INTERNATIONAL RADIATION PROTECTION ASSOCIATION

Fifth International Congress

Date: March 9-14, 1980
Place: Jerusalem, Israel: Jerusalem Convention Center
Sponsor: Israel Health Physics Society; Internat'l Radiation Protection Assoc. (IRPA)
Requests for Information: Israel Health Physics Society, c/o Soreq Nuclear Research Center, Yavne 70600, Israel
Content: Sessions will cover all aspects of protection against ionizing and nonionizing radiation

0439 QUANTIFICATION AND MEASUREMENT OF INTERNAL ELECTROMAGNETIC FIELDS INDUCED IN FINITE BIOLOGICAL BODIES BY NONUNIFORM ELECTROMAGNETIC FIELDS. Chen, K. (Michigan State Univ., Sch. Engineering, Dept. Electrical Engineering & Systems Science, Engineering Building, East Lansing, MI 48824).

A theoretic basis will be developed for quantification and measurement of internal electromagnetic fields induced in finite biologic bodies by nonuniform electromagnetic fields. Experimental confirmation will be sought by use of implantable probes in simulated models. A theoretic study of implanted probes and their response within the medium will be made. The Army is using electromagnetic radiation to provide communication links; to probe the battle environment for enemy presence, equipment, and activities; to control defensive ordnance; and to control guidance of ordnance. Individual and cumulative levels of these radiated energies are becoming a considerable concern because of their effects on the natural environment and on man. The theoretic method will be tested on numeric solution of a tensor integral equation quantifying the internal electromagnetic field induced in a finite, heterogeneous biologic body by an incident, non-uniform electromagnetic field. In this method the body is subdivided into a selected number of small sub-volumes, and the individual electric properties determined. Measurements with sample probes immersed in various simulant media will determine parameters for testing the theoretic derivations of probe interactions. (funding period 4/76-n/a)

Supporting Agency:U.S. Dept. Defense: Army, Army Material Development & Readiness Command, Army Res. Office

0440 TERATOGENIC STUDY OF MICROWAVE RADIATION IN MICE. Staples, R. E.; McRee, D.; Nawrot, P. S. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Lab. Environmental Toxicology, P.O. Box 12233, Research Triangle Park, NC 27709).

Groups of pregnant Charles River CD1 mice are being exposed to 5, 21, and 30 mW/cm^2 of constant or pulsed electromagnetic radiation at 2,450 MHz from days 1 through 6 or days 6 through 15 of gestation. All mice will be autopsied at day 18 of gestation and fetuses will be examined for gross external, visceral, and skeletal changes. (funding period 00/79-n/a)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0441 BIOLOGICAL INTERACTIONS WITH AND HAZARDS OF MICROWAVE RADIATION. Larsen, L. E.; Jacobi, J. H. (U.S. Dept. Defense: Army, Medical Res. & Development Command, Neuropsychiatry Div., Washington, DC 20012).

In order to protect the health and effectiveness of military units and affected civilian populations in microwave and radio frequency environments, system developers and agencies responsible for safety standards will provide technical information to the surgeon general. This requires an analysis of the biophysics and bioeffects attributable to nonionizing radiation under laboratory conditions that reasonably simulate operational exposures. Basic and applied research on the problem of microwave and radio frequency interactions will be performed at all levels of analysis from the cellular and molecular to metazoan physiology, pathophysiology, and behavior. This requires (1) development of measurement systems for dosimetric analysis ex vacuo, in vitro, and in situ; (2) evaluation of frequency, power level, polarization and modulation as important parameters of the radiation; and (3) use of low level energy to assess the functional state of cells and tissues. (funding period 7/71-cont.)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Walter Reed Army Inst. Res.

0442 NEUROBEHAVIORAL TOXICITY OF DEVELOPMENTAL EXPOSURE OF JAPANESE QUAIL TO MICROWAVE IRRADIATION. Tilson, H. A.; McRee, D. I.; Mitchell, C. L. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Behavioral Toxicology Group Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The long-term neurobehavioral effects of perinatal exposure of Japanese Quail eggs *(Coturnix coturnix iaponica)* to 2,450 MHz continuous wave microwave irradiation at a power density of 5 mW/cm^2 for the first 12 days of development will be assessed. Sexual and reproductive behaviors, a battery of behavioral and neurologic measurements, learning and retention, and baseline performance on an operant schedule will be evaluated. (funding period 10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0443 TUMOR RADIOCHEMOTHERAPY: EFFECTS OF ULTRASOUND AND HEAT. Hahn, G. M.; Marmor, J. B. (Stanford Univ., Sch. Medicine, Dept. Radiology, Stanford, CA 94305).

The interaction of x-irradiation and chemotherapy with hyperthermia generated by ultrasound and microwaves in effecting tumor cures in laboratory animals will be investigated. Specifically, the effects of ultrasound and microwaves in cells will be examined in vitro and in vivo at temperatures above 37 C. Combined treatments of x-irradiation (or chemotherapy) and ultrasound- and microwave-induced hyperthermia will be quantitated in tissue culture systems and in experimental tumors. Both cell survival studies of EMT-6 tumors as well as tumor cure experiments with EMT-6 and other tumors will be performed. Combinations that prove promising

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will be examined for possible clinical applications. Equipment to carry out laboratory, and eventually clinical studies, will be developed. (funding period 12/77-11/79)

Supporting Agency:HEW, PHS, NIH, NCI

0444 NAVY ENVIRONMENT: MECHANISMS OF MICROWAVE-INDUCED BLOOD-BRAIN BARRIER ALTERATIONS. Lin, J. C.; Noonan, S. M. (Wayne State Univ., Sch. Engineering, 5950 Cass Ave., Detroit, MI 48202).

Microwave fields, such as those emitted by radar equipment, have been shown to alter the blood-brain barrier system in rats. At this time, the mechanisms of this alteration are not known. The objective of this research is to determine the possible interaction mechanisms with the use of biochemical and biophysical analyses. The first phase of this study will be directed toward the biophysical aspects of absorbed energy inside the rat brain. Emphasis will be placed on any direct correlation between absorbed energy and observed alteration in permeability. The second phase will deal with the implications of pulsed microwave-induced thermoelastic displacement of, and stress in, the brain tissue. In addition, any physical manifestations of change as might be seen by electron microscopy of the specific regions of the brain that show permeability changes will be investigated. (funding period 4/78-cont.)

Supporting Agency:U.S. Dept. Defense: Navy, Office Naval Res.

0445 THE EFFECT OF MICROWAVE RADIATION ON THE HEART OF EMBRYONIC QUAIL. Hamrick, P. E.; McRee, D. I. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

This project will determine if and how microwave radiation interacts with the embryonic quail heart or causes a change in heart rate. If a heart rate effect is found, the change in heart rate as a function of absorbed microwave energy will be studied. Changes in heart rate due to temperature changes will be controlled. (funding period 10/77-9/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0446 EFFECTS OF 2450 MHz MICROWAVE RADIATION ON BIOLOGICAL MATERIALS AT CELLULAR LEVEL. Hamrick, P. E.; McRee, D. I. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The objectives of this project were to determine how 2,450 MHz microwave radiation interacts with biologic material at the cellular and macromolecular level, to observe any effects of this interaction, and to relate the amount of microwave energy absorbed to the effects. Biologic systems employed in the study were: bacteria and bacteriophage, solutions of DNA, 2-4 cell stage embryos from mice, rabbit erythrocytes, and rat lymphocytes. The temperature, humidity, and other growth conditions were carefully monitored to eliminate any effects not intrinsically caused by the microwave radiation. Very few nonthermal differences between exposed and control samples were detected. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0447 PHYSICAL SCIENCE COLLABORATIVE RESEARCH. Atkinson, E. R.; Kim, Y. W.; Mahendroo, P.; Bull, J. M.; Vanecho, D. A. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Cancer Inst., 9000 Rockville Pike, Bethesda, MD 20014).

Physical science collaboration is being conducted in automated tissue culture colony counting, millimeter wave spectroscopy of tumor cells, whole body hyperthermia patient treatment, whole body hyperthermia animal studies, toxicity of chemotherapeutic agents at elevated temperatures, nonthermal effects of microwaves, precision measurement of size of biologic objects, mass spectroscopy of biopolymers and unnatural isotopes, nuclear magnetic resonance of membrane specific proteins, human thermoregulation, receptor site tertiary structure by electron spin resonance, dielectric properties of normal and tumor tissues, pion production at low energies in the laboratory frame, tissue sensitizers for ionizing radiation, microwave imaging techniques, ultrasonic temperature measurement, liquid crystal effects in biologic materials, optical and viscometric techniques for temperature measurement, and actin and myosin mechanics. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, NCI

0448 MICROWAVE EXPOSURE SYSTEMS AND MICROWAVE DOSIMETRY. McRee, D. I. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

Exposure systems for bioeffects research and test techniques for measuring energy absorption are being developed. The waveguide system for exposing isolated neurons to 2,450 MHz microwave radiation has been modified so that longer survival times and constant temperatures of the nerves during exposure can be achieved. Small thermistor probes have been used to measure deep colonic temperatures in pregnant mice during exposures to 2,450 MHz microwave radiation. Using the temperature profiles measured in the dead animals to calculate average absorption rates, the results agreed well with both calculated and measured whole-body absorption reported in the literature. A system for exposing groups of marine animals to different intensity levels simultaneously

without significant perturbation of the microwave field by the location and orientation of the animals has been developed and tested. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0449 EFFECTS OF MICROWAVES ON NEURAL RESPONSE. McRee, D. I.; Wachtel, H. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The effect of microwave radiation on neurologic response will be determined. Isolated neurons, such as, the abdominal ganglion of *Aplysia*, the sciatic nerves of frogs, and the saphenous nerves of cats will be exposed to continuous wave, pulsed, and modulated microwave radiation in the power density range of 1-10 mW/cm^2. The effects of the radiation on the strength-duration of a stimulus to produce an action potential, amplitude of the response, and conduction velocity will be investigated. Fatigue and recovery of the neurons under rapid, multiple stimulation will also be studied. A series of experiments to determine if continuous wave, 2,450 MHz microwave radiation increases the fatigue rate or changes the vitality of the frog sciatic nerve were completed. The frog sciatic nerves were exposed in a waveguide to specific absorption rates of 100, 50, and 20 W/kg. The nerves were stimulated with twin pulses (separated by 5-msec intervals) at a repetition rate of 500 pulses/sec to accelerate the rundown time. Distinct changes in the excitability and refractoriness of the exposed nerve were seen in comparison to the control nerve. The vitality of the nerve was affected and was greater for the higher dose rates. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0450 TISSUE INTERACTIONS WITH NONIONIZING ELECTROMAGNETIC FIELDS. Adey, W. R.; Bawin, S. M.; Sheppard, A. R.; Sagan, P. M.; Bishop, D. F. (U.S. Veterans Admin. Hosp., Dept. Medicine & Surgery, 11201 Benton St., Loma Linda, CA 92357).

The biologic effects of environmental electromagnetic (EM) fields at extra low frequencies, very high frequencies, and microwave frequencies will be studied with special reference to interactions with the central nervous system. A multifaceted research program will examine (1) molecular biology of cell membrane surfaces and macromolecular mechanisms in weak electric field transduction; (2) microphysiology of cellular responses to EM field exposure, performed on special brain tissue preparations, invertebrate ganglion cells, bone cell cultures, and red and white blood cell elements; (3) behavior and correlated biochemistry of chicks, rats, cats, and monkeys, with observations on free and learned behavior, and on biologic rhythms; and (4) biophysical models of macromolecular transductive coupling of natural and imposed weak EM fields. (funding period 10/78-n/a)

Supporting Agency:U.S. Veterans Admin., Dept. Medicine & Surgery

0451 DETERMINATION OF TIME-DOSE MICROWAVE RADIATION TO INACTIVATE *B. ANTHRACIS* SPORES IN BONE MEAL. Whitford, H. W.; Newton, R. W. (Texas A & M Univ., College Station Campus, Sch. Veterinary Medicine, College Station, TX 77843).

The time and intensity of microwave radiation required to inactivate *B. anthracis* spores suspended in bone meal will be determined. Researchers will (1) determine the time/heat responses of bone meal at different microwave intensities; (2) inoculate bone meal with *B. anthracis* (Sterne strain) spores; (3) expose bone meal-spore mixture at different microwave intensities for varying periods of time; (4) rehydrate bone meal with medium and determine presence or absence of viable spores; and (5) calculate the time-dose of microwave required to inactivate spores. (funding period 5/77-1/79)

Supporting Agency:Texas A & M Univ. System

0452 EFFECTS OF LONG AND SHORT TERM EXPOSURE TO EMR ON SPECIFIC LEARNED BEHAVIOR OF ANIMALS. Gage, M. I. (EPA, Office of Res. & Development, Health Effects Res. Lab., Research Triangle Park, NC 27711).

The lowest levels of microwave exposure needed to alter the ability of rodents and primates to learn, remember, and perform specific behavioral tasks will be determined. Conditions of electromagnetic radiation exposure that alter behavioral performance and changes in conditions of exposure that alter the effects of specific power densities of radiation on behavior also will be determined. Learning and previously trained operant behavior in rodents and monkeys will be measured, and performance after single exposures or during the course of chronic exposures will be compared with baseline behavior. Current work has shown that increased ambient temperature exacerbates the effect of a given power density of microwaves on behavior of rats. The next phase will be to repeat these experiments with monkeys. (funding period 10/77-10/81)

Supporting Agency:EPA, Office Res. & Development, Health Effects Res. Lab.

0453 NONLINEAR INTERACTIONS OF ELECTROMAGNETIC WAVES WITH BIOLOGIC MEMBRANES. Barnes, F. S.; Hu, C. J.; Igor, G. R.; Bottger, B. (Univ. Colorado, Boulder Campus, Sch. Engineering & Applied Science, 1200 University Ave., Boulder, CO 80302).

The nonlinear interaction of electromagnetic (EM) waves with biologic membranes will be examined in addition to the effect of EM fields on the alignment of long chain molecules in the presence of cells. Theoretic calculations indicate that there should

be a small direct current component associated with the application of microwave and radio frequency fields that in turn would lead to an imbalance in the charged particle concentrations across the membrane. The size of this coefficient will be measured. The effect of electric fields on the orientation of long chain molecules can be observed with the use of birefringence and polarized light. This effect has been observed in plasma and, in this study, the effect will be sought in cell cultures. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, FDA

0454 HYPERTHERMIA PRODUCTION AND MEASUREMENT IN TISSUES. Christensen, D. A.; Johnson, C. C.; Durney, C. H.; Iskander, M. F.; Plenk, H. P. (Utah Higher Education System, Univ. Utah, Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Hyperthermia for cancer therapy will be generated in tissues using prototype 915 MHz microwave applicators. New applicators will be designed and fabricated at lower frequencies for better tissue penetration. A temperature profile control system will be developed and evaluated using surface cooling and microwave power control loops. In situ temperature measurements will be made by nonperturbing GaAs semiconductor fiberoptic probes. Demonstration tests of the hyperthermia system will be performed in animals to demonstrate its therapeutic potential. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, NIH, NCI

0455 EFFECTS OF 2450 MHz MICROWAVES ON THE EMBRYONIC DEVELOPMENT, IMMUNOLOGY AND FERTILITY OF JAPANESE QUAIL. McRee, D. I.; Thaxton, J. P.; Parkhurst, C. R. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The effects of microwave radiation on the embryonic development, immunology, and fertility of mature quail, which were exposed during development, are being investigated. Fertilized Japanese quail eggs were exposed to 2,450 MHz microwave radiation at an incident power density of 5 mW/cm^2 for the first 12 days of embryogenesis. The eggs were then transferred to a regular hatching incubator until hatch (17 days). Control eggs were treated identically except for the microwave exposure. No differences were found in the hatchability or development in the controls and exposed quail. The quail were then placed in regular feeding and housing facilities and were not exposed to any microwave radiation after hatch. Reproductive performance in the quail was monitored from 6 through 22 wk of age. Nonexposed controls of both sexes, as well as exposed females, performed normally. However, the exposed males did not. It was found that there were reduced sperm numbers, reduced sperm motility, and a decreased percentage of fertile eggs produced by control or exposed females when paired with exposed males. Mating behavior was normal in both exposed and nonexposed males. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0456 EFFECTS OF CHRONIC EXPOSURE TO EMR ON IMMUNE DEFENSE MECHANISMS OF ANIMALS. Smialowicz, R. J. (EPA, Health Effects Res. Lab., Durham, NC 27711).

Rats will be exposed to 100-MHz continuous wave (CW) microwave radiation in utero and/or through early life to determine whether long-term exposure causes changes in lymphocyte function. The effect of 915 MHz on the immune function of exposed rats also will be determined. Rats will be exposed daily to a forward power of 500 W at 100 MHz (CW) under controlled, environmental conditions, throughout gestation and early post-natal life. Adult rats will be exposed for at least 20 hr/day to 915 MHz for 1-2 mo. Hematologic and immunologic indices will be measured and compared between sham- and microwave-exposed rats. Complete blood counts, enumeration of frequencies of B- and T-lymphocytes in lymph nodes, nitrogen-stimulated lymphocyte responses, and growth rates in rats will be compared. Rats are presently being exposed to 100 MHz in a chronic study. These rats were exposed in utero and will be exposed through 90 days of age. Data from rats sacrificed at 22 and 42 days of age showed no differences in the hematologic and immunologic indices measured between sham- and microwave-exposed rats. Exposure of rats to 915 MHz will begin in a few months. (funding period 3/78-3/79)

Supporting Agency:EPA, Office Res. & Development, Health Effects Res. Lab.

0457 EFFECTS OF MICROWAVES ON SISTER CHROMATID EXCHANGE IN BONE MARROW CELLS OF MICE. McRee, D. I.; Livingston, G. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709).

The effects of whole body irradiation of the mouse on the number of sister chromatid exchanges (SCE) in bone marrow cells were investigated. The measurement of SCE constitutes the most sensitive indicator yet developed for detecting cytogenetic effects of mutagens and carcinogens. This assay was used to investigate potential mutagenic bioeffects of 2,450 MHz continuous wave microwave radiation by comparing the incidence of SCE in bone marrow cells of 12 exposed mice, 12 sham controls, and 12 standard controls. The animals were exposed from above for 8 hr/day to an incident power density of 20 mW/cm^2 (specific absorption rate determined to be 15.4 mW/g) for 28 days. Results after scoring more than 300 cells showed that the incidence of SCE's in the exposed group was not significantly different from that of the unexposed controls. The

value was approximately 3.0 exchanges per cell. (funding period 10/77-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0458 REMOTE STIMULATION BY RADIO-FREQUENCY TRANSMISSION. Glenn, W. W.; Gee, J. B.; Allison, T.; Goff, W. R.; Lange, R. C. (Yale Univ., Sch. Medicine, Dept. Surgery, 333 Cedar St., New Haven, CT 06510).

A method of long-term stimulation of the phrenic nerve will be developed specifically for the treatment of chronic ventilatory insufficiency. Clinical studies will include monitoring the electronic apparatus and the stimulation of the nerves by evaluating pulmonary function, nerve conduction, and diaphragm function. Of particular interest are those patients who exhibit upper airway obstruction combined with central alveolar hypoventilation. Stimulation parameters will be varied first in experimental animals and then in patients to minimize as much as possible the current delivered to the phrenic nerve and still provide adequate ventilation. Stimulation parameters will include current level, wave form, pulse interval, respiratory rate, and electrode design. Other studies will include the completion of a prototype totally implantable diaphragm pacemaker unit for patients. (funding period 1/78-12/79)

Supporting Agency:HEW, PHS, NIH, Natl. Heart, Lung & Blood Inst.

0459 X-RAY AND MICROWAVE HYPERTHERMIA FOR CANCER TREATMENT. Robinson, J. E.; Cheung, A. Y.; Samaras, G. M.; Harrison, G. H.; Sjodin, R. S. (Univ. Maryland, Baltimore Professional Sch., Sch. Medicine, Dept. Radiology, 1420 N. Charles St., Baltimore, MD 21201).

Researchers will design, construct, and test a system for simultaneously irradiating cell cultures with microwaves and x-radiation at pre-selected and controlled elevated temperatures between 37.5 and 45 C. Using this system, cells will be subjected to a range of microwave power levels at carefully controlled temperatures; the microwave power levels will range from a few mW/cm^2 to powers high enough to produce massive thermal cell killing in exposure times less than 1 min. Using cell survival and cell membrane damage as primary criteria, it will be determined whether the effects of microwave hyperthermia are different from water bath heating, and whether hyperthermia produced by pulsed microwave sources yields significantly different effects from those caused by continuous wave microwave sources operating at the same average power levels. It will also be determined whether there are significant differences between the effects of simultaneous x-irradiation and water bath heating, and simultaneous x-irradiation and microwave-induced hyperthermia. It is essential to determine the effects of strong electromagnetic fields (high microwave power) at elevated temperatures, since short exposures at high instantaneous power levels are being used to develop shaped thermal fields for hyperthermal treatment of cancer patients. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, NIH, NCI

0460 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P. (Utah Higher Education System, Univ. Utah, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The behavioral and biologic effects of resonant electromagnetic power absorption in rats will be determined in order to develop realistic exposure criteria for military personnel. The parallel-plate waveguide will be used to generate plane waves for exposure of the experimental animals. Exposures will be made with animals oriented along the E, H, and K axes. Frequency will be established based on the frequency of peak absorption; frequencies of 0.5, 0.75, 1.0, 1.25, and 1.5 times this resonant frequency will be used. (funding period 5/74-n/a)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command

0461 INTERACTION OF DNA DOUBLE HELIX WITH E.M. FIELDS. Prohofsky, E. W.; Van Zandt, L. L.; Ascarelli, G. (Purdue Univ. Sch. Science, Dept. Physics, Executive Building, West Lafayette, IN 47907).

The interaction of DNA double helices with an electromagnetic field will be calculated. An effective charge model calculation, which should be a reasonable approximation for both far infrared and microwave regions, will be employed. The models will be refined by comparison with infrared absorption observations. The refined model will be used to predict microwave absorption. Comparison of these predictions with observed microwave effects will be carried out and correlations examined. Methods will be explored to determine the mechanism by which microwave action on vibrational modes can affect biologic processes. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, FDA

0462 IDENTIFICATION OF PERIPHERAL AND CENTRAL RECEPTORS MEDIATING THE EFFECTS OF MICROWAVE RADIATION ON THE BRAIN. Wilson, B. (Res. Triangle Inst., P.O. Box 12194, Durham, NC 27709).

One of the primary reported effects of microwave radiation is on the central nervous system. Basic studies to determine the interaction mechanisms are required. Recent findings have covered some deficits in the present understanding of the mechanisms of effects of microwave radiation on the activity of

the auditory system. Specifically, the thermo-acoustic expansion pulse hypothesis cannot account for the observed effect of pulsed microwave radiation on auditory nerve resulting from direct stimulation of cochlear hair cells. One set of experiments proposed is designed to elucidate the mechanisms of these effects of microwave radiation on auditory activity. Recordings of response of single units in auditory nerve and cochlear nucleus to microwave and acoustic stimuli will be used as the primary method for the first set of experiments. The ^{14}C-labeled 2-deoxyglucose method will also be used in some instances, however, to corroborate and complement the results obtained with the electrophysiologic method. An additional set of experiments is proposed to detect effects of nonionizing radiation on the activity of brain structures other than nuclei of the auditory system. For these experiments, the ^{14}C-labeled 2-deoxyglucose method will be used. Because the method allows for simultaneous, in vivo determination of glucose consumption at individual structures of the brain, effects on the activity of nuclei in sensory systems resulting from stimulation of peripheral receptors can be identified and separated from pervasive effects on brain activity resulting from radiation-induced shifts in the environment of central neurons. Possible effects on brain activity resulting from stimulation of vestibular and hypothalamic receptors will be evaluated, as will possible effects resulting from radiation-induced alterations in the permeability of the blood-brain barrier and in the binding of calcium ions in cerebral tissue. (funding period 00/78-n/a)

Supporting Agency:EPA, Office Energy Minerals & Industry

0463 EFFECT OF ENVIRONMENTAL AGENTS ON ONTOGENESIS AFTER PARENTAL EXPOSURE. Staples, R. E.; Cook, R. O.; McRee, D. I.; Nawrot, P. S. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709).

This project will determine the developmental toxicity and teratogenic potential of selected environmental agents on mammals by application of the test agents to the parent(s) before mating or to the dam during gestation. Studies will employ various types of noise up to 130 dB, microwaves, and solvents. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0464 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE RADIATION. Justesen, D. R.; Levinson, D. M. (Univ. Kansas Medical Center, Dept. Psychiatry, Sch. Medicine, 39th St. & Rainbow Blvd., Kansas City, KS 66103).

In progress is a behavioral-developmental-longevity study of C3H mice that were sham radiated or microwave radiated in utero (three exposures between days 9 through 15 of gestation: 2.45 GHz at 60-Hz sine modulation, 43-mW/g whole-body dose rate for 20 min in a multimode cavity; dams' LD$_{02}$ = 10). The following observations have been made: (1) mortality of radiated pups of surviving dams was higher than that of controls, but there is little difference to date in death rates of weaned animals; and (2) indices of development (e.g., eye-opening, latency, growth of pelt, body mass) have been essentially the same for radiated and control animals. Future research will consider differences, if any, in longevity of animals and rate of development of spontaneous tumors in this mammary-tumor-prone strain of mouse. (funding period 9/77-8/79)

Supporting Agency:HEW, PHS, FDA, BRH

0465 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Rutgers State Univ., New Brunswick Campus, Dept. Environmental Science, Agricultural Experiment Station, Old Queens Building, New Brunswick, NJ 08903).

The investigators will evaluate the effect of chronic low level microwave exposures on the mammalian anterior lens as they relate to cataract formation at various age levels. Fundamental data will be obtained relevant to the understanding of the chemical and biological processes involved in the interaction of radiation with organisms. The results will be used to develop practical means to inhibit, neutalize, or reverse the biologic damage caused by radiation. The mitotic index of chosen mammalian species of different age groups will be measured after various exposure periods, using a tritiated thymidine-autoradiographic technique, followed by observing cataract producing doses. The relative radiation sensitivity of experimental animals (e.g., rats) with or without treatment by radiated gas will be determined by standard procedures. Preliminary results on the test animals showed no significant changes in thyroid function following single or multiple exposures at various power levels. (funding period 7/71-6/81)

Supporting Agency:New Jersey State Government

0466 EFFECTS OF MICROWAVE IRRADIATION ON EMBRYONIC BRAIN TISSUE. Rioch, D. M. (Inst. Behavioral Res., Inc., 2429 Linden Lane, Silver Spring, MD 20910).

See Current Research 0418 for description of this research. (funding period 4/77-cont.)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Environmental Protection Res. Div.

0467 EVALUATION OF MICROWAVE OVENS AS A POTENTIAL METHOD OF STERILIZATION. Lyon, T. C.; Brunner, D. (U.S. Dept. Defense, Army, Medical Res. & Development Command, Preventive Dentistry Div., Washington, DC 20012).

See Current Research 0415 for description of this research. (funding period 6/78-6/79)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Inst. Dental Res.

0468 MINIATURE OMNI-DIRECTIONAL RF MONITOR PROBE. Ireland, W. C. (Westinghouse Electric Corp., P.O. Box 746, Baltimore, MD 21203).

See Current Research 0412 for description of this research. (funding period 4/77-n/a)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command

0469 NON-IONIZING, ELECTROMAGNETIC RADIATION--INFLUENCE ON CANCER CELLS. Riley, V. (Pacific Northwest Res. Foundation, Dept. Microbiology, 1102 Columbia St., Seattle, WA 98104).

No descriptive information is available. (funding period 12/78-11/79)

Supporting Agency:American Cancer Soc., Inc.

6022 DIELECTRIC BEHAVIOUR OF BIOLOGICAL MOLECULES IN SOLUTION. *(Eng.)* Grant, E. H.; Sheppard, R. J.; South, G. P. (Oxford: Oxford Univ. Press): 237 pp.; 1978. (353 refs)

A monograph on the dielectric behavior of biologic molecules in solution is presented. The book is divided into six chapters covering the following general subject areas: the role of dielectric studies in biophysics; dielectric theory; the measurement of permittivity; an analysis of experimental results; water and small biologic molecules; and proteins and larger structures. The book contains an extensive bibliography and is indexed by both author and subject. An example of how the knowledge of the dielectric properties of tissue can be used to evaluate the possibility of solving problems of biologic or medical importance is illustrated in connection with the use of microwaves and radiowaves for producing heat in tissues in the treatment of various diseases. The energy absorbed by a given tissue depends on the permittivity and conductivity at the frequency of radiation being used. If these electrical parameters are known, it is possible to build a phantom body of the appropriate shape to measure the isopower lines and hence evaluate the distribution in temperature throughout the medium. In connection with the use of radiowave- and microwave-induced hyperthermia for the treatment of malignant disease, there are reasons for believing that the dielectric behavior of normal and malignant cells may be sufficiently different to be optimistic about this therapeutic approach. Although a considerable amount of work will have to be done before the precise differences between the water structure in normal and malignant cells are understood, the method of external beam hyperthermia offers encouraging possibilities in the treatment of cancer. Studies of the dielectric properties of molecules and tissues are also important in relation to hazards of microwave radiation. For example, one form of biologic damage that can be caused by microwaves of appropriate intensity is cataract. The lens of the eye is vulnerable to microwave injury partly because of its poor blood supply resulting in fewer paths for heat transfer. It is also significant that the lens has a higher proportion of water, both free and bound, which causes the energy to be readily dissipated in the first place. It is suggested that future progress of dielectric methods in biophysics will depend on the ability to devise methods that measure rapidly the permittivity and conductivity of conductive solutions over a wide frequency range and on the understanding of the local structure of the region surrounding a biologic molecule in solution.

6023 HEALTH ASPECTS OF RADIO FREQUENCY AND MICROWAVE EXPOSURE: PART 2. *(Eng.)* Stuchly, M. A. (Radiation Protection Bureau, Health and Welfare Canada, Ottawa, Canada). 107 pp.; 1978. [available through Information Directorate, Dept. of Natl. Health and Welfare, Brooke Claxton Building, Ottawa K1A 0K9, Canada. Environmental Health Criteria Document No. 78-EHD-22]. (313 refs)

A comprehensive review of the health implications of exposure to radio frequency and microwave radiation in the frequency range of 10 MHz-300 GHz is presented. The biologic effects of such radiation are discussed in terms of human perception, hyperthermia, ocular effects, cellular effects, hematologic and immunologic effects, reproductive and developmental effects, cardiovascular effects, neuroendocrinologic effects, nervous system and behavioral effects, excitable cell systems, and the blood-brain barrier system. Epidemiologic and clinical studies on the effects of microwave and radio frequency radiation are also reviewed along with the setting of radiation protection standards. Major difficulties in assessing potential health hazards of human exposure to radio frequency and microwave radiation and in quantifying the results of the experiments with animals stem from the complex relationship between the exposure conditions and absorbed energy. Reliable methods of measuring the energy dose routinely do not exist. There appears to be a strong consensus among scientists that the great majority of the effects of exposure to radio frequency and microwave radiation is thermal in nature. Two new interesting effects investigated in the last few years, which may lead to establishing interaction mechanisms and a better understanding of observed effects, are changes in efflux of calcium ions and blood-brain barrier permeability. Calcium ion efflux through brain membranes is affected by extremely low frequency fields (6-20 Hz) or radio frequency fields that are amplitude modulated at these frequencies. Changes in the permeability of the blood-brain barrier have been observed at relatively low power density levels (about 10 mW/cm^2) at frequencies close to the resonant frequency of the rat. Further progress has been made in obtaining quantitative data on the effects of exposure to fields at relatively low average power densities (about 10 mW/cm^2) on the neuroendocrine and central nervous system of small animals and on fetal development following irradiation during critical stages of gestation.

6024 RETARDED TUMOR GROWTH AND GREATER LONGEVITY IN MICE AFTER FETAL IRRADIATION BY 2450-MHZ MICROWAVES. *(Eng.)* Preskorn, S. H. (Dept. Psychiatry, Univ. Kansas Sch. Medicine, Kansas City, KS 66103); Edwards, W. D.; Justesen, D. R. *J Surg Oncol* 10(6): 483-492; 1978. (36 refs)

The effect of fetal irradiation by 2,450-MHz microwaves on tumor growth in conventional CFW strain mice was studied in two separate experiments. In the first study, 48 mice were given four in utero treatments for 20 min/day with either sham radiation or with 2,450 MHz microwaves at a dose of 35 mW/g during days 11-14 of gestation. On day 16 postpartum, all of these mice were implanted with a homogenate of a lymphoreticular cell sarcoma. Commencing on day 19, they underwent a series of 36 daily exposures to the sham or microwave radiation. Fetal exposure to radiation, which elevated dams' colonic temperatures by an average of 2.24 C, was associated with a 13% incidence of tumors

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compared with a 46% incidence for fetally sham-irradiated mice. In a second experiment, all microwave-induced hyperthermal treatments were administered in utero; 84 CFW mice were given four radiation treatments in utero (35 mW/g for 20 min) on days 11-14 of gestation, and 60 mice were sham-irradiated in utero according to the same schedule. All of these mice were implanted with tumor homogenate on day 16 postpartum and were observed for 36 mo. At 2.5 mo after tumor implantation, the percentage of fetally irradiated mice with tumors was 15% compared with 37% for sham-irradiated controls. Subsequently, the difference narrowed; after the 4th mo, the final percentage of fetally irradiated mice with tumors (46%) exceeded that of controls (40%) slightly. Both tumor-bearing and tumor-free animals that had been irradiated as fetuses lived longer on the average than respective controls. Long-term augmentation of immunocompetency by in utero hyperthermia was believed to be responsible for the delayed induction of tumors and for the enhancement of survival.

6025 POTENTIAL TEMPERATURE RISE INDUCED BY ELECTROMAGNETIC FIELD IN BRAIN TISSUES. *(Eng.)* Kritikos, H. N. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19174); Schwan, H. P. *IEEE Trans Biomed Eng* BME-26(1): 29-34; 1979. (12 refs)

The differential temperature rise induced by a 1,000-MHz electromagnetic field in a spherical region simulating a potential hot spot in the central region of a human head was determined, taking into account heat conduction and heat convection due to blood flow. For a heat deposition rate of 10 mW/g in a hot spot of 1 cm in radius, the differential temperature rise over the ambient tissues and blood was approximately 0.5 C. This was an interesting result considering that the heating potential in the hot spot region was larger than that occurring at the surface of the test object by a factor of 10-15. The reason for this relatively small temperature rise was the effect of blood circulation, which tends to wash out the temperature differences. The case under consideration involved an energy deposition of 10 mW/cm^3 in the hot spot, which corresponded to an incident flux of about 10 mW/cm^2 for the case of a cat brain as previously reported. For a given incident flux, the heating potential in the hot spot reduced rapidly with increasing head radius, and temperature elevations for man in the center of the head were much lower.

6026 RADIATION AND MICROWAVE THERAPY IN THE TREATMENT OF ADVANCED CANCER. *(Eng.)* Hornback, N. B. (Dept. Radiation Oncology, Indiana Univ. Sch. Medicine, 1100 W. Michigan St., Indianapolis, IN 46202); Shupe, R.; Shidnia, H.; Joe, B. T.; Sayoc, E.; George, R.; Marshall, C. *Radiology* 130(2): 459-464; 1979. (38 refs)

The effect of microwave-induced heat prior to radiotherapy (H + RT) was compared with that after radiotherapy (RT + H) in a nonrandomized study of 72 evaluable patients (38 males and 34 females; ages, 4-85 yr) with advanced cancer that did not respond to previous treatment. The histology of the cancer was squamous cell in 33 patients, adenocarcinoma in 25, malignant melanoma in 3, and miscellaneous in 11 patients. The primary tumor site was head and neck in 23 patients, gastrointestinal tract in 18, gynecologic in 16, breast in 4, genitourinary tract in 3, central nervous system in 2, bone in 2, and miscellaneous in 4 patients. Heat treatments were performed for 30 min either before or after radiotherapy using a standard European diathermy machine operating at a frequency of 433.92 MHz. Skin temperature measurements in the treatment port area increased 2.8-3.3 C; the highest intraoral temperature obtained was 40.2 C. Radiation doses varied from 50-600 rads/day and total tumor doses from 3,000-6,500 rads. Among 60 patients treated with H + RT, only 32 (53%) achieved a complete objective response compared with 11 of 12 (92%) who were treated with RT + H. There are 12 of 72 patients (17%) who are alive without any evidence of disease from 4-14 mo after therapy; 20 of 72 patients (26%) are alive with disease (treated area controlled) from 2-22 mo after therapy. No adverse reactions developed during microwave therapy, and no unusually severe normal tissue reactions were noted in any patients beyond those expected with radiation alone.

6027 STUDIES ON BLOOD-BRAIN BARRIER PERMEABILITY AFTER MICROWAVE-RADIATION. *(Eng.)* Merritt, J. H. (Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks AFB, TX 78235); Chamness, A. F.; Allen, S. J. *Radiat Environ Biophys* 15(4): 367-377; 1978. (10 refs)

The effects of pulsed or continuous wave (CW) microwave radiation at frequencies of 1.2 or 1.3 GHz on blood-brain barrier permeability were examined in male Sprague Dawley rats. At a frequency of 1.2 GHz, the radiation was delivered at a pulse repetition rate of 1,000 pulses/sec, a pulse width of 0.5 msec, and peak powers ranging from 2-75 mW/cm^2. For radiation at 1.3 GHz, the radiation was pulsed at 1,000 pulses/sec over various power densities at a pulse width of 10 μsec. Some animals were irradiated in the CW mode with 1.3-GHz radiation. No transfer of parenterally-administered (femoral vein) fluorescein across the blood-brain barrier of rats was observed after 30 min of 1.2-GHz radiation at power densities ranging from 2-75 mW/cm^2. Increased fluorescein uptake was seen only when the rats were made hyperthermic in a warm air environment. When the effect of 20 min of exposure to 1.2-GHz radiation on the uptake of radiocarbon-labeled mannitol in the hypothalamus was examined, none of the radiation regimens used increased mannitol uptake into the brain parenchyma. When rats were irradiated at 1.3 GHz for 35 min at power densities of 0.1, 1, 10, and 50 mW/cm^2 in the CW mode, no difference in uptake of labeled mannitol was observed at any power level. An attempt to alter the permeability of the blood-brain barrier for serotonin with microwave radiation was also unsuccessful. Only in animals made hyperthermic

in a warm air environment was any uptake of the neurotransmitter noted. It appears that the brain must be made hyperthermic for changes in permeability of the barrier induced by microwave radiation to occur.

6028 ANENCEPHALUS, DRINKING WATER, GEOMAGNETISM AND COSMIC RADIATION. *(Eng.)* Archer, V. E. (Div. Surveillance, Hazard Evaluation and Field Studies, Natl. Inst. Occupational Safety and Health, Salt Lake City, UT 84101); Elwood, J. M. *Am J Epidemiol* 109(1): 88-99; 1979. (49 refs)

Mortality rates from anencephalus in Canadian cities over the period 1950-1969 were found to be correlated with city growth rate, horizontal geomagnetic flux (which is directly related to cosmic radiation intensity), and magnesium content in drinking water. City size appeared to have no direct association with deaths from anencephalus but did have an indirect association through its relationships with horizontal geomagnetic flux and city growth factor. An association of magnesium in tap water with city growth factor appeared to be just as strong as its association with anencephalus. An analysis of rates of anencephalus with simultaneous stratifications for both city growth factor and horizontal geomagnetism produced a surprisingly good separation of the associations of the two factors, yielding statistically significant differences. The analysis revealed a strong, possibly linear, relationship between low horizontal geomagnetic flux and high anencephalus rates when the city growth factor was low and consistently low rates of anencephalus when the city growth factor was high, regardless of horizontal geomagnetic flux. The hypothesis that anencephalus results from genetic damage produced by background radiation during the parent's lifetime is discussed, and it is concluded that the findings of the present study are consistent with the concept that background radiation has definite biologic effects on man. In a followup letter to the editor concerning this study, the negative association between anencephalus mortality and horizontal geomagnetic flux is refuted.

6029 LOW-INTENSITY MICROWAVE RADIATION AND THE VIRULENCE OF *AGROBACTERIUM TUMEFACIENS* STRAIN B6. *(Eng.)* Moore, H. A. (Dept. Physics, Bradley Univ., Peoria, IL 61625); Raymond, R.; Fox, M.; Galsky, A. G. *Appl Environ Microbiol* 37(1): 127-130; 1979. (13 refs)

The effect of low-intensity microwave radiation on the virulence of *Agrobacterium tumefaciens* strain B6 was investigated. When 48-hr cultures of virulent cells of *A. tumefaciens* strain B6 were exposed to 10,000-MHz radiation at an intensity of 0.58 mW/cm^2 for 30-120 min, their ability to produce tumors on potato and turnip disks was reduced by approximately 30-60%. To determine if this microwave-induced change in virulence was unique to strain B6, a similar microwave treatment was given to *A. tumefaciens* strain TT-107; a similar reduction in virulence of TT-107 was observed. The microwave exposure did not affect the viability of these bacteria or their ability to attach to a tumor-binding site nor did it induce thermal shock. The loss of virulence induced by microwave radiation was completely reversible within 12 hr after exposure. However, only about 75% of the virulence was restored when these bacteria were kept at 4 C for 12 hr after radiation exposure. Since restoration to full virulence was slowed when the bacteria were held at 4 C, the possibility that one or more metabolic processes affecting virulence are temporarily altered by microwave exposure cannot be excluded.

6030 BIOLOGICAL EFFECTS OF HIGH STRENGTH ELECTRIC FIELDS ON SMALL LABORATORY ANIMALS. ANNUAL REPORT: APRIL 1977 TO MARCH 1978. *(Eng.)* Battelle Pacific Northwest Laboratories. (Battelle Pacific Northwest Labs., Richland, WA 99352). 218 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. PC A10/MF A01). (11 refs)

The results of exposing rats and mice to 60-Hz electric fields at 100 kV/m for up to 60 days are reported. The exposures produced no statistically significant, reproducible effects except in behavioral experiments. Rats, given a choice, spent more time out of the electric field than in it at a field strength of 90 kV/m or greater. The results of three experiments showed trends that suggest the possibility of the following effects: decreased cell-mediated immunity, increased prostatitis, and increased excitability of synapses. In-depth studies are in progress to evaluate these potential effects. One measure of delayed hypersensitivity response (skin thickness) to keyhole limpet hemocyanin was decreased, but another (reaction diameter) was unchanged in exposed mice. In a replicate experiment, the effect was not statistically significant; however, the trend was consistent, i.e., the skin thickness in exposed mice was 22% less than that of sham-exposed animals. This potential effect will be studied in another experiment. It is possible that longer exposure durations (e.g., 4 mo) may enhance subtle effects not evident with the 30- and 60-day exposures employed in this study.

6031 EXPOSURE OF PRIMATES FOR ONE YEAR TO ELECTRIC AND MAGNETIC FIELDS ASSOCIATED WITH ELF COMMUNICATIONS SYSTEMS. *(Eng.)* Grissett, J. D.; Kupper, J. L.; Kessler, M. J.; Brown, R. J.; Prettyman, G. D.; Cook, L. L.; Griner, T. A. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). 315 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD-A055 399/0GA]. (12 refs)

Thirty experimental rhesus monkeys (matched with 30 controls) were exposed for 1 yr to electric and magnetic fields similar to or greater than those that would be experienced by humans living near the antenna of the Navy's proposed extremely low frequency (ELF) submarine communications system.

The experimental animals were exposed to fields equivalent in waveform to those experienced by living organisms in contact with the soil surface directly above the buried ELF antenna. The magnitude of the magnetic field (2 G) was 10 times greater than the average field along the ELF antenna. The electric field (20 V/m) was over 300 times greater than at the soil surface above and along the antenna, and it was two times greater than at the soil surface near the ground terminal. The electric field was applied to the animal via stainless steel bars that formed the walking surface of the floor of the environmental chamber. The ELF fields were on for 22 hr daily. The most significant finding was the difference in rate of weight gain between exposed and control male monkeys. The exposed males gained weight at a slightly faster rate than the control males, and at the end of 1 yr were approximately 11% heavier than the controls. The difference in weight was not accompanied by an increase in bone length measurements. The linear body measurement showing the most agreement with the growth rate difference was chest circumference. Blood urea nitrogen was lower ($p=0.05$) in exposed males; this is consistent with the growth rate findings. Gamma-glutamyl transpeptidase (GGTP) was lower in exposed males ($p=0.06$), and although consistently lower in exposed females, the difference was not significant ($p=0.37$). It appeared that the GGTP and growth rates observed in this study were consistent. Three serum enzymes (glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, and creatine phosphokinase) were significantly ($p=0.05$) lower in exposed males than in control males for day plots in wk 1. Serum triglycerides were lower in exposed females ($p=0.05$ rank) than in control females. Respiratory quotient was also lower in the exposed females ($p=0.04$). The significance of these differences are at present unknown. There is no indication that the above findings have any adverse clinical significance, and both groups of animals appear healthy. It is recommended that these animals should continue to be exposed and that the data collection protocol should concentrate on identifying the mechanisms for these effects so that the long term effects can be predicted on the basis of physiologic theory. The sexual specificity of these results suggests that endocrine involvement should be studied extensively.

6032 OBSERVATIONS OF MOUSE FETUSES AFTER IRRADIATION WITH 2.45 GHZ MICROWAVES. *(Eng.)* Berman, E. (Health Effects Res. Lab., Experimental Biology Div. MD-72, Environmental Res. Center, EPA, Research Triangle Park, NC 27711); Kinn, J. B.; Carter, H. B. *Health Phys* 35(6): 791-801; 1978. (22 refs)

The effect of exposing pregnant CD-1 mice to 2.45-GHz continuous wave microwave radiation for 100 min daily at power densities ranging from 3.4-28 mW/cm^2 on gross external morphology of near-term fetuses was studied. At the highest power density exposure, the mean live fetal weight per litter was decreased significantly (0.89 ± 0.13 g versus 0.97 ± 0.15 g for sham-irradiated controls). The mean value for these irradiated litters was also lower than the mean of any other sham or irradiated group studied. Although the occurrence of cranioschisis was not different statistically at any one power density, there was a significantly higher occurrence in the irradiated group (sham = 0, irradiated = 7) when the occurrence of this anomaly was summed by all sham or irradiated groups. The total numbers of sham or irradiated litters with any anomaly were significantly different, with more than twice as many anomalous litters being seen in the irradiated group. Exposure of the dams for 100 min at the above power densities did not appear to be significant thermally. Estimates of the mean dose rate as determined with twin-well calorimetry ranged from 2.0-22.2 mW/g. It appears that microwaves at the range used in this study, especially at a power density of 28 mW/cm^2, are embryopathic.

6033 EFFECT OF MAGNETIC FIELD ON THE RECOMBINATION FLUORESCENCE OF PHOTOSYNTHETIC BACTERIA. *(Rus.)* Vozniak, V. M. (Inst. Photosynthesis, USSR Acad. Sciences, Pushchino, Moscow Oblast, USSR); Elfimov, E. I.; Proskuriakov, I. I. *Dokl Akad Nauk SSSR* 242(5): 1200-1203; 1978. (11 refs)

The effect of an electromagnetic field (0-900 G) on the recombination fluorescence of *Rhodopseudomonas sphaeroides* (wild strain), *Rhodospirillum rubrum*, and *Rh. sphaeroides* R-26 cells was studied. The electromagnetic field increased the fluorescence intensity of all cells; the increase was most pronounced in the *Rh. sphaeroides* (wild strain), and least pronounced for *Rh. sphaeroides* R-26. The fluorescence intensity increased with increasing field intensity, especially in the lower field intensity range.

6034 SURVIVAL OF MICROBIAL FILMS IN THE MICROWAVE OVEN. *(Eng.)* Page, W. J. (Dept. Microbiology, Univ. Alberta, Edmonton, Alberta T6G 2E9, Canada); Martin, W. G. *Can J Microbiol* 24 (11): 1431-1433; 1978. (7 refs)

The survival of microbial films in a Toshiba model ER776BT microwave oven operating at a frequency of 2,450 MHz and at a full power of 650 W was investigated. Air-dried films of *Escherichia coli*, *Saccharomyces cerevisiae*, and *Bacillus subtilis* spores on Amicon Microporous filters that were exposed to the above irradiation showed a 5-, 2-, and 0-log reduction of viable organisms, respectively. Suspensions of cells or spores in phosphate buffer that were irradiated under similar conditions showed 8 logs of killing within 30 sec for *S. cerevisiae*, 45 sec for *E. coli*, and within 10 min for *B. subtilis* spores. Complete killing of the vegetative cell suspensions was obtained with 60 sec of exposure and within 12 min of exposure of the spore suspension. These results are consistent with those of other investigators who showed that the death of microbes in suspension during microwave irradiation was equivalent to that expected by conventional heating. The microbes in the films

probably also suffer thermal death, but in their dehydrated state the heating achieved is probably less rapid and severe. It has been suggested that the object exposed to microwaves must be at least one-tenth the size of the wavelength to absorb microwave energy; this would make most microbes too small to act as individual targets for microwaves. However, the data in this study show that death does occur in the microbial films. These death rates probably are the result of exposure to the moist heat generated from the heated load. These results indicate the importance of proper sanitation of the interior of the microwave oven, especially in self-service areas where handling the oven is increased.

6035 EFFECT OF MICROWAVE RADIATION ON CEREBRAL CATECHOLAMINE METABOLISM. *(Rus.)* Grin', A. N. (Biologic and Hygienic Res. Lab., A. N. Marzeev Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR). *Vrach Delo* (10): 129-130; 1978. (7 refs)

The effect of microwave irradiation (wavelength 12.6 cm, 50 and 500 $\mu W/cm^2$, 7 hr/day for 5-30 days) on the cerebral catecholamine level was studied in 132 male albino rats with an initial body weight of 180-450 g. In the groups exposed to 50 $\mu W/cm^2$, the epinephrine level was increased after 20-days exposure (0.05 µg/g compared with 0.04 µg/g measured before exposure and after 30-days exposure). The norepinephrine, dopamine, and dopa levels were slightly but significantly increased throughout the exposure. In the groups exposed to 500 $\mu W/cm^2$, the epinephrine, norepinephrine, and dopamine levels showed a significant increase during the first 10 days of exposure, which was followed by a steady decline to the end of the experiment. The decline in the dopa level was not preceded by any initial increase. These findings indicate the exhaustion of the sympatheticoadrenal system during long-term microwave irradiation with 500 $\mu W/cm^2$, and the stimulating effect of irradiation with 50 $\mu W/cm^2$.

6036 MAGNETIC FIELD EFFECTS ON RADICAL PROCESSES IN BIOLOGIC MEMBRANES. *(Ukr.)* Kadnikov, O. G. (Kharkov State Univ., Kharkov, USSR); Zaliubovs'kii, I. I.; Kobizs'kii, V. I.; Vitovtova, T. I. *Dopov Akad Nauk Ukr RSR* (10): 927-930; 1978. (12 refs)

The suitability of using magnetic fields (MF) to study reaction kinetics and mechanisms, and the properties of radicals in biologic membranes was analyzed. The effect of MF on the rate of oxygen consumption during auto-oxidation of unsaturated fatty acids was studied in model membrane structures, e.g., liposomes obtained by ultrasonic treatment of lipids from bull brain white matter. Changes in the reaction kinetics of free-radical oxidation of lipids (oxygen consumption, peroxide radical formation) altered the macroscopic characteristics (viscosity, surface tension) of the biomembrane lipid component exposed to a MF. The effect of MF on enzymes in biomembranes was studied based on the riboflavin (RF) oxidation rate in a constant MF. The concentration of the intermediary product decreased as a function of MF intensity. The increase in the oxidation rate of the reduced forms $RF \cdot H_2$ was related to MF sensitivity of the stages of intermediary radical $RF \cdot H_2$ interaction with the superoxide radical O_2^-; the magnetic effect was determined by a Δg mechanism. The effect of MF on electron transfer in the respiratory chain was studied in rat liver mitochondria; respiration was inhibited by 37 ± 5% in a 9-kE MF. This may be related to the participation of enzymes with metals of variable valence. Transformation of free radicals occurring in a MF was also studied during gamma-irradiation of a human serum albumin solution with ^{22}Na and ^{60}Co. A 9-kE MF increased the effectiveness of radical pair recombination by 1.8 ± 0.2%. This may explain the protective properties of a MF during the exposure of a living organism to ionizing radiation.

6037 EXPERIENCE WITH THE USE OF GLUCOCORTICOSTEROIDS AND MAGNETIC FIELDS IN THE INTENSIVE THERAPY OF SEVERE FORMS OF VIRAL HEPATITIS. *(Rus.)* Il'inskii, Iu. A. (Central Scientific Res. Inst. Epidemiology, USSR Ministry of Public Health, Moscow, USSR); Syzdykov, M. S.; Zhumanbaev, K. A.; Shvedova, A. I.; Kuz'min, A. I. *Sov Med* (9): 72-74; 1978. (14 refs)

The treatment of 18 patients with severe viral hepatitis with precoma or coma is described. In addition to basic therapy (glucose, Ringer's solution, potassium chloride, diuretics, Trasiol, Contrical, cardiac glycosides, neomycin or monomycin) all patients received prednisolone (360 mg/day), hydro-ortisone (1,000 mg/day), and adresone (300 mg/day). Ten of the 18 patients were clinically cured by this therapy. Five other patients who did not respond to this therapy subsequently were exposed to magnetic fields (450-550 Oe, 2x20 min/day for 1 wk, then 20 min/day for 8-10 days). Three patients had precoma and two were comatose. All five patients were cured clinically; the time necessary for the cure was 10-15 days shorter than in the 10 other patients who did not receive magnetic field therapy. The pigment metabolism, thymol test, and ALAT activity dropped to normal levels by the end of the magnetic field treatment. The findings indicate the therapeutic effectiveness of magnetic fields in viral hepatitis.

6038 EFFECTS OF HEAVY METAL IONS AND ELECTRICAL FIELD ON THE ELECTROKINETIC PROPERTIES OF MICROBIAL CELLS. *(Rus.)* Kul'skii, L. A. (Inst. Colloid and Water Chemistry, Ukrainian SSR Acad. Sciences, Kiev, USSR); Deinega, Iu. F.; Savluk, O. S.; Ul'berg, Z. R.; Marochko, L. G.; Dem'ianenko, A. P. *Dokl Akad Nauk SSSR* 244(1): 217-219; 1979. (3 refs)

The effects of Ag^+ and Cu^{++} ions and their combination with an electromagnetic field (10-30 V/cm, length of exposure 30 min) on the electrokinetic characteristics and survival of *Escherichia coli*

commune 734 were studied. The electrophoretic mobility of the cells increased with increasing field intensity. Exposure to the electric field increased the antimicrobial effect of Ag^+; at an Ag^+ concentration of 0.001 mg-ion/l, the cell count was 980/ml after exposure to 10 V/cm, 40/ml after exposure to 20 V/cm, and 2/ml after treatment with 30 V/cm. In a concentration range of 0.001-0.2 mg-ion/l, Cu^{++} ions alone had no antimicrobial effect, but an antimicrobial effect was seen in the combination of Cu^{++} ions (0.05-0.1 mg-ion/l) with electrical field (30 V/cm). The increased antimicrobial effect of Ag^+ and Cu^{++} ions in the electrical field was due to intensified sorption as a result of the increased negative charge of the cells.

6039 OCCUPATIONAL PATTERNS OF PATIENTS WITH LEUKEMIA AND LYMPHOGRANULOMATOSIS (ACCORDING TO DATA FOR THE KUIBYSHEV REGION). *(Rus.)* Plotnikov, Iu. K. (First Dept. Hosp. Therapy, D. I. Ul'ianov Kuibyshev Medical Inst., Kuibyshev, USSR). *Probl Gematol Pereliv Krovi* 23(1): 18-21; 1978. (26 refs)

The occupational pattern of 1,161 patients with leukemia or lymphogranulomatosis was studied by comparison with 1,215 matched non-cancer patients living in the same area. Patients exposed to ultra high frequency (UHF) or super high frequency (SHF) fields or ionizing radiation accounted for 2% of all patients with leukemia and lymphogranulomatosis, but only 1% of the controls were exposed to such factors ($p<0.001$). This group included 15 patients exposed to UHF and SHF fields, and 8 exposed to ionizing radiation. Seven patients had acute leukemia, 6 had chronic myelogenous leukemia, 6 had lymphocytic leukemia, and 4 had lymphogranulomatosis. The length of occupational exposure was 3-7 yr in 5 cases, 8-12 yr in 7, and over 12 yr in 11. The relative risk compared with the controls was 2.4 for acute leukemia, 2.1 for chronic myelogenous leukemia and lymphogranulomatosis, and 1.5 for chronic lymphocytic leukemia. There was no significant difference between the subgroups exposed to UHF or SHF fields and ionizing radiation in terms of relative risk.

6040 EFFECT OF ALTERNATING MAGNETIC FIELDS ON THE ACTIVITY OF CARBOHYDRATE METABOLIZING ENZYMES AND TISSUE RESPIRATION IN TESTICULAR TISSUE. *(Rus.)* Udintsev, N. A. (Tomsk Medical Inst., Tomsk, USSR); Khlynin, S. M. *Ukr Biokhim Zh* 50(6): 714-717; 1978. (25 refs)

The effect of single-time (24 hr) and repeated (6.5 hr/day for 5 days) exposure to an alternating magnetic field (50 Hz, 200 Oe) on the activity of carbohydrate metabolizing enzymes and oxygen consumption of testicular tissue was studied in 100 male albino rats up to 28 days after exposure. Following single-time exposure, there was no significant change in the cytoplasmic hexokinase activity and in the succinate dehydrogenase activity of the mitochondria, while the hexokinase activity of the mitochondria was decreased significantly compared with the non-exposed controls on day 2 (15.4 nmoles of NADPH per mg of protein per min versus 20 in the controls), the malate dehydrogenase activity of the mitochondria was reduced on day 2 (432 nmoles of NADH per mg of protein per min compared with 584 in the controls), and the cytochrome oxidase activity of the mitochondria was reduced on day 1 (4.2 U/mg/min versus 5.7 in the controls). The cytoplasmic glucose-6-phosphate dehydrogenase activity was decreased on day 1 (6.3 nmoles of NADPH per mg of protein per min versus 8.3 in the controls), but a significant increase was seen 1 hr after exposure. The cytoplasmic lactate dehydrogenase activity was increased on day 2 (685 nmoles of NADH per mg of protein per min versus 532 in the controls). Following repeated exposure, there were no significant changes in the cytoplasmic hexokinase activity, but the mitochondrial hexokinase activity was decreased 1 hr and 2 days after exposure (18.2 and 15.9 nmoles of NADH per mg of protein per min, respectively, versus 25.6 in the controls). The cytoplasmic glucose-6-phosphate dehydrogenase and mitochondrial cytochrome oxidase activities were also decreased significantly 1 hr and 2 days after exposure, and the malate dehydrogenase activity in the mitochondria was reduced 1 hr after exposure. The succinate dehydrogenase activity of the mitochondria was significantly decreased after 1 hr (1.49 U/10 mg of protein per min), and it increased significantly 14 days after exposure (2.28 U/10 mg of protein per min). The changes seen following single-time exposure were interpreted as the adaptive reaction of the body, while the changes following repeated exposure indicated disorders in the metabolic processes.

6041 PRACTICAL EXPERIENCE WITH INTERFERENCE-CURRENT THERAPY OF MEN WITH VEGETATIVE UROGENITAL COMPLAINTS. *(Ger.)* Leuthausel, W. (No affiliation given); Rugendorff, E. W. *Therapiewoche* 28(47): 9219-9221; 1978. (3 refs)

Forty-three men with vegetative urogenital syndrome received interference-current therapy on the inguinal region by means of a Nemectrodyn apparatus (90-100 Hz, 50% and then 100% of individual optimal current intensity, 8-12 min/session, 10 sessions). Therapeutic response was achieved in 90%. At the end of the treatment 50-60% of the patients were completely symptom-free, and another 30-40% achieved considerable improvement.

6042 CARDIOVASCULAR CHANGES IN RABBITS EXPOSED TO A STATIC MAGNETIC FIELD OF 600 Oe. *(Jpn.)* Nakagawa, M. (Dept. Public Health, Medical Sch. Nagoya City Univ., Nagoya, Japan). *Jpn J Ind Health* 20(2): 112-113; 1978. (5 refs)

Cardiovascular changes were investigated in domestic white rabbits (3-3.5 kg) following a 5-wk exposure to a static magnetic field of 600 Oe. The animals were exposed in a room at 24 ± 1 C, 60 ± 5% relative humidity that was lit from 0600-1800 hr. The 6 experimental and 4 control rabbits were injected intramuscularly with 1 mg/kg Reserpine 24 hr prior

to measurement of magnetic field effects to suppress reaction to external stimuli. Rabbits exposed to the magnetic field for a comparatively long period had an increased heart rate and peripheral blood volume compared with controls. The increase in blood volume was thought due to excitation of heart function and not vasodilation.

6043 DYNAMICS OF CHANGES OF THE CORTICAL-SUBCORTICAL CORRELATIONS IN EXPERIMENTAL ANIMALS EXPOSED TO ELECTROANALGESIC PULSED CURRENTS. *(Rus.)* Persianinov, L. S. (All-Union Scientific Res. Inst. Obstetrics and Gynecology, USSR Ministry of Public Health, Moscow, USSR); Tkachenko, N. M.; Dmitrieva, O. K.; Smetnik, V. P. *Akush Ginekol* (10): 29-34; 1978. (8 refs)

The effect of pulsed current (0.08-0.1 mA, 150-160 Hz, length of treatment about 1 hr with 2-5 min pauses at 10-15 min intervals) on the cortical and subcortical electrical activity was studied in 48 rabbits. Electrodes were implanted in the midbrain reticular formation, hippocampus, anterior and posterior hippothalamic nuclei, nonspecific thalamic nucleus, and in the sensorimotor, occipital, and parietal regions of the cerebral cortex. The stimulation of the hippocampus led to the activation of the thalamic structures, whose stimulation caused sleep. The pulsed-current stimulation of the hippocampus inhibited the ascending activating effect of the reticular formation, and this facilitated the manifestation of slow diencephalic rhythms. The current was found to directly inhibit the activating effect of the cortex and reticular formation alike, and, due to reciprocity, facilitated the expression of the inhibiting effect of the hippocampus. The findings suggest that all mechanisms are involved in the formation of the inhibiting activity under the effect of pulsed current, and that the predominant effect of each of these mechanisms is dependent on the functional status of the brain.

6044 STATUS OF OXIDATIVE PHOSPHORYLATION PROCESSES IN LIVER MITOCHONDRIA UNDER THE EFFECT OF ELECTRICAL FIELD. *(Rus.)* Koziarin, I. P. (A. A. Bogomolets Kiev Medical Inst., Kiev, USSR); Rudichenko, V. F. *Gig Sanit* (11): 26-29; 1978. (6 refs)

The effect of exposure to electrical field (1-15 kV/m, 50 Hz, 2 hr/day for 4 mo) on the copper and iron levels of the liver and on the oxidative phosphorylation processes in the liver mitochondria was studied in male albino rats with an initial body weight of 120 g. The exposure to the electrical field caused a field intensity-dependent, significant decrease in the hepatic copper and iron levels: the copper level decreased from 603 μg% in the group exposed to the 1 kV/m-field to 288.7 μg% in the group exposed to the 15 kV/m field, compared with 759.3 μg% in the non-exposed controls. The iron level dropped from 29.5 mg% in the group exposed to the 1 kV/m field to 10.9 mg% in the group exposed to 15 kV/m, compared with 39.8 mg% in the controls. Exposure to 1-4 kV/m fields caused no significant changes in the oxidative phosphorylation processes, but fields with higher intensities caused pathologic changes (dissociation of respiration and phosphorylation).

6045 ASSESSMENT OF THE POSSIBILITY OF PREDICTION OF INDIVIDUAL RADIOSENSITIVITY BY THE RESPONSE TO NON-RADIATION EFFECTS. *(Rus.)* Darenskaia, N. T. (No affiliation given); Kuznetsova, S. S.; Chekhonadskii, N. A. *Radiobiologiia* 18(6): 931-935; 1978. (14 refs)

Correlations were studied between the effect of stress factors (30-min hyperthermia at 40-50 C, 24-hr starvation, and 0.5 to 5-hr exposure to a 600-Oe constant magnetic field) and the sensitivity of 2- to 3-mo-old male mongrel and Wistar rats to ionizing radiation (telecobalt, single 600 R dose) in an attempt to predict the radiosensitivity from the response to the stress factors. Changes in the leukocyte count, ranging from a decrease by 5,600 to an increase by 15,450 cells, were seen only following 4- to 5-hr exposure to the magnetic field. The leukocyte count normalized in 20 hr. The changes in the erythrocyte count and Hb level ranged from -18% to +16% and the changes in the exhaled carbon dioxide ranged from -25% to +32%. The body weight decreased by up to 10%, but some animals showed almost no weight loss. Correlation was found between the response to the stress factor and the radiosensitivity in about 50% of the animals only.

6046 THERMORADIOTHERAPY IN AN ANIMAL EXPERIMENT: TUMOR GROWTH AND CURE. *(Ger.)* Dietzel, F. (Abteilung Nuklearmedizin, Klinikum der Justus-Liebig-Universitat, Friedrichstrasse 25, 63 Giessen, W. Germany); Linhart, G.; Kovacs, G. *Strahlentherapie* 154(12): 861-868; 1978. (36 refs)

The effects of single-time x-ray irradiation (tumor dose 2,000 R, dose rate 285 R/min), local hyperthermia (39-43 C, induced by electromagnetic field, 461.04 ± 0.20 MHz, 150 W, 1-4 min) and their combination on the 30-day tumor volume reduction, tumor growth retardation, mean survival time, and cure rate were studied in female albino NMRI mice with solid Ehrlich carcinomas implanted in the neck. The treatment was given about 10 days after tumor implantation, when the tumor size reached 1.0 ± 0.2 ml. The hyperthermic treatment was given before or after x-ray irradiation, with a 20-sec interval between the two treatments. Hyperthermia alone had no significant effect on the parameters investigated, but it enhanced the effect of x-ray treatment. The sequence of the two treatments was not important. The 30-day tumor reduction was 29.5% after x-ray irradiation alone, 49.9-52.5% after x-ray + 1-min hyperthermia, 64.4-71.6% after x-ray + 2-min hyperthermia, 71.3-71.8% after x-ray + 3-min hyperthermia, and 69.8-71.6% after x-ray + 4-min hyperthermia. The mean survival time was 22.2 days after x-ray treatment alone, 29.5-34.2 days after x-ray + 1-min hyperthermia, 38.4-39.9 days after x-ray + 2-min hyperthermia, 48.8-49.9 days after x-ray + 3-min hyperthermia, and 33.2-40.7

days after 4-min hyperthermia. The cure rate was 2.1% after x-ray alone, 5.1-12.5% after x-ray + 1-min hyperthermia, 17.5-20% after x-ray + 2-min hyperthermia, 23.1-33.3% after x-ray + 3-min hyperthermia, and 15.8-21% after x-ray + 4-min hyperthermia. The findings indicate the potentiating effect of hyperthermia, especially in moderate doses (2 and 3 min).

6047 EFFECT OF STRONG MAGNETIC FIELDS ON ACTIVE TRANSPORT IN THE CHOROID PLEXUS. *(Rus.)* Bresler, S. E. (B. P. Konstantinov Leningrad Inst. Nuclear Physics, USSR Acad. Sciences, Leningrad, USSR); Bresler, V. M.; Vasil'eva, N. N.; Kazbekov, E. N. *Dokl Akad Nauk SSSR* 242(2): 465-468; 1978. (6 refs)

The effect of a magnetic field (5-50 kOe) on the active transport of fluorescein (10^{-4} M) in the isolated choroid plexus of rabbits was studied. The choroid plexus was incubated in Ringer-Hanks solution for 15 min. At high calcium ion concentration (normal medium) in the incubating medium, the magnetic field increased the fluorescein transport by nearly 100%, but it inhibited the transport of fluorescein in a medium with low calcium ion concentration (0.12 mmole) compared with that found without magnetic field. The rate of inhibition increased with increasing field intensity up to about 40 kOe, after which the further increase in the field intensity caused no considerable further increase in the inhibition rate.

6048 SHORTWAVE DIATHERMY AND ULTRASOUND IN PHYSIOTHERAPY (LETTER TO EDITOR). *(Eng.)* Moth, B. (Dept. Physiotherapy, Groote Schuur Hosp., Observatory, Cape Town, South Africa). *S Afr Med J* 54(27): 1119; 1978. (1 ref)

A statement in a previous article contending that the bulk of patients with chronic aches and pains obtain no benefit from shortwave diathermy and ultrasound is refuted in a letter to the editor. It is suggested that the use of diathermy has stood the test of time and that numerous patients return time and again for the pain relief obtained. It is also suggested that ultrasonic treatment, correctly given with an apparatus that has been carefully maintained, has also stood the test of time.

6049 PERCUTANEOUS CENTRAL GRAY STIMULATION FOR CANCER PAIN. *(Eng.)* Meyerson, B. A. (Dept. Neurosurgery, Karolinska Sjukhuset, S-104 01 Stockholm, Sweden); Boethius, J.; Carlsson, A. M. *Appl Neurophysiol* 41(1/4): 57-65; 1978. (16 refs)

Intracerebral electrical stimulation of the periventricular and periaqueductal gray matter via percutaneous electrodes was used on nine cancer patients in an attempt to relieve pain with midline and bilateral distribution. The average follow-up time was about 3 mo, with the longest being 1 yr. There were no major surgical complications or any later signs of local infections or meningitis. Good pain relief was experienced by four patients, moderate pain relief by three patients, and no pain relief by two patients. No patient experienced total alleviation of pain as a result of electrical stimulation. In one patient, a 64-yr-old woman with uterine cancer who initially experienced very good pain relief, the efficiency of stimulation seemed to decrease after about 2 wk, and the poststimulatory period of pain reduction was successively shortened from about 6 hr to less than 2 hr. However, one patient still experienced good pain relief after having used the stimulation for more than 1 yr, and the duration of poststimulatory pain relief has remained unchanged. As a rule, stimulation was performed at a frequency of about 30 Hz and at a pulse duration of 0.2 msec. Stimulation generally had to be on for about 20 min for maximal pain relief and was performed at intervals of about 4 hr. The stimulus intensity was kept at a level subthreshold to subjective sensations. The pain relieving effect of stimulation was very dependent on the exact position of the electrode. In order to investigate the role of endorphin activation in pain relief, endorphins in lumbar cerebrospinal fluid were estimated in eight of the patients. Two of four patients with good pain relief showed a significant increase of endorphin content as a result of stimulation; however, in both patients the endorphin level was higher than normal also prior to stimulation. Since stimulation-produced analgesia in animals is readily reversed by opiate antagonists, such as, naxolone, this drug was given as slow intravenous injections shortly after the cessation of stimulation when patients reported maximal pain relief. In three of the patients who had good or moderate pain relief, there was an unequivocal reversal of the effect of stimulation, which occurred 5-10 min after the injection. The idea that pain relief with central gray stimulation is accomplished by the activation of an opiate receptor system was further supported by the fact that one patient who had become slightly dependent on a narcotic analgesic found that increasing the dose of the drug resulted in a decrease in the pain-relieving effect of electrical stimulation.

6050 MECHANISM OF INTERACTION OF ALTERNATING ELECTRICAL FIELD OF INDUSTRIAL FREQUENCY WITH THE HUMAN AND ANIMAL BODY. *(Rus.)* Kolesnikov, S. V. (No affiliation given); Chukhlovin, B. A. *Pismi Zh Tekh Fiz* 4(15): 935-939; 1978. (3 refs)

The mechanism of action of alternating electrical fields of industrial frequency (50 Hz) on the human and animal body was studied in model experiments. The computations revealed that during exposure to an electric field of 100 kV/m intensity, the current flowing through the human body amounted to 1,230 μA. The corresponding current intensities found for rabbits, rats, and mice were 40, 5.4, and 1.03 μA, respectively. The experiments in rats revealed no changes in energy metabolism during exposure to a field of 300 kV/m and 50 Hz, but significant changes were found in energy metabolism during

exposure to 300 kV/m at 500 and 1,000 Hz. The findings indicate that the observed reaction of the body is elicited by the current flowing through the body, which is proportionate to the frequency, and not by the field intensity. Another experiment revealed that the current flowing through the human body during exposure to a body surface field intensity of 10 kV/m equaled that elicited by exposure to 117 kV/m in rabbits, to 123 kV/m in rats, and to 151 kV/m in mice.

6051 EVALUATION OF LENS TRANSPARENCY IN PERSONS EXPOSED TO ELECTROMAGNETIC RADIATION AT 27-30 MHz FREQUENCY. *(Pol.)* Smolarz-Dudarewicz, J. (Instytut Medycyny Pracy, Racjonalizatorow 5, m. 10, 91-837 Lodz, Poland). *Med Pracy* 29(4): 349-353; 1978. (14 refs)

The transparency of the crystalline lens of the eye was evaluated in 55 women (welders) (average 35.3 yr) who had been occupationally exposed to electromagnetic radiation with a frequency of 27-30 MHz for periods ranging from less than 2 yr to 19 yr (average 6.3 yr) and in 101 healthy unexposed controls. The field strength to which the welders were exposed ranged from 3.2 to 135 V/m. Considerable opacification of the lens was found in 10/55 welders (18.2%) and in 21/101 controls (20.8%). Moderate opacification was seen in 19/55 welders (34.6%) and in 33/101 controls (32.7%). The frequency of opacification increased with age in both groups, but there was no correlation between the incidence and the length of occupational exposure among the welders. The findings failed to show any significant effect of electromagnetic field exposure on lens opacification.

6052 INFLUENCE OF ALTERNATING MAGNETIC FIELDS OF INDUSTRIAL FREQUENCY ON THYROID GLAND FUNCTIONAL ACTIVITY AND ^{131}I-THYROXIN BINDING BY TISSUES OF ALBINO RAT ORGANS. *(Rus.)* Udintsev, N. A. (Dept. Biochemistry, Tomsk Medical Inst., Tomsk, USSR); Serebrov, V. Iu.; Tsyrov, G. I. *Biull Eksp Biol Med* 86(11): 544-546; 1978. (13 refs)

The effect of exposure to an alternating electromagnetic field (50 Hz, 200 Oe, single exposures of 0.25, 6.5, or 24 hr or multiple exposures of 6.5 hr/day for 5 days) on the uptake of ^{131}I (0.5 μCi, administered subcutaneously) by the thyroid gland, on the protein-bound iodine (PBI) level of the serum, and on the uptake of ^{131}I-thyroxin by the testes, adrenals, heart, liver, and spleen was studied in 280 adult albino rats. The uptake of ^{131}I by the thyroid gland was increased significantly 12 hr after irradiation for 5x6.5 hr (65.01% of the dose administered, versus 58.96% in the nonirradiated controls), but there were no significant differences from the controls in the single-exposure group animals. The PBI level was increased after 15-min irradiation (4.72 mg/ml versus 2.94 mg/ml in the controls), reduced after 6.5-hr irradiation (1.69 mg/ml versus 2.68 mg/ml) and after 24-hr exposure (0.245 mg/ml versus 0.475 mg/ml), and increased after 5x6.5-hr exposure (2.02 mg/ml versus 1.48 mg/ml), 24 hr after the exposure. The ^{131}I-thyroxin uptake was significantly reduced ($p<0.05$) in the liver and spleen after the single 6.5-hr exposure and in all organs after the 5x6.5-hr or 24-hr exposure. The findings indicate the considerable effect of exposure to a 50-Hz electromagnetic field of 200 Oe on thyroid function, and the influence of exposure duration.

6053 ELECTROMAGNETIC FIELDS IN THE VICINITY OF RADAR THERAPY EQUIPMENT. *(Ita.)* Grandolfo, M.; Ranghiasci, C. (Laboratorio delle Radioazioni, Istituto Superior di Sanita, Viale Regina Elena 299, 00161 Rome, Italy). pp. 31-35; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. N78-20765]. (3 refs)

The electromagnetic field intensities and their angular distribution were measured around a therapeutic radar equipment (Siemens Radiotherm 306, power output 0-200 W, frequency 2.45 GHz) with rectangular and circular-field emitters. Field intensities of 10 mW/cm^2 or higher were measured even at distances of 1 m or slightly greater. The 10 mW/cm^2 level has been adopted in the USA and many West European countries as a maximum permissible intensity in the human environment. The field intensities were in the same order of magnitude with the rectangular and circular-field emitters. The findings indicate the hazards of exposure to therapeutic radar equipment for radiation therapists.

6054 INFLUENCE OF THE AGE OF MICE ON THE EFFECTIVENESS OF STIMULATION OF THE IMMUNE SYSTEM BY ELECTROMAGNETIC RADIATION. *(Fre.)* Pautrizel, R. (Laboratoire d'Immunologie et de Biologie parasitaire, Universite Bordeaux-II, 146, rue Leo-Saignat, 33076 Bordeaux Cedex, France); Chateaureynaud-Duprat, P. *C R Acad Sci [D] (Paris)* 287(5): 575-578; 1978. (5 refs)

The effect of microwave stimulation of the immune system on the course of *Trypanosoma equiperdum* infection (1,000 cells/animal administered intraperitoneally) was studied in young female Swiss mice. The animals were infected at the age of 0-40 days, and irradiation began on the day of the infection with a modulated electromagnetic field (9.4 and 17 MHz, 1,200 G, 6 hr/day for 4 days). All animals that were infected at the age of 0-28 days developed considerable parasitemia (nearly 10^6 cells/mm^3 of blood) and died 82-96 hr after infection. Some of the animals infected at the age of 28-31 days became *Trypanosoma*-negative, and survived. All animals that were infected at the age of 35-40 days became *Trypanosoma*-negative and survived. The investigation of other nonirradiated subgroups, infected at the age of 0-40 days, demonstrated the development of the immune system, including the appearance of agglutinating antibodies, during that period. The findings indicate that a mature immune system is required for microwave stimulation to be effective.

6055 STUDIES ON ELECTROMAGNETIC-FIELD EXPOSURE IN THE COURSE OF HEAT TREATMENT OF METALS BY MEDIUM- AND HIGH-FREQUENCY CURRENTS. *(Rum.)* Herman, H. (Institutul de Cercetari Stiintifice pentru protectia Muncii, Bucharest, Rumania); Badescu, L.; Rafaila, E. *Rev Ig (Pneumoftiziol)* 27(2): 139-146; 1978. (10 refs)

Workers from 48 industrial plants, who had been occupationally exposed to electromagnetic fields (2,500-8,000 Hz or 200-450 MHz, maximum 5 A/m and maximum 12.4 V/m) in metal hardening, melting, and joining operations were examined for possible health effects. Compared with an unexposed control group, no particular changes were found in clinical, endocrinologic, biochemical, and hematologic parameters. No cumulative effect of the electromagnetic fields was seen.

6056 ASPECTS OF THE MECHANISM OF ACTION OF PULSED CURRENTS WITH RESPECT TO ELECTRO-ANALGESIA. *(Rus.)* Persianinov, L. S. (All-Union Scientific Res. Inst. Obstetrics and Gynecology, USSR Ministry of Public Health, Moscow, USSR); Tkachenko, N. M.; Smetnik, V. P. *Akush Ginekol (Mosk)* (8): 7-14; 1978. (21 refs)

Cortical and subcortical structures were stimulated by square waves (pulse duration 0.2-0.9 msec, frequency 8-10 and 100-300 Hz, 0.3-0.8 mA) in adult experimental animals (species not specified). Spikes (3-4/sec, amplitude 120-150 μV) were found in all areas of the cortex, including the occipital and sensorimotor regions, following short-term (5-6 sec) stimulation of the anterior hypothalamic nuclei. Continued stimulation caused progressive inhibition; the amplitude of the rhythmic oscillations rose to 150-180 μA, and their frequency decreased. There was also a change in the response to afferent stimuli; in response to a single light flash, the amplitude of the basic negative wave and the amplitude and duration of the secondary components of the evoked potential increased. The findings indicate that local stimulation of the anterior hypothalamus plays an active role in the formation of the inhibitory activity under the effect of pulsed-current stimulation.

6057 CHANGES IN CONDUCTIVITY OF ALAMETICIN-MODIFIED PHOSPHOLIPID MEMBRANES IRRADIATED BY A HIGH-FREQUENCY ELECTROMAGNETIC FIELD. *(Rus.)* Tiazhelov, V. V. (Inst. Biological Physics, USSR Acad. Sciences, Pushchino [Moscow Oblast], USSR); Alekseev, S. I.; Grigor'ev, P. A. *Biofizika* 23(4): 732-733; 1978. (1 ref)

The conductivity of lecithin membrane systems was studied under the effect of a high-frequency electromagnetic field (0.9 GHz, 1.6-8 W, maximum pulse duration 4 sec, minimum pulse interval 10 sec) in KCl and NaCl solutions (0.5-2 moles) in the presence of alameticin (0.8 μg/ml). The pulsed electromagnetic field caused a sharp and sudden reversible drop in the resistance (increase in the conductivity); the new conductivity value established itself in 0.2-0.4 sec at the beginning of the pulse, and reverted to the initial level just as rapidly. The observed effect may have been due to local heating of alameticin channels in the membrane by the high-frequency field.

6058 SUTURELESS ANASTOMOSIS IN GASTROINTESTINAL SURGERY WITH AND WITHOUT STEADY MAGNETIC FIELD--AN EXPERIMENTAL STUDY. *(Rus.)* Kanshin, N. N. (Third Surgical Clinic, N. V. Sklifosovskii Moscow Municipal Scientific Res. Inst. Emergency Aid, Moscow, USSR); Permiakov, N. K.; Dzhalagoniia, R. A.; Nikulin, B. I.; Kuznetsov, A. A. *Arkh Patol* 40(8): 56-61; 1978. (10 refs)

Sutureless gastroduodenal and cecojejunal side-to-side anastomoses were performed in 52 dogs by means of simple compressing devices with and without steady magnetic fields (field intensity not specified). The anastomosis formation was completed in 6-7 days after the operation, and the compressing elements were discharged spontaneously in 7-8 days in both variants, signifying that the steady magnetic field had no effect on the healing of the anastomosis.

6059 CHANGES IN MUSCULAR FORCE CAUSED BY ELECTRICAL STIMULATION IN ELDERLY SUBJECTS. *(Pol.)* Dobkowska, A. (Klinika Rehabilitacji AM, ul. Wierzejewskiego 12, 05-510 Konstancin k/W-wy, Poland); Gorski, W.; Wirski, J. *Pol Tyg Lek* 33(48): 1849-1852; 1978. (10 refs)

The effect of electrical stimulation of the tibia (1-msec stimuli, frequency 50-60 Hz in 2-sec volleys at 10-sec intervals, 15-20 min/day for 3 wk) on the force of the soleus muscle was studied in 20 women aged 60-85 yr with functional disorders of the lower extremities. The force of the soleus muscle increased in all patients during the treatment; the initial force was in the range of 9-86 kg, and 30-122 kg were measured at the end of the treatment. The increase was 300-350% in the patients with low initial values, and 50-200% in patients whose muscular force was not reduced excessively before the treatment. The increase was less than 50% in three cases only.

6060 STIMULATION WITH AUTOMATIC RADIOFREQUENCY SYNCHRONIZATION AND PACING IN THE LONG-TERM TREATMENT OF HYPERKINETIC ARRHYTHMIA. *(Fre.)* Critelli, G. (Istituto di Patologia Medica dell' Universita II, Policlinico, Via Pansini 5, 80131 Naples, Italy); Grassi, G.; Perticone, F.; Adinolfi, L.; Maione, S.; Condorelli, M. *Arch Mal Coeur* 71(11): 1279-1282; 1978. (19 refs)

A pacemaker using radio frequency signals for synchronization and pacing, and seeking automatically the phase of the cycle at which tachycardia may be interrupted, is described. There is an electromagnetic coupling between the external unit that can be activated by the patient and the implanted unit by means of a loop antenna. The program of the

external transmitter, which scans nearly all R-R cycles of the tachycardia, can be preset to transmit one or two synchronized stimuli, with a progressive delay of 5 or 10 msec. If the tachycardia is interrupted, the pacing stops automatically. The implantable unit can be connected to a normal endocardial electrode, has no batteries, is of small size, and weighs only 33 g. The unit was used successfully in 4 patients with reciprocal junctional tachycardia (3 of these patients had Wolff-Parkinson-White syndrome), and in one case of chronic recurrent ventricular tachycardia. All patients had been refractory to conventional drug treatment.

6061 EFFECTS OF ELECTRICAL STIMULATION OF VAGAL NUCLEI IN ANESTHETIZED AND UNANESTHETIZED CATS. *(Eng.)* Dugin, S. F. (Dept. Physiology Man and Animals, Moscow State Univ., Moscow, USSR); Zakharov, S. I.; Samonina, G. E.; Udel'nov, M. G. *Neurosci Behav Physiol* 8(4): 317-320; 1978. (16 refs)

Changes in heart rate were studied during electrical stimulation (1.75-4.0 V, 30-70 Hz, 0.1 msec) of the effector nuclei of the vagus nerves in anesthetized and unanesthetized cats. Tungsten microelectrodes with a tip diameter of 10-25 micron were inserted into the dorsal vagal nucleus and into the nucleus ambiguus of the medulla of cats under pentobarbital anesthesia. In seven cats, seven points were investigated, four in the dorsal vagal nucleus and three in the nucleus ambiguus. Stimulation of these points in anesthetized animals caused a slowing of the heart beat after a relatively short latent period (1-2 sec), and the effect stopped virtually as soon as the stimulation ceased. Changes in heart rate and various types of motor responses were obtained by stimulation of the same points in unanesthetized cats. The motor responses consisted of slight twitching of the neck muscles, the tips of the ears, and the whiskers. In contrast with anesthetized cats, stimulation of the dorsal vagal nucleus or nucleus ambiguus in unanesthetized cats was usually accompanied by a quickening of the heart beat; in some cases quickening was followed by slowing. Just as with the bradycardia in the anesthetized cats, tachycardia developed after a short latent period (1-2 sec) and it ceased virtually immediately after stimulation was ended. The increase in the heart rate of unanesthetized cats after stimulation of the effector nuclei of the vagus nerves was not due to activation of the sympathetic nervous system as was demonstrated in experiments with Obsidan, a β-adrenoblocker. The injection of Obsidan never abolished the effect of tachycardia. This applied both to groups of neurons whose stimulation led to the development of tachycardia alone and to groups of neurons whose stimulation produced tachycardia accompanied by motor responses. It was concluded that the tachycardia arising in response to stimulation of the vagal nuclei is parasympathetic in nature. This conclusion was confirmed by the character of the tachycardia, i.e., its short latent period and the quick termination of the effect after stimulation ceased. Opposite effects were also obtained in anesthetized and unanesthetized cats during stimulation of the same group of neurons of the anterior hypothalamus (preoptic region). Bradycardia arising in anesthetized cats was replaced by tachycardia when stimulation was applied after the end of the anesthesia. This tachycardia also was parasympathetic since it remained after the administration of Inderal. In an animal in the normal state, stimulation of efferent neurons of the parasympathetic pathways is thus accompanied by an increase in the heart rate, suggesting that accelerator influences are among the regulatory functions of the parasympathetic innervation of the heart. Dominance of the inhibitory effects on stimulation of the same efferent neurons in anesthetized animals suggests that the widely held view that the function of the vagal innervation of the heart is purely inhibitory is evidently based on the inadequate responses of the heart of anesthetized animals.

6062 PHANTOM LIMB PAIN TREATED BY ELECTRICAL STIMULATION. *(Eng.)* Miles, J. (Center for Pain Relief and Regional Dept. Medical and Surgical Neurology, Walton Hosp., Liverpool 9, England); Lipton, S. *Pain* 5(4): 373-382; 1978. (11 refs)

The suitability of using an electrical stimulator implant to the peripheral nerve or spinal cord for the treatment of phantom limb pain was assessed in 20 patients with this condition. Of 12 patients who were so treated, 7 obtained excellent relief of pain such that they required no analgesics. Three patients obtained only partial relief of pain and occasionally required simple analgesics. Three patients achieved such a satisfactory relief of pain on transcutaneous stimulation that they were maintained on this form of treatment; one continues to obtain excellent pain relief after 1 yr. Two patients obtained no pain relief, and both of these patients were subsequently recognized to have had evidence suggestive of ipsilateral cord injury. None of the patients responding to electrical stimulation had evidence of ipsilateral cord injury or even ptosis or myosis.

6063 MICROWAVE PROPERTIES OF CRYOPROTECTANTS. *(Eng.)* Macklis, J. D. (Cryogenic Engineering Lab., Massachusetts Inst. Technology, Cambridge, MA); Ketterer, F. D. *Cryobiology* 15(6): 627-635; 1978. (6 refs)

The temperature dependence of both the dielectric constant and loss tangent of three membrane-penetrating, hydrogen-bonding cryoprotectants commonly used in organ preservation, i.e., dimethylsulfoxide (DMSO), ethylene glycol (EG), and glycerol (GCL), was investigated to elucidate the process of microwave thawing of cryopreserved tissue. The tests were performed over a temperature range of +15 to -70 C. The microwave frequency used ranged from 1.45-1.55 GHz; this frequency range is about midway