opportunity of clearly differentiating between the various types of respiratory movements. Wavelike changes in respiratory movement amplitude were observed during the examination of patients suffering from afflictions of the bulbar regions of the brain, both before and after corrective surgery. The use of frequency-related and spatial (that is, vector-type) field signal selection methods made it possible to isolate that component of an aggregate external electric field signal which originates from the bioelectric processes occurring in the human body.

1606 ELECTROMAGNETIC NATURE OF THE PROCESSES INVOLVED IN THE ORIGIN AND EVOLUTION OF LIVING ORGANISMS (MEETING ABSTRACT). (Rus.) Prishchep, L. G. (Institute of Water Conservation, Soviet Ministry of Agriculture, Moscow, USSR); Kitlaev, B. N. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 144-145; 1982.

A hypothesis is proposed concerning electromagnetic mechanisms in the processes involved in the origin and evolution of living organisms, and the regulation of their functions. The electromagnetic mechanisms associated with the various rungs of the biological evolutionary hierarchical ladder are examined and include: (1) the mechanism of the electromagnetic 'affinity' of the atoms and molecules in organic compounds as a factor that is linked to their selective interaction and self-assembly within a densely clustered droplet that is situated in a primordial broth; (2) the mechanism of the self-development and modification of organic formations under the influence of a parent material's evolving structured electromagnetic field; (3) the mechanism of the influence exerted on organic protoplasts by

the electromagnetic rhythms of the Sun and the Earth, together with the mechanism of the constant electromagnetic interaction occurring between an organic material and its environment, as factors which contribute to the formation of densely clustered droplets, as well as to the formation of the relaxational probiological processes that take place therein; (4) the role of prebiological electromagnetic relaxational processes as concerns the transformation of densely clustered droplets into primary life cells called protocells; (5) the electromagnetic models of chloroplasts and mitochondria as protocells that exist independently during the early stage of evolution, and which function in accordance with a relaxation-related blueprint; (6) the role of the structured hierarchical electromagnetic fields of protocells, cells, and multicellular organisms as blueprints for the performance, interaction, and regulation of biological functions, including self-replication and self-development, and; (7) the electromagnetic nature of the regulation of vital processes in plant and animal communities as a stage in the evolution of electromagnetic blueprints for the development of living matter. The generalized positions adopted under the theory of the determinative role of electromagnetic processes in the origin of organisms and the regulation of vital processes therein are presented.

1607 RECORDING HUMAN BIOELECTRIC FIELDS (MEETING ABSTRACT). (Rus.) Kolesnikov, G. G. (Kiev Scientific Research Institute of Renal and Urinary Tract Disorders, Ukrainian Ministry of Public Health, USSR); Polubelov, A. A. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 145; 1982.

The measurement of fluctuations in the magnitude and gradients in the body's electrostatic field by mechanical movements of the heart muscle has made it possible to view the heart as a modulator, which simplifies the construction of measurement equipment. Study of the electric field around the human body involves not only the identification of this field's local sources, but also the investigation of the human body's surface as a transmitter with distributed parameters. The multiple-electrode measurements carried out by the authors of the distribution of the electric conductivity of the skin demonstrated a significant level of anisotropy, even in small skin sections. Here, the marked dependence of this anisotropy upon the measurement frequency was also detected. The electric conductivity distribution is closely linked to the distribution of temperatures over these same skin areas, as measured using film-type liquid-crystal indicators. A study of electromagnetic field sources (e.g., those along the wall of the ureter during its peristalsis) identified a contribution from fields of electrochemical origin, which are generated as a result of the changes occurring in the double electric layers (DEL) at the phase inter-

tremely high field intensity and an extremely low intensity was noted in one of the body regions studied, with the exception of the thoracic region, over the course of 2-3 wk. The average daily QCBEF intensity fluctuated within limits ranging from -5 to +1,100 V/m. The subjects were divided into three categories on the basis of the maximum average daily field intensity observed during a 2-wk measurement period: those with a low field intensity ranging from 50 to 150 V/m, those with an average field intensity ranging from 150 to 600 V/m, and those with a high field intensity above 600 V/m. During investigations that lasted several days, a study of QCBEF dynamics among all of the test subjects revealed fluctuations in the magnitude of the average daily intensity for a field with a high amplitude and ranging from 3 to 9 days. These fluctuations occurred in phase with the majority of the body regions studied, but exhibited a phase advance or phase lag of 1-3 days in one or two of these regions. Over a period of 9 to 22 hr, QCBEF intensity in the regions of the body examined was seen to fluctuate, with 1-3 peaks being present. In most cases (73%), the first peak coincided with the 11th, 12th, or 13th hr, and the first, second, and third categories of around-the-clock human QCBEF dynamics were thus identified by this peak's appearance time. The average magnitude of the first peak for the aforementioned categories of field dynamics exceeded the average daily field intensity by 1.3- to 2.6-fold, while the intensity rise-and-fall time associated with this intensity peak fluctuated within limits that ranged from 2 to 6 hr as a function of the type of field dynamics present and the region of the body examined. For the most part (in 66% of the cases studied), a second peak was observed some 3-11 hr after the first peak, depending upon the type of field dynamics present and the region of the body examined. The type of around-the-clock QCBEF dynamics occurring in a specific region of the body changed, as a rule, in 1 to 2 days. Here, the majority of the bodily regions were characterized on any day by identical dynamic categories, with the exception of one or two regions. The fluctuations detected in the intensity of QCBEFs with multiple-hour or multiple-day periods should be viewed as manifestations of the biological rhythms inherent in the human organism.

1611 ELECTROSTATIC FIELDS IN THE SIGNALING AND ORIENTATION SYSTEMS OF INSECTS (MEETING ABSTRACT). (Rus.) Es'kov, E. K. (Ryazan State Teachers' Institute, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 148-149; 1982.

The body shells of insects are electrically charged by the friction associated with different surfaces. The magnitude of the body charge present in active honeybee worker specimens reaches 50-80 pC. In passive bees, this magnitude value is found at the 1-3 pC level. Position shifts by electrically charged

insects and/or the fluctuations occurring in the various sections of their bodies generate variable electric fields. For example, a bee which signals that it has found a food source or that it is approaching the hive wags its abdomen in the lateral plane. The frequency of the vibration generated in this instance comes to 15 Hz. An electric field with a frequency of this type is easily recorded by an electrical probe positioned a distance of 0.5-1 cm from the signaler. These electric fields are sensed by mechanical receptor organs. The role of these organs may be to act as antennae or piliform sensillae. In order to excite a receptor, it is necessary that its movable component be pulled forward or pushed back by the field of a statically charged insect. The relationships involved in this principle are also employed in the intrahive communications systems of honeybees. Putting this principle to use, bees pinpoint a signaler from among a large number of family members and follow its progress over a certain distance. This is essential to decode the signaler's reports concerning the distance to its designated flight target. Utilizing this same principle, insects can use static fields when visual orientation is not possible due to a low level of illumination.

1612 INVESTIGATION ON THE MAGNETIC FIELDS OF BIOLOGICAL OBJECTS IN A SHIELDED AREA (MEETING ABSTRACT). (Rus.) Kozlov, A. I. (All-Union Scientific Research Inst. of Current Sources, Moscow, USSR); Avdeev, B. V. In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 149; 1982.

The use of quantum magnetic field gradiometers (QMFG) based on radiooptical double resonance for investigating the magnetic fields of biological objects, including humans, has been the subject of numerous reports. The best performance characteristics for of an instrument of this type are observed in nonmagnetic test areas. However, for medical and biological research, it is necessary to perform measurements in insulating chambers to stabilize survival parameters. This poses the problem of studying and optimizing the performance of magnetic field gradiometers within magnetic shields. The results obtained from an investigation into magnetic fields and the performance of QMFG in the shielding chamber of a Biotron apparatus are presented. Biotron is the conventional term applied to a special installation that makes it possible to reproduce, separately or in different combinations, all of the components of an atmospheric medium. During research on the magnetic fields of humans or other biological objects (for example, when recording magnetocardiograms in the chambers of a Biotron) that part of the chamber space which has a minimum constant field gradient is identified beforehand. To successfully perform such measurements, it is also necessary to make allowance for the magnetic field of an industrial frequency cur-

trum of an organism's recordable external electric fields. The amplitude of these ultralow-frequency oscillations diminishes with frequency; however, this amplitude exceeds the potential differences recordable on the body surface using contact methods, reaching magnitudes of 100-300 mV at distances of up to 5 cm. It is also ascertained that the capability exists of evaluating the motor performance of the stomach using the dynamics of oscillations that occur within a range of 0.05 ± 0.02 Hz by positioning field sensors over a particular point on the body surface. A field's quasistatic potential at distances of up to 5 cm reaches a magnitude of more than 1,000 mV. In this instance, the symmetry of the equipotential surfaces relative to the body's center line is a significant feature. A statistical analysis of the data confirms that any deviations in the asymmetry factor that fall within limits of ± 8 relative to the mean datum level can serve as standard criteria for the individual differences in the level of a field on the order of $\pm 25\%$. It is known that the pathological conditions in an organism not only distort the geometry of the equipotential surfaces, but also lead to persistent asymmetry in an external field. In addition, the author demonstrates that a state of tension alters the magnitude of the asymmetry indicator as well. Dynamic physical loads produce an average variation of 0.2 in the asymmetry factor. Here, a reaction is developed in an organism during the first few minutes following exposure. The author links this reaction to the changes occurring both in nervous processes and in the exchange of chemicals. In a number of cases, the asymmetry factor has a higher level than its original value for more than 10-20 min after the physical loads

have been removed. This may suggest the presence of stress in the principal regulatory systems. Comparative analysis suggests that an electric field's asymmetry factor can serve as an integral indicator of the functional condition of a human subject.

1616 PHENOMENON OF LIGHT SCATTERING NEAR HUMANS AND OTHER BIOLOGICAL OBJECTS (MEETING ABSTRACT). (Rus.) Zolotov, A. V. (Kalinin Branch, All-Union Scientific Research Institute of the Geophysical Investigation of Exploratory Geological Wells, USSR). In: All-Union Symposium on the Biological Effects of Electromagnetic Fields, Pushchino, USSR, p. 152-153; 1982.

Under certain conditions, a low-level glow is observed visually against black background in the air around the human body and other biological objects during their illumination by natural or artificial light. The intensity of this glow is more than 10- to 100-fold weaker than daylight. In the present study, the author successfully recorded the glow around a biological object on film using conventional photographic techniques. The low-level glow was photographed in the visible range of the optical spectrum against a black background using a high degree of overexposure (by 10-100 times or more), and its intensity was subsequently measured by a photometric evaluation of the film's density at different points around the object being investigated. The low-level glow is observed around humans, animals, plants, and other biological objects.

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