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BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

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Literature Selected and Abstracted
by
Biomedical Group, Science Information Services Department

Bruce H. Kleinstein, Ph.D., J.D., Project Manager
Elena P. Saboe, Production Manager, Editor

ANSI #75-187

4600 POWER DEPOSITION IN A MULTILAYERED SPHERICAL MODEL OF THE HUMAN HEAD (PROCEEDINGS ABSTRACT). (Eng.) Neuder, S. M. (Div. Electronic Products, Bureau Radiological Health, Food and Drug Admin., Rockville, MD); Hill, D. H.; Kellogg, R. B. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 200; 1975.

A theoretic investigation was conducted of the magnitude and spacial variations of power depositions in a multilayered spherical model of the human head exposed to microwave radiation of various frequencies in the assigned industrial, scientific and medical frequency band. Numeric and graphic results are presented, which locate hot spots within the spherical regions and the fields both within and external to the spheres. (No refs.)

75-188

4601 LIGHT AND ELECTRON MICROSCOPIC INVESTIGATION OF BRAINS EXPOSED TO NON-IONIZING RADIATION (PROCEEDINGS ABSTRACT). (Eng.) Albert, E. (Dept. Anatomy, George Washington Univ. Medical Center, Washington, DC). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 224; 1975.

Chinese hamsters were exposed to power densities of 10, 25, and 50 mW/cm^2 at 1700 and 2450 MHz frequencies for 30 min to 10 weeks. The brains were serially sectioned for light microscopy, but only selected areas were examined for electron microscopy. The light microscopic examinations were conducted on paraffin, and frozen sections were stained with Nauta, cresyl violet, thionine and hematoxylin and eosin. Neuronal histopathology was observed in most of the irradiated animals in the hypothalamus and subthalamus; whereas, cerebral and cerebellar cortices, pons, medulla, and spinal cord appeared normal. The affected neurons exhibited swelling, vacuolation, and chromatolysis. The blood vessels appeared normal. There was no suggestion of edema, hemorrhage, or congestion. (No refs.)

75-189

4602 MUTAGENICITY INDUCED BY NON-IONIZING RADIATION IN SWISS MALE MICE (PROCEEDINGS ABSTRACT). (Eng.) Varma, M. M. (Bio-Environmental Engineering and Sciences Research Lab., Sch. Engineering, Howard Univ., Washington, DC); Dage, E. L.; Joshi, R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 134; 1975.

The testes of Swiss mice were irradiated with microwaves at 2.45 GHz in three experiments to investigate the mutagenicity induced by non-ionizing radiation. The mice were irradiated at: (1) 100 mW/cm^2, a single exposure of 10 min; (2) at 50 mW/cm^2, three exposures of 10 min each in one day; and (3) at 50 mW/cm^2, four exposures of 10 min each during 2 weeks. Treated males were tested by the dominant lethal assay for mutagenicity by mating them with untreated females for 6 weeks. Fertility was not impaired following irradiation, but induced mutagenicity was significantly higher subsequent to single exposure and multiple exposures during one day. No effects were observed when multiple exposures were extended over a period of 2 weeks. The results suggest that high-level acute exposures are potentially more hazardous than chronic exposures at lower power densities. (No refs.)

75-190

4603 THE EFFECTS OF MICROWAVE RADIATION ON BEHAVIOR AND TEMPERATURE IN RHESUS MONKEYS (PROCEEDINGS ABSTRACT). (Eng.) de Lorge, J. O. (Naval Aerospace Medical Research Lab., Pensacola, FL). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 195-196; 1975.

Male rhesus monkeys, trained to respond on a vigilance task, were exposed to vertically polarized 2450 MHz microwaves in an anechoic room. Power densities of 4, 16, 32, 42, 52, and 62 mW/cm^2 (measured at the level of the animal's head) and exposure times of 30, 60, and 120 min were used. The transmitter system was a Holaday Magnetron with up to 1500 W of radiofrequency output; while all levels employed continuous waves, pulsed waves were also used at 4 and 16 mW/cm^2 (PRF = 1 sec, P.D. = 0.1 sec). The monkeys performed the vigilance task, while being irradiated from the front. Body temperature was monitored during exposure at all but the lowest power density. Vigilance performance was not affected until 52 and 62 mW/cm^2 illuminations occurred; and even in these instances behavior was only minimally and inconsistently changed. Mild body heating (0.4°C to 1.7°C) was associated with the higher densities (32-62 mW/cm^2), although body temperature was not related to observed behavioral changes at these same levels. (No refs.)

75-191

4604 PHYSIOLOGICAL AND BEHAVIORAL EFFECTS OF CHRONIC LOW LEVEL MICROWAVE RADIATION OF RATS (PROCEEDINGS ABSTRACT). (Eng.) Moe, K. E. (Bioelectromagnetics Research Lab., Univ. Washington, Seattle, WA); Lovely, R. H.; Guy, A. W. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 197-198; 1975.

Eight male rats were irradiated for 3 mo with 918 MHz microwaves pulse-modulated at 11 Hz, for 8 hr/day, at field strengths ≤ 10 mW/cm^2. Rats were exposed during the active part of the day-night cycle.

The exposure apparatus consisted of a cylindrical waveguide capable of delivering circularly polarized guided waves (TE_{11} mode) and a living chamber compatible with normal laboratory living conditions required by rats. The cylindrical waveguide allowed for easy quantification of the fields for each exposed animal independent of other rodents being simultaneously exposed. Biological and behavioral comparisons between the eight irradiated and eight sham-irradiated controls included food and water intake, body weight, blood sugar, metabolic hormones, and operant behavior during the exposure period. These variables were assessed every 3 weeks, and the effects of chronic irradiation by 918 MHz pulse-modulated microwaves on them are presented. (No refs.)

75-192

4605 NON-THERMAL EFFECTS OF ELECTROMAGNETIC FIELDS ON THE CENTRAL NERVOUS SYSTEM (PROCEEDINGS ABSTRACT). (Eng.) Kritikos, H. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA); Takashima, S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 223-224; 1975.

A series of experiments in the radiofrequency (RF) (1-30 MHz) and microwave region (2.45 GHz) were conducted *in vitro* to determine whether electromagnetic fields induce any non-thermal effects on the activities of the central nervous system. In the RF region the giant axon of the myxicola worm in constant temperature (6-8°C) saline solution was exposed to current densities of approximately 100 mA/cm^2 corresponding to a heat deposition rate of .6 W/cm^3. It was found that the triggering threshold level does not change and that there were no detectable effects on the shape of the action potential. RF pulses of approximately .5 msec duration did not trigger the nerve. It was found that triggering was possible only in the low frequency region by .5 msec pulses from direct current to 20 KHz. The sciatic nerve of the *Rana pipiens* was exposed to power densities of .5 W/cm^3, while immersed in a constant temperature ringer solution. It was found that no effects were induced in the triggering threshold level pulse shape and that it was not possible to trigger the nerve with microwave pulses. Higher exposure rates (1.5 W/cm^3) associated with a temperature rise up to 39°C did, however, damage the nerve. In both cases electrode pick-up induced artifacts and may have presented a potential electromagnetic hazard. (No refs.)

75-193

4606 MICROWAVE AND INFRARED RADIATION EFFECTS ON AN OPERANT RESPONSE IN RHESUS MONKEYS (PROCEEDINGS ABSTRACT). (Eng.) McAfee, R. D. (Medical Research Dept., Veterans Admin. Hosp., New Orleans, LA); Elder, S. T.; Lipscomb, R. J.; May, J. G.; Holland, M. G. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 196; 1975.

Four unrestrained rhesus macaques were trained to lever press for a reward. The reward was obtained, if they placed their mouth on an acrylic drinking tube positioned so that drinking from it would place the rhesus' eyes in the center of a 9.3 GHz microwave field. They were irradiated for 15 min at power densities ranging from 350 mW/cm^{-2} to 450 mW/cm^{-2}. Microwave irradiation did not suppress their lever press rate, which suggests that the power density and times used in the experiment were not aversive to the rhesus. (No refs.)

75-194

4607 MICROWAVE FREQUENCY AS A FACTOR IN THE INDUCTION OF LENS OPACITIES IN THE RABBIT EYE (PROCEEDINGS ABSTRACT). (Eng.) Hagan, G. J. (U.S. Dept. Health, Education, Welfare, Food and Drug Admin., Bureau Radiological Health, Div. Biological Effects, Winchester, MA); Carpenter, R. L. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 320; 1975.

The role of microwave frequency in the experimental induction of lens opacities was tested by irradiating the eyes of rabbits for 30 min at several power levels of either 2.45 or 10 GHz continuous wave radiation. The aim was to discover whether the lowest incident power density provoking lens changes in at least 50% of the irradiated eyes in each group was the same or different for the two frequencies. In an anechoic chamber, a dielectric lens was employed to focus radiation on the eye region. Distances from the emitting horn to the dielectric lens and from the latter to the eye were kept the same in all experiments. The effects were observed by ophthalmoscopy and slit-lamp biomicroscopy. It was found that at 10 GHz, lens changes were induced at a lower power density than at 2.45 GHz. At 10 GHz, the power density causing change in 50% of the subjects was 250 mW/cm^2. At 2.45 GHz, it was 320 mW/cm^2. (No refs.)

75-195

4608 THE EFFECT OF MICROWAVES (2400 MHz) ON LYMPHOCYTE BLAST TRANSFORMATION *IN VITRO* (PROCEEDINGS ABSTRACT). (Eng.) Smialowicz, R. J. (Experimental Biology Div., Health Effects Research Lab., U.S. Environmental Protection Agency, Research Triangle Park, NC). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 130-131; 1975.

The proliferative capacity of lymphocytes that are responsible for cellular immune responses (T cells) and humoral immune responses (B cells) was examined following exposure *in vitro* to microwave radiation at 2450 MHz. Spleen cells from BALB/c mice were cultured in 35 x 10 mm plastic dishes maintained at 37°C in a temperature controlled exposure chamber during irradiation for 1-4 hr at an absorbed dose

rate of approximately 19 W/kg. Following irradiation, the temperature of the cultures did not differ appreciably from that of controls, and cell viability was comparable in both cultures. The ability of exposed lymphocytes to undergo blast transformation in response to mitogens that selectively stimulate either T or B cells was studied using ^{3}H-thymidine labeling. No consistent difference was found between the blastogenic response of microwave-irradiated and control splenic lymphocytes cultured in the presence of the mitogens phytohemagglutinin, pokeweed mitogen, concanavalin A, or *Escherichia coli* lipopolysaccharide. (No refs.)

75-196

4609 MICROWAVE-INDUCED AUDITORY RESPONSE--COCHLEAR MICROPHONICS (PROCEEDINGS ABSTRACT). (Eng.) Chou, C. K. (Bioelectromagnetics Research Lab., Univ. Washington Sch. Medicine, Seattle, WA); Guy, A. W.; Galambos, R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 36-37; 1975.

An electrical potential oscillating at 50 kHz was recorded from the round window of guinea pigs during irradiation with 918 MHz pulsed microwaves to assess microwave evoked cochlear microphonics. This potential promptly followed the stimulus, outlasted it by about 200 μsec, and measured up to 50 μV in amplitude. The potential was time-locked to the onset of the microwave pulses. It preceded the auditory nerve response and disappeared with death. Its intensity function versus microwave energy absorption density resembled that of the cochlear microphonics versus sound pressure level. It is concluded that this potential was a cochlear microphonic response to the microwave pulses. This cochlear microphonic response suggests that the microwave auditory effect is accompanied by a mechanical disturbance of the hair cells of the cochlea. (No refs.)

75-197

4610 A THEORETICAL STUDY OF MICROWAVE-GENERATED AUDITORY PHENOMENA IN MAMMALIAN CRANIAL STRUCTURES (PROCEEDINGS ABSTRACT). (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI); Lam, C. -K. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 36; 1975.

A theoretic analysis of the stress and displacement generated by impinging microwave pulses in a spherical model of mammalian cranial structure is presented. Assuming homogeneity of the brain matter, the absorbed energy pattern obtained from the electromagnetic wave equation was used as the source function for the equation of heat conduction in the spherical head. This displacement was found by solving the thermoelastic motion equation with stress free boundary conditions. The solution consisted of two parts: a steady state term, which was directly proportional to the width of the incident pulse and a transient term made up of an infinite sum of oscillating components. Numeric results will indicate the magnitude of the induced stress and displacement as well as the applicability of the theory to the microwave auditory phenomenon. (No refs.)

75-198

4611 THYROID RESPONSE TO LOCALIZED MICROWAVE EXPOSURE (PROCEEDINGS ABSTRACT). (Eng.) Magin, R. L. (Univ. Rochester, Rochester, NY); Lu, S. -T.; Michaelson, S. M. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 317-318; 1975.

Localized microwave exposure of the canine thyroid gland was undertaken to determine its thermal sensitivity. The experiments were conducted at 2450 MHz utilizing a small (2" x 1") dielectrically loaded rectangular waveguide applicator. One of the two paired thyroid glands was heated with microwaves, while the other was used as a control. Both thyroid glands were surgically exposed and blood was collected directly from caudal veins draining each gland so that its thyroxine secretion rate could be determined. The glands were allowed a 1-hr equilibration period. One gland was then subjected to a 2-hr exposure to microwaves. The animals were divided into three groups according to the temperature rise in the exposed gland (39, 42, and 45°C) with at least five animals per group. A sham-exposed group (37°C) was also studied. An increase in the exposed gland's thyroxine secretion rate (ng T4/min) was observed in each group. The smallest increase occurred during the 39°C exposure, and successively larger increases occurred during the 42°C and 45°C heating. It is concluded that thyroid gland function can be stimulated by temperature increases at the gland of 2°C or more above normal. (No refs.)

75-199

4612 THE EFFECTS OF 1.7 AND 2.45 GHz MICROWAVES ON DRUG-INDUCED SLEEPING TIME IN THE RABBIT (PROCEEDINGS ABSTRACT). (Eng.) Cleary, S. F. (Dept. Biophysics, Virginia Commonwealth Univ., Richmond, VA). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 193; 1975.

The effect of thermal stress on the reduction in sleeping time was investigated by rectal temperature measurements in irradiated, sham-irradiated, and animals exposed to thermal stress by increased environmental temperatures. The effects of pulse modulation and variation in drug dosage were also investigated to ascertain the extent to which the sleeping time alterations are dependent upon alter-

ation of body temperature in the rabbit. Exposure of anesthetized rabbits to 1.7 and 2.45 GHz pulsed and continuous wave (CW) microwave radiation led to a dose dependent decrease in mean sleeping time. The 2.45 GHz irradiations caused a greater decrease than 1.7 GHz microwaves at all power densities in the range of from 5 to 50 mW/cm^2. Exposures of 2.45 GHz produced a 15% decrease at 5 mW/cm^2, CW, in contrast to 1.7 GHz radiation, which did not significantly reduce sleeping time at this intensity. (No refs.)

75-200

4613 HIGH VOLTAGE ELECTRIC FIELD COUPLING TO HUMANS USING MOMENT TECHNIQUES (PROCEEDINGS ABSTRACT). (Eng.) Spiegel, R. J. (IIT Research Inst., Washington, DC). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975*, USNC/URSI. (Washington, D.C.): 230; 1975.

A numeric method for predicting current and normal electric field distributions was developed for humans situated in the vicinity of extra high voltage and ultra high voltage lines. The technique was based on the method of moments in which the human body is modeled as a collection of straight cylindrical sections. Various scenarios were considered, e.g., a well insulated person standing on the ground beneath the transmission line, an individual in good contact with the earth, or a lineman working in very close proximity to an energized conductor. The position of the arms was varied, for example, arms extended or down at the side. The question of biologic hazards from exposure to fields of these systems is also discussed. (No refs.)

75-201

4614 EFFECTS OF WEAK ELF ELECTRIC FIELDS ON SCHEDULE-CONTROLLED BEHAVIOR OF MONKEYS (PROCEEDINGS ABSTRACT). (Eng.) Medici, R. G. (Brain Research Inst., Univ. California, Los Angeles, CA). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 271; 1975.

Performing monkeys (both implanted with electroencephalogram electrodes and unimplanted) were exposed to microwave frequencies from 7-75 Hz at voltages from 1 to 100 V/m in three different experiments. Significantly shorter interresponse time and reduced variability of responding were observed for a specific frequency (7 Hz) at 10 V/m. At higher voltages the effect occurred at other frequencies as well, and the magnitude of the change was markedly increased. (No refs.)

75-202

4615 EFFECT OF AC ELECTRIC FIELD APPLICATION UPON HUMAN VISUAL THRESHOLD (PROCEEDINGS ABSTRACT). (Eng.) Sugiyama, S. (Kwansei Gakuin Univ., Nishinomiya, Hyogo, Japan); Mizuno, K. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 271-272; 1975.

A 90 Hz alternating current (AC) electric field (E.F.) was applied to the head of human subjects while the critical fusion frequency was depressed by application of low frequency photic stimulus in order to depress the functional state. The result was compared with the depression state made by application of low frequency photic stimulus. The result showed that depressed functional state could be normalized to some extent by application of 90 Hz AC E.F. (No refs.)

75-203

4616 PSEUDOSUBSTRATE BINDING TO RIBONUCLEASE DURING EXPOSURE TO MICROWAVE RADIATION AT 1.70 AND 2.45 GHz (PROCEEDINGS ABSTRACT). (Eng.) Allis, J. W. (Experimental Biology Div., Environmental Protection Agency, Research Triangle Park, NC); Fromme, M. L. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 318-319; 1975.

The binding between the enzyme ribonuclease and several pseudosubstrates was measured during coincident exposure to 1.70 or 2.45 GHz electromagnetic radiation using a crossed-beam exposure-detection system. This enzyme, isolated from bovine pancreas, hydrolyses ribonucleic acid at the position of the pyrimidine nucleotides. Measurements were made spectrophotometrically between 240 and 300 nm using a difference spectral technique, i.e., the sample chamber enzyme and binding agent were in the same solution but were kept separate in the reference chamber by use of split compartment cells. The pseudosubstrates, which bind to the enzyme but do not undergo reaction, were 2'-cytidine monophosphate, 3'-cytidine monophosphate, and 3'-uridine monophosphate. Association constants for these agents range from $9.\times 10^3\ M^{-1}$ to $300 \times 10^3\ M^{-1}$ at pH 5.5. The solutions in the sample chamber were irradiated at a waveguide termination. Measurements were performed immediately after exposure and after exposure for 30 min. The absorbed dose rate for the irradiated samples was 40 W/kg. All experiments were carried out at 25°C, and the temperature of the sample and reference solutions was monitored continuously. No difference in the binding of ribonuclease in irradiated solutions and unirradiated controls could be detected. (No refs.)

75-204

4617 THE INFLUENCE OF MICROWAVE EXPOSURE ON NEUROENDOCRINE FUNCTION IN THE RAT AND DOG (PROCEEDINGS ABSTRACT). (Eng.) Michaelson, S. M. (Univ. Rochester, Rochester, NY). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the*

University of Colorado, Boulder, Colorado, 20-23 October, 1975. USNC/URSI. (Washington, D.C.): 317-318; 1975.

Because of the importance of the neuroendocrine system in physiologic regulation and integration of body function, the first phase of studies were performed in rats and dogs during various periods of their lifespan (prenatal, postnatal, juvenile, adult, old) to relate hormone levels (adrenal, thyroid, growth hormone) to various regimens of low to high (1 mW/cm^2-80 mW/cm^2) 2450 MHz continuous wave (CW) microwaves by single acute and repeated or chronic exposures. Dogs were subjected to regional or whole-body microwave exposure for assessment of individual endocrine sensitivity and interspecies comparisons. Endocrine perturbation occurred in rats and dogs acutely exposed to certain power density/time durations of 2450 MHz (CW) microwaves. Such perturbation, however, was of a transient nature and was related to increase in temperature of the body or the individual endocrine gland. Chronic exposure at low power density (1-10 mW/cm^2) will be required to establish the physiologic significance of these neuroendocrine perturbations. (No refs.)

75-205

4618 THE USE OF STRIPLINE TO STUDY MICROWAVE BIOLOGICAL EFFECTS (PROCEEDINGS ABSTRACT). (Eng.) Seaman, R. L. (Dept. Biomedical Engineering, Duke Univ., Durham, NC); Wachtel, H.; Joines, W. T. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 322; 1975.

The stripline (rectangular coaxial transmission line) technique was used to irradiate isolated neural tissue, while recording electrical activity from the neurons. The confined electromagnetic fields allowed essentially artifact-free recording and insured investigator safety. Intracellular recordings from individual neurons of *Aplysia* indicated effects on neural activity and synaptic efficiency at absorbed power levels of a few mW/cm^3. Neural output of the optic nerve of *Limulus* was changed by similar absorbed power levels. Results were obtained at experimental frequencies of 1.5 GHz and 2.45 GHz. Stripline minimized many of the problems associated with researching microwave effects on neural tissue. (No refs.)

75-206

4619 BIOMEDICAL ASPECTS OF RADIOFREQUENCY AND MICROWAVE RADIATION: A REVIEW OF SELECTED SOVIET, EAST EUROPEAN, AND WESTERN REFERENCES (PROCEEDINGS ABSTRACT). (Eng.) Glaser, Z. R. (Biomedical Research Detachment, Naval Surface Weapons Center, Dahlgren, VA); Dodge, C. H. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 315; 1975.

A survey of recent selected Soviet and East European references reveals few new trends in the interpretation of the effects of radiofrequency and microwave fields, at least at the clinical level. Soviet and East European investigators continue to report a variety of reversible changes in nervous and related functions, which can occasionally be correlated with changes in animal behavior and organelle shifts under experimental conditions. Western investigators, however, have been largely unsuccessful in repeating these findings until recently. There is evidence that some Western investigators are beginning to obtain certain functional and morphological data suggestive of Soviet and East European findings. Recent Soviet, East European, and/or Western experimental findings, coupled with the pressure of public opinion, may have a significant effect on their unique positions with regard to the occupational exposure levels. This report represents a continuing effort to comprehensively compile the world literature on the subject and complements a 1969 review of the subject. New emphasis has been placed on experimental and theoretical research. (No refs.)

75-207

4620 NUMERICAL SIMULATION OF THE EFFECTS OF NON-IONIZING MICROWAVE RADIATION UPON THE HUMAN BODY (PROCEEDINGS ABSTRACT). (Eng.) Emery, A. F. (Dept. Mechanical Engineering, Univ. Washington, Seattle, WA); Guy, A. W.; Kraning, K. K.; Short, R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 231; 1975.

A human-body model was developed using a finite difference numeric procedure to compute the thermal response of a man subjected to microwave irradiation of the entire body and the head. Transient head and body temperatures and sweating rates were computed to determine the maximum levels of irradiation permissible for long- and short-time exposures. Since the thermal response is strongly affected by the local sweat rate, four different models were used in which the hypothalamus, average skin and local skin temperatures, and the time rate of change of these temperatures were the controlling parameters. The best of these different models, as judged by comparison of the results with measured data, was then used in microwave simulations. (No refs.)

75-208

4621 A SUMMARY OF CELL AND TISSUE LEVEL EVENTS PRODUCED BY RF FIELDS PREDICTED FROM CONSIDERATION OF REGIONAL HYPERTHERMIA (PROCEEDINGS ABSTRACT). (Eng.) Frazer, J. W. (U. S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 132; 1975.

Absorption of electromagnetic energy in any object causes an increase in collision probability of its constituent molecules, leading to the production of heat. Even in relatively homogenous absorbers, the distribution of this heat is not uniform throughout the absorber but is critically dependent on the size of the absorber relative to the wavelength, the field impedance, and the electrical characteristics of the absorber. Prediction of one set of biologic results from exposure to such a field is dependent on knowledge of the regional thermal environment and also knowledge of the tissue response to such thermal environment. One set of such interdependencies showed that release of metals from one organ leads to uptake by another. Other sets of events are becoming clearer as a result of studies of the prospective application of hyperthermia to the treatment of cancer. It has been shown that shifting of division cycling occurs in cultured tumor cells and in tumors in animals exposed to hyperthermia. Similar events have been seen with many types of normal cells extracted from animals exposed to a variety of electromagnetic fields. Another corollary, as yet unexamined in radiofrequency fields, is loss of intracellular materials from such cells. (No refs.)

75-209

4622 MODIFICATION OF INTERNAL DISCRIMINATIVE STIMULUS CONTROL OF BEHAVIOR BY LOW LEVELS OF PULSED MICROWAVE RADIATION (PROCEEDINGS ABSTRACT). (Eng.) Thomas, J. R. (Naval Medical Research Inst., Bethesda, MD); Yeandle, S. S.; Burch, L. S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 194; 1975.

The behavioral effects of pulsed microwave radiation were determined on rats performing on a reinforcement schedule regulated by internal stimulus control. The reinforcement schedule required that at least eight consecutive responses be made on one response lever before a response on a second lever would be reinforced with food. If the animal switched to the second lever before the count of eight, the sequence of eight responses had to be restarted. Over a 6-mo period there was a discrimination of the number of responses counted on the first lever, since switching responses occurred with the largest frequency following eight or more responses. Exposure to a pulsed 2.45-GHz radiation source for 30 min with power densities of 5, 10, or 15 mW/cm^2 produced changes in the performance on the fixed consecutive number schedule. All power densities led to increased frequency of premature switching, with the highest power producing the most disruption of the counting discrimination. Premature switching responses due to radiation exposures were associated with pronounced reductions in the percentage of correctly performed response runs that produced reinforcements. Microwave radiation had no effects on overall or running response rates or on response variability. Performance changes were not related to induced hyperthermia. (No refs.)

75-210

4623 MICROWAVE FREQUENCY AND E-FIELD ORIENTATION INTERACT WITH ANIMAL SIZE (PROCEEDINGS ABSTRACT). (Eng.) Schrot, J. (Dept. Microwave Research, Walter Reed Army Inst. Research, Washington, DC); Hawkins, T. D. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 233; 1975.

The interaction between microwave frequency, E-field orientation, and animal size was investigated using elapsed time to tonic-clonic convulsion as the dependent variable. The frequencies employed were 710, 985, 1700, 2450, and 3000 MHz. The subjects were exposed in two E-field orientations at each frequency, namely, E parallel and E vertical to the long axis of the animal's body. At each frequency-orientation combination, groups of 11 mice (25-35 g), small rats (100-125 g), and large rats (380-420 g) were exposed. Individual exposures took place in an anechoic chamber, with the animal restrained in a plexiglas enclosure. All exposures were performed with a 150 mW/cm^2 continuous wave signal. The results clearly demonstrate that the frequency, orientation, and body size variables contributed significantly in determining elapsed time to convulsion. The horizontally aligned E-field produced consistently faster times to convulsion across animal size and frequency. In general, increasing animal size produced greater vulnerability (shorter convulsion times) with lower frequencies. For example, mice were most vulnerable in the 1700-2450 MHz range, small rats at 985 MHz, while large rats convulsed most quickly at 710 MHz. The frequency-vulnerability relationships were most clearly demonstrated with the E-field polarized horizontally. These data indicate the importance of considering frequency, orientation, and subject size when evaluating vulnerability to microwave exposure. (No refs.)

75-211

4624 INVESTIGATION OF ELECTROMAGNETIC EFFECTS OF A 1000 FT. TV TOWER ON MIGRATORY BIRDS (PROCEEDINGS ABSTRACT). (Eng.) Burks, D. G. (Electrical Engineering Dept., Auburn Univ., Auburn, AL); Graf, E. R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 311; 1975.

The high incidence of bird collisions at a 1000 ft TV tower north of Tallahassee, Florida, motivated this study of possible electromagnetic effects in bird navigation. Data collected over a 19-year period (1956 to 1975) concerning daily bird kills, number of birds, species, and position found formed the basis of a correlation study to determine factors responsible for high bird kills. Evidence indicates that bird navigation is a complicated process involving the integration of many sensory inputs including sight, pressure, smell, and magnetic field. This study investigated bird responses to (1) TV radiation from the tower, (2) disturbances

of natural magnetic and electric fields, and (3) lights of the tower. Interference with the bird's navigation process that results in an attraction to the tower was responsible for bird kills not resulting in random incidence. The electromagnetic environment of the tower and theories of bird navigation regarding this problem are discussed. (No refs.)

75-212

4625 EFFECTS OF 45 HERTZ ELECTRIC FIELD EXPOSURE ON RATS (PROCEEDINGS ABSTRACT). (Eng.) Mathewson, N. S. (Armed Forces Radiobiology Research Inst., Defence Nuclear Agency, Bethesda, MD): Oosta, G. M.; Oliva, S. A.; Blasco, A. P. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 269; 1975.

The effect of a vertical sinusoidal electric field exposure of 45 Hz was studied in the adolescent rat. Exposures were conducted in six identical horizontal air gap parallel plate capacitors. The applied electric field of each chamber could be varied individually and each chamber contained 16 uniformly illuminated cages. The cages were designed to house one animal, to allow the food and water consumption to be measured, and to produce a minimum perturbation of the applied field. Electric and magnetic field map data indicated that 45- and 75-Hz magnetic field levels were less than 2 mG, and electric field variations within the cage areas were typically ± 5%. Exposures at electric field strengths from 2-100 V/m were performed for 28 days. Animal growth during the exposure period was estimated by monitoring the body weights of all animals. Gross metabolism was estimated by monitoring the food and water consumption on a per animal and per gram of body weight basis. At the termination of the 28-day exposure period animals were sacrificed, and a complete blood count was obtained on each animal. In addition, the serum protein and lipid fractions of each animal were monitored, and a necropsy was performed on selected animals of control and irradiated groups. Preliminary analysis of data from 18 groups of 16 animals each at five electric field strengths suggested that the 45-Hz vertical electric field exposure did not significantly affect the rats. (No refs.)

75-213

4626 CHRONIC LOW-LEVEL EXPOSURE OF RABBITS TO MICROWAVES (PROCEEDINGS ABSTRACT). (Eng.) Ferri, E. S. (U.S. Dept. Health, Education, Welfare, Food and Drug Admin., Bureau Radiological Health, Div. Biological Effects, Winchester, MA); Hagan, G. J. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 319; 1975.

To determine whether biologic effects occur after chronic low-level irradiation, six rabbits were exposed to 2.45 GHz continuous wave radiation in an anechoic chamber to an incident power density of 10 ± 1 mW/cm^2 for 8 hr/day, 5 consecutive days a wk for periods ranging from 8-17 wk. Body weight, food and water consumption, and coat condition were monitored daily for possible radiation responses. Counts of total red and white blood cells were made weekly, and the lens of the eye was examined by slit lamp for changes. Six litter mates of the above group, similarly treated and sham-exposed during identical periods of time, served as controls. A slight lowering of food and water consumption was observed in the irradiated group during the first week of exposure. The lowered consumption was not accompanied by a detectable weight loss. No other differences were detected between experimental and control animals. No latent effects were observed up to 2 mo post-irradiation. (No refs.)

75-214

4627 SOME DEVELOPMENTAL AND BEHAVIORAL FACTORS OF LOW INTENSITY X-BAND RADIATION (PROCEEDINGS ABSTRACT). (Eng.) Kindt, C. W. (Regional Primate Research at the Univ. Washington, Seattle, WA); Bowden, D. M.; Spelman, F. A.; Morgan, M. K. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 311-312; 1975.

To determine possible toxic effects of low intensity X-band radiation, four pregnant Sprague Dawley rats were exposed (dosage not specified) for the duration of pregnancy (21 days). The offspring were further exposed at the same level for an additional 28 days. The offspring and mothers were studied to determine the effects of irradiation on weight gain, righting, exploratory behavior, eye opening, ear flap development, internal and external anatomic malformations, tooth eruption, corticosteroid levels and adrenal weight, and maturation of reproductive systems. This experiment precedes the use of infant monkeys in a remote respiration monitoring system using X-band radar. (No refs.)

75-215

4628 BIOLOGIC EFFECTS OF PULSED HIGH FREQUENCY ELECTROMAGNETIC RADIATION (PROCEEDINGS ABSTRACT). (Eng.) West, B. (M.C.V./V.C.U., Richmond, VA); Regelson, W. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 93-94; 1975.

A pulsed electromagnetic nonionizing radiation source utilizing a carrier frequency of 27.12 MHz delivered at one of six preselected pulsed frequencies significantly altered survival time and size of implanted B-16 melanoma and Lewis lung tumors in syngeneic mice. The highest pulsation rate (600 pulses/sec) had a pulse length of 65 microsec delivery at 975 W peak power at an average 38 W. Mice irradiated for 20 min daily for 3 days prior

to tumor exposure showed an enhancement of tumor growth and a decrease in life span. Postoperated models irradiated at 400 pulses/sec showed increased life span. Effects against the P388 and L1210 ascites leukemia have been equivocal. Biologic activity, including body weight change and speed of drug metabolism, differed from controls. Decreases in sleeping time of mice injected with sodium pentobarbital immediately before whole-body high frequency exposure was associated with an increase in liver cytosol protein, implying the P450 drug hydrolase system may be stimulated. Significant inhibition of weight gain and differential development patterns in maturing male mice occurred after 30 min daily exposure for 14 days at the highest pulse frequency. Female mice showed a different weight inhibitory pattern initiated during the 14-day radiation schedule. Adult weight levels for both controls and treated mice were similar, which indicated a temporary effect in developmental gain equalized at approximately 2-4 wk. These effects appeared independent of overall effects on body temperature and were not associated with any gross alterations in organ to body weight ratios. (No refs.)

75-216

4629 TIME-COURSE OF ADRENAL RESPONSE IN MICROWAVE-EXPOSED RATS (PROCEEDINGS ABSTRACT). (Eng.) Guillet, R. (Univ. Rochester, Rochester, NY); Lotz, W. G.; Michaelson, S. M. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 316; 1975.

Adrenal function was studied in six unanesthetized young adult male Long Evans rats exposed to microwaves. Corticosterone levels were determined in sequential blood samples obtained via chronic indwelling jugular catheters. Samples were taken before, during, and following exposure to microwaves (2450 MHz, continuous wave) at power densities of 30, 40, or 60 mW/cm^2 for 15, 30, or 60 min. Plasma corticosterone levels rose in all six rats exposed to 60 mW/cm^2, regardless of duration of exposure; most rose within 15 min; all rose within 30 min of start of exposure. Plasma corticosterone levels rose in all six rats exposed to 40 mW/cm^2 for 30 or 60 min, but not in those (2/2) exposed for 15 min. One of four rats responded with an increase in plasma corticosterone to exposure to 30 mW/cm^2. Plasma corticosterone levels tended to plateau during exposure and, in general, began to drop sharply following termination of exposure, returning to baseline within 30 min in all cases. The data on rats exposed to thermogenic power density-time relationships demonstrate the transient nature of the response. (No refs.)

75-217

4630 BIOLOGICAL THERMAL EFFECT OF MICROWAVE RADIATION ON HUMAN EYES (PROCEEDINGS ABSTRACT). (Eng.) Al-Badwalhy, K. A. (Dept. Electrical Engineering, Cairo Univ., Cairo, Egypt); Youssef, A-B. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 39; 1975.

A spherical model for the head irradiated by microwaves was studied to assess the effects of microwave radiation on human eyes. The two eyes properly located in the head were also assumed spherical with the eye lens in its most probable place inside the eye. The electromagnetic transmission problem was first solved to find the fields in the eye and the heat diffusion equation was then solved in spherical coordinates inside the eye. A constant temperature gradient G_1 was assumed on the cornea and the part of sclera exposed to air. Another temperature gradient G_2 was assumed constant on the remaining part of the eye ball. The constant G_1 accounted for cooling by aqueous humour, eye lid tears, and radiation; whereas, G_2 accounted for both metabolic heat gengration and blood cooling by means of retinal arteries, and retinal, intrascleral, and episcleral veins. Body reaction in the form of increased blood circulation in blood capillaries to avoid such forced temperature rise was accounted for by an increase in G_2. Temperature profiles were presented for different levels of the incident plane microwave and for varying degrees of body reactions. The capability of blood circulation to protect the eye lens from overheating was critically evaluated because such blood circulation is not close enough to the eye lens. Safe long-term microwave leakage exposure levels were also calculated. (No refs.)

75-218

4631 THE EFFECT OF MICROWAVE EXPOSURE ON BACTERIA: MUTATION INDUCTION (PROCEEDINGS ABSTRACT). (Eng.) Blackman, C. F. (Environmental Protection Agency, Experimental Biology Div., Research Triangle Park, NC); Surles, M. C.; Benane, S. G. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 134-135; 1975.

The mutagenic potential of continuous wave electromagnetic radiation at 1.70 and 2.45 GHz was examined in a strain of the bacterium, *Escherichia coli*, which was used to detect both forward and reverse mutations. Log phase cultures of the bacterial strain were placed in 35 mm diameter sterile plastic tissue culture dishes and irradiated for 3-4 hr at 35°C. Exposures at 2.45 GHz were conducted at far field power densities of 10 and 50 mW/cm^2, which correspond to absorbed dose rates of 14 and 69 W/kg, respectively. Exposures at 1.70 GHz, at a near field power density of 2.0 mW/cm^2, were estimated to correspond to an absorbed dose rate of 2.8 W/kg. Sensitivity for mutation induction was optimized by exposing the bacteria during at least one complete DNA replication cycle. Although positive controls using ultraviolet light demonstrated the expected exponential survival curve and increase in mutation induction, no mutagenic activity could be demonstrated for either microwave frequency. (No refs.)

75-219

4632 THE EFFECTS OF ENVIRONMENTAL TEMPERATURE ON THERMOREGULATORY, SERUM LIPID, CARBOHYDRATE, AND GROWTH HORMONE RESPONSES OF RATS EXPOSED TO MICROWAVES (PROCEEDINGS ABSTRACT). (Eng.) Houk, W. M. (Naval Aerospace Medical Research Lab., Pensacola, FL); Michaelson, S. M.; Belscher, D. E. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.); 309; 1975.

Long Evans rats were exposed to 2450 MHz continuous wave horizontally polarized microwave radiation at room temperature (22.5° C), at low (17.5° C), as well as at high (27.5° C) environmental temperature. Three different exposure intensities (10.2, 19.6, and 30.5 mW/cm^2) (± 0.8 dB) were used in a 1.8 x 1.8 x 1.8 m semi-enclosed anechoic environmental control chamber. Sets of four animals were exposed simultaneously to a selected temperature and radiation environment for 150 min followed by a 60-min post-exposure period. After exposure the animals were weighed, decapitated, exsanguinated, and colonic temperature was measured within 90 sec after death. This procedure with sets of four animals was repeated with the animal sacrificed at different times during the exposure period. None of the sham-exposed rats demonstrated significant colon temperature alterations in the normal, low, or high temperature environments. In rats exposed at room temperature to 10.2 mW/cm^2, there were no differences in colon temperatures compared to the sham-irradiated group. The 19.6 and 30.5 mW/cm^2 exposure groups were observed to have from 0.7 to 1.0° C colon temperature increases in the normal environment. Cooling the room negated the colonic temperature increase in the 19.6 mW/cm^2 exposed group and suppressed the increase in the 30.5 mW/cm^2 group. Heating the room caused all colon temperature responses seen in all three microwave-exposed animal groups to rise incrementally (0.3, 0.8, and 2.4° C), with an obvious generalized stress response observed in the 30.5 mW/cm^2 irradiated group. The complex serum parameter interrelationships, which correlate with the environmental temperature alterations and the microwave exposures, are discussed. (No refs.)

75-220

4633 COMPARISON OF THERMAL EFFECTS IN THE RABBIT EYE FROM MICROWAVE RADIATION AND FROM EXTERNAL HEATING (PROCEEDINGS ABSTRACT). (Eng.) Carpenter, R. L. (U.S. Dept. Health, Education and Welfare, Food and Drug Admin., Bureau of Radiological Health, Div. Biological Effects, Winchester, MA); Hagan, G. J. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 321-322; 1975.

The effects of external heating on the rabbit eye were investigated and compared with the cataractogenic effects of microwave irradiation. The intraocular temperature of rabbits was elevated by the same amount as occurs during a cataractogenic exposure to 2450 MHz microwave radiation and for the same duration but without employing microwaves. Heat was applied externally to the scleral region overlying the ciliary body, thus heating the blood flowing to it, the iris, and the corneal limbus. The heat source was a thin copper girdle shaped to the contour of this region of the eye. A circular brass tube was soldered to its upper surface to carry a flow of water from a thermostatically regulated water bath. In an initial series of experiments, water bath temperatures were correlated with temperature measurements made by thermocouple in the vitreous body close behind the lens. This type of heating inflicted more severe damage than does equivalent microwave heating. Local venous stasis was observed as well as hemorrhage in ciliary body and iris vessels, corneal neovascularization, and many instances of extensive hyphemia. The few opacities that developed were in the anterior lens cortex, thereby differing in location from those induced by microwaves. (No refs.)

75-221

4634 DISCRIMINATIVE CONTROL OF APPETITIVE BEHAVIOR BY PULSED MICROWAVE RADIATION IN RATS (PROCEEDINGS ABSTRACT). (Eng.) Johnson, R. B. (Dept. Rehabilitation & Psychology, Univ. Washington, Seattle, WA); Myers, D.; Guy, A. W.; Lovely, R. H.; Galambos, R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 37-38; 1975.

To assess the effects of pulsed microwave radiation on rat appetitive behavior, food deprived albino rats were trained in an anechoic chamber to make a nose-poking operant, while restrained in a plexiglas rat holder. During daily 1.5-hr sessions, individual animals were presented alternating 5-min stimulus-on/stimulus-off periods during which food was made available as reward for responding only during stimulus-on periods. A response consisted of extending the nose forward and upward to break a lightbeam photo cell arrangement. The original stimulus was a 7.5 kHz audible click produced by a high frequency tweeter driven by a 1 V, 3 μsec duration square-wave pulse at the rate of 10 pulses/sec. Within 2 weeks, these animals learned to sufficiently inhibit responding such that 85-90% of a session's total responses were made during the appropriate stimulus-on periods. During one of the stimulus-off periods in which each animal was not responding, it was exposed for 30 sec to pulsed microwave radiation at the same pulse width and rate as the auditory stimulus and at field strength < 5 mW/cm^2. These animals showed definite "orienting responses" and began to respond during the presentation. During subsequent sessions in which microwaves, not the audible clicks, were present during the stimulus-on periods, all animals demonstrated a continued ability to respond at the 85-90% level. Although the results suggest an auditory component in the microwave control of this behavior, the demonstrations also indicate that stimulus control of appeti-

tive behavior can indeed be obtained with pulsed microwaves. This is in contrast to reports that such control cannot be obtained with modulated microwave radiation. These findings also stand in contrast to, and suggest other possible interpretations of, recent reports of detection and avoidance of pulsed microwave radiation in rats. (No refs.)

4635 EXPOSURE OF DOMESTIC FOWL TO ELF ELECTRIC AND MAGNETIC FIELDS (PROCEEDINGS ABSTRACT). (Eng.) Durfee, W. K. (Dept. Animal Science, Univ. Rhode Island, Kingston, RI); Plante, P. R.; Martin, P.; Muthukrishnan, S.; Polk, C. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 269-270; 1975.

The domestic fowl, *Gallus domesticus*, was used in two series of experiments designed to evaluate the influence of continuous wave, extremely low frequency (ELF) magnetic and electric fields upon: (1) growth, development, and hatchability of the chick embryo; (2) early post-natal growth and development of the chick; and (3) growth of the sexually immature bird. Special equipment was constructed to provide uniform ELF fields (60 and 75 Hz) at identical frequencies (45, 60, and 75 Hz) and amplitudes for continuous exposure of embryos and chicks throughout the preincubation holding, incubation, and hatching periods and through the first 4 wk of brooding. The magnetic fields were maintained at 1, 5, 8, or 30 G, and the electric fields were maintained at 1, 10, or 3600 V/m. These ELF fields had no significant or consistent effects on: (1) hatchability of fertile eggs, (2) embryonic survival during the most critical stages of development, (3) early post-embryonic growth (to 4 wk of age), and (4) learning and memory consolidation in the neonatal chick. Growth and development to 10 wk of age was not affected by earlier (4-wk) exposure. A 60 Hz, 5 G magnetic field had no effect on metabolic activity of chick embryos as determined by embryo growth rate and CO_2 production. (No refs.)

75-222

4636 EFFECTS OF WEAK LOW FREQUENCY ELECTRIC FIELDS ON CALCIUM EFFLUX FROM ISOLATED CHICK AND CAT BRAIN (PROCEEDINGS ABSTRACT). (Eng.) Bawin, S. M. (Dept. Anatomy, Univ. California, Los Angeles, CA); Adey, W. R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 267; 1975.

Freshly isolated chick cerebral hemispheres were equilibrated with a calcium Ringer's solution containing $^{45}Ca^{2+}$ for 30 min. Washed tissue portions were exposed to sinusoidal electric fields at either 1, 6, 16, or 32 Hz with electric gradients of 5, 10, or 56 V/m in air for each frequency for 20 min. Then $^{45}Ca^{2+}$ efflux was measured in 0.2 ml of supernatant and compared with efflux from unexposed control samples. All tissues were maintained at 36°C and checked for specific activity after the experiments. A frequency sensitive "tuning curve" showed sharply reduced efflux of 15-20% at 6 Hz ($p<0.05$) and 16 Hz ($p<0.01$) for 10 V/m fields. Similar but slightly smaller reductions ($p<0.05$) occurred at 56 V/m. Threshold was around 10 V/m, but non-significant trends occurred at 5 V/m. Cat visual, auditory, suprasylvian, and sensory-motor cortex tested at 1, 6, 16, 32, or 75 Hz, 56 V/m showed significantly decreased effluxes at 6 Hz ($p<0.05$) and 16 Hz ($p<0.01$) but with non-significant trends at all other frequencies tested. At 10 V/m, non-significant decreases occurred at 6 and 16 Hz. It is concluded that oscillating electric low frequency fields at 6 to 30 Hz reduce Ca efflux; whereas, weak very high frequency fields amplitude modulated at the same frequencies increase efflux. A model for both effects based on cooperative interactions of Ca with fixed charges on stranded biopolymers is proposed. (No refs.)

75-223

4637 MICROWAVE-INDUCED HYPERTHERMIA AND RADIATION SENSITIVITY OF MOUSE INTESTINE (PROCEEDINGS ABSTRACT). (Eng.) Gordon, G. A. (Dept. Radiology and Bioengineering, Univ. Utah, Salt Lake City, UT); Livingston, G.; Dethlefsen, L. A. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 92-93; 1975.

Recent data show that heat applied alone both *in vitro* and *in vivo* selectively kills cancer cells and that heat plus radiation have a synergistic interaction. Normal tissue tolerance has been studied using only hot-water immersion of mouse skin. In this investigation, C3H mouse intestine was irradiated to define normal tissue response more adequately. Microwaves were generated by a 2450 MHz microwave magnetron and delivered through a wave guide, which was collimated to encompass the upper abdomen. The mid-upper abdomen temperature of the mouse was monitored continuously with a liquid crystal thermometer inserted into the rectum up to the epigastrium. At a fixed power, microwaves were pulsed until the intestine attained the desired temperature (43 and 45°C), which was then sustained for varying periods of time. Immediately post-heating, 1000 rads of whole body radiation were administered and at 3½ days post-treatment, the intestine was removed with histopathologic sections prepared, and the regenerative crypts counted. With heat alone (45°C for 15 min), preliminary data suggested survival was reduced to less than 45% (12 to 28 animals). Similar low survival (4/13) was seen with 45°C for 2 to 4 min. Crypt-cell survival was strikingly reduced with combination heat and radiation (45° for 2 min). Since the systemic rise in temperature related to vascular heating may have caused the high mortality, the above technique was altered to improve survival. The subcutaneous temperature was monitored when cool air was blown on a wet mouse, and this caused the subcutaneous tempera-

ture to remain at, or less than, normal with no change in mortality. To avoid the vascular organs of the liver, lung, and heart, the distal colon was heated, and again there was poor survival (4/28; 45°C for 3 min). Heating of externalized bowel resulted in the same low survival. Further studies will pursue these techniques to develop complete radiation dose-response curves and evaluate implanted tumor response. (No refs.)

75-224

4638 A STUDY OF THE EFFECTS OF MICROWAVE IRRADIATION OF THE RAT TESTES (PROCEEDINGS ABSTRACT). (Eng.) Muraca, G. J., Jr. (U.S. Dept. Health, Education, Welfare, Food and Drug Admin., Bureau Radiological Health, Div. Biological Effects, Winchester, MA); Ferri, E. S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 320-321; 1975.

Because of the thermal sensitivity of mammalian germinal tissues, the testes constitute a critical organ of interest in the study of microwave biologic effects. To investigate the possibility that thermal stress by microwave irradiation, as opposed to conventional heating, induces unique biologic effects, the testes of albino Sprague-Dawley rats were exposed *in vivo* to 2.45 GHz continuous wave radiation. The testes were then histologically compared to testes heated by immersion of the scrotum in warm water. Preliminary experiments indicated that an intratesticular temperature rise to 40°C by microwave irradiation, maintained for periods of 5-25 min, produced degenerative changes in less than 50% of the animals exposed. The effects of temperature rises to 38°C and 42°C were also investigated for single and repetitive exposures. In both microwave and water bath experiments the intratesticular temperature was continuously monitored and maintained at selected temperatures for chosen periods of time. The testes of 100 animals were exposed to microwave irradiation, and 50 animals had their scrotum immersed in warm water. Similar histologic damage was observed in both exposure categories with observations classified in four categories from normal to severely damaged. The results, however, are not inconsistent with a thermal mechanism of microwave injury to the testes. (No refs.)

75-225

4639 LONG TERM EXPOSURE STUDIES OF HIGH PEAK POWER (HPP) PULSED ELECTROMAGNETIC RADIATION ON MICE (PROCEEDINGS ABSTRACT). (Eng.) O'Grady, T. C. (Biomedical Research Lab., Naval Surface Weapons Center, Dahlgren, VA); Glaser, Z. R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 310-311; 1975.

Three separate groups of mice were exposed to high peak power (HPP) pulsed radiation over a 6-mo period, 1 hr/day, 5 days/wk to assess the effects of long-term exposure. Group I, which consisted of 59 experimental animals and 29 control animals, was exposed from birth to 180 days total exposure; Group II, which consisted of 77 experimental animals and 22 controls, was exposed from birth to 180 days; Group III was exposed from birth to 60 days of age. At 20-day intervals in Groups I and II (every other day or biweekly in Group III) six experimental animals and three control animals were sacrificed and analyzed for a variety of biologic parameters. These parameters included clinical blood chemistries (hematocrit, white blood cell count, platelet count, differential counts), serum electrophoresis, liver, heart and skeletal muscle enzyme activities, and gross morphologies. The exposures were made between the plates of a HPP pulser operating at ∿27 MHz with a field strength of ∿100 kV/m, pulse duration ∿200 nanosec, and a repetition rate of 20 pulses/sec. The presence of changes in any of the biologic parameters would indicate a stress effect resulting fro... the radiation. (No refs.)

75-226

4640 ALTERATIONS IN THE SLEEP PROCESS OF THE RABBIT AS A FUNCTION OF CHRONIC LOW INTENSITY ELECTROMAGNETIC RADIATION EXPOSURE (PROCEEDINGS ABSTRACT). (Eng.) Manthei, R. C. (Biomedical Research Lab., Naval Surface Weapons Center, Dahlgren, VA); Glaser, Z. R. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 192-193; 1975.

To study the effects of nonionizing radiation exposure on brain electrical activity, continuous recordings of electrocorticogram (ECOG), electrooculogram (EOG), and electromyogram (EMG) were obtained from adult male rabbits on a 24-hr basis following daily 2-hr microwave exposure at 5 mW/cm^2 for 60 days. The surgical implant assembly allowed chronic post-irradiation recording, while allowing no metallic elements to be associated with the subjects during microwave exposure. Logic circuitry allowed the quantification of both the frequency and duration of rapid eye movement (REM) stage episodes. It is concluded that prolonged exposure of an organism to microwave radiation will decrease the frequency and duration of REM stage sleep. The sleep process is viewed as a potential index of central nervous system adaptation to prolonged electromagnetic radiation exposure. (No refs.)

75-227

4641 BEHAVIORAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. (PROCEEDINGS ABSTRACT). (Eng.) D'Andrea, J. A. (Dept. Electrical Engineering and Bioengineering, Univ. Utah, Salt Lake City, UT); Gandhi, O. P. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 195; 1975.

Two experiments were performed to determine the ef-

fect of RF absorption on the awake active rat. First, to determine the resonant absorption frequency, 15 male Long Evans rats, weighing 350-380 g, were each habituated for 30 min/day for 4 days to a cylindrical Plexiglas restraining chamber (6.5 x 24 cm). On RF exposure days, each rat was fitted with a liquid crystal fiberoptics temperature probe (3 cm rectally). Each rat was given 10 min exposure to RF radiation within a transverse electromagnetic mode parallel plate waveguide at 15 frequencies within the 220-500 MHz band. RF absorption at 500 MHz, with the length of the rat body parallel to the electric field, was three times greater than the average absorption at the other frequencies. RF absorption at 500 MHz in the electric field orientation was 15 times greater than with the rat body parallel to the direction of propagation. Second, to determine the effect of RF absorption on a well trained behavior, six male Long Evans rats were trained to press a Plexiglas lever for dry food pellets on a variable interval 30-sec reinforcement schedule while in the parallel plate waveguide. Preliminary results indicated that resonant (500 MHz) RF exposure in the electric field orientation disrupted lever-pressing behavior sooner than RF exposure at nonresonant frequencies. Future experiments will investigate RF absorption extended to 750 MHz. (No refs.)

75-228

4642 ELECTROMAGNETIC RADIATION EFFECTS ON THE BLOOD-BRAIN BARRIER SYSTEM OF RATS (PROCEEDINGS ABSTRACT). (Eng.) Oscar, K. J. (U.S. Army Mobility Equipment Research & Development Center, Fort Belvoir, VA); Hawkins, T. D. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 222; 1975.

The effect of microwave energy on the blood-brain barrier (BBB) system of rats was investigated. A quantitative radioactive isotope method was used in an attempt to verify the increased BBB permeability of rats using a fluorescein dye technique. Male Wistar rats were subjected to microwave energy at a frequency of 1.3 GHz. The permeability measurement used two radioactive labeled indicators injected simultaneously into a common carotid artery of the anesthetized rat. One test substance was labeled with ^{14}C and the other with tritiated water, which is highly diffusible in the brain tissue and provides a standard for comparison. The rats were sacrificed 15 sec after injection, and tissue samples from five different regions of the brain were counted. This quantitative technique was used to measure the uptake of a test molecule into the brain tissue relative to water to differentiate between a true BBB alteration and vasodilation or stasis. The study used controls (sham-irradiated) and animals exposed to microwaves with various modulation parameters. The double-blind study used D-Mannitol as the test substance in most experiments, although substances of other molecular weight also were used. The results indicated a statistically significant increase in BBB permeability with both pulsed and continuous wave (CW) microwave energy at average power levels considerably below 10 mW/cm^2. The possible differences between CW and pulsed energy, molecular weight of test molecule, functional dependence of the BBB alteration with microwave parameters, and duration of BBB alteration are discussed. (No refs.)

75-229

4643 ADRENOCORTICAL RESPONSE IN RATS EXPOSED TO MICROWAVES (PROCEEDINGS ABSTRACT). (Eng.) Lotz, W. G. (Univ. Rochester, Rochester, NY); Michaelson, S. M. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 139; 1975.

Whole-body acute microwave (2450 MHz, continuous wave) exposure of 120 male Long Evans rats was carried out in the far field of a horn antenna. The rats were housed in non-restraining cages during exposure and sacrificed by decapitation immediately after exposure. Plasma collected from individual rats was analyzed for corticosterone levels to determine the response of the hypothalamic-hypophyseal-adrenal (HHA) axis to the microwave exposure. Circulating corticosterone (CC) levels were significantly higher in rats exposed to 50 mW/cm^2 or 60 mW/cm^2 than they were in control rats, but there was no difference between the CC levels of rats exposed to 10 mW/cm^2 or 20 mW/cm^2 and control rats. Rats exposed to 30 mW/cm^2 or 40 mW/cm^2 showed an inconsistent tendency toward higher CC levels after 1 hr of exposure—the longest exposure used in this study. The data suggested that for 2450 MHz exposures of up to 1 hr, the rat HHA axis was not stimulated unless incident power densities ≥ 30 mW/cm^2 were used. The adrenocortical response at the higher power densities was analogous to the adrenocortical response to other nonspecific stress stimuli and appeared to be a "thermal stress," since those power densities that resulted in increased CC levels also increased the rectal temperature of the rat by 1 to 3°C. (No refs.)

75-230

4644 STUDY OF THE MICROWAVE-INDUCED PERTURBATIONS OF THE BEHAVIOR BY THE OPEN-FIELD TEST INTO THE WHITE RAT (PROCEEDINGS ABSTRACT). (Eng.) Gillard, J. (Ecole d'Application du Service de Sante pour la Marine, Hopital d'Instruction des Armees Sainte-Anne, Toulon Naval, France); Servantie, B.; Bertharion, G.; Servantie, A. M.; Obrenovitch, J.; Perrin, J. C. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 192; 1975.

The open-field test was used to study the effect of a microwave field on white rats. The spontaneous behavior of the animal was studied using four parameters: locomotor activity, exploration activity, vigilance, and emotivity. Rats (106 control and 82 irradiated animals) were exposed during 2 wk to an X-band 9.4 GHz pulse-modulated microwave field with an average power-density of 0.7 mW/cm^2. In

control animals, locomotor activity, emotivity, and vigilance decreased during the test, while exploratory activity increased. In irradiated animals, exploratory activity increased more slowly; vigilance at first increased then decreased; and locomotor activity was uniform. (No refs.)

75-231

4645 REDUCTION IN SENSITIVITY TO AUDIOGENIC SEIZURE FOLLOWING A SINGLE, 2450 MHz, CW IRRADIATION OF RATS (PROCEEDINGS ABSTRACT). (Eng.) Hawkins, T. D. (Dept. Microwave Research, Walter Reed Army Inst. Research, Washington, DC); Hunt, E. L. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 223; 1975.

Male and female Wistar rats from sound-sensitive breeding lines were assessed for convulsive response to high intensity sound 2 min after the termination of a 30-min period of 2450 MHz, continuous wave irradiation. Subjects were preselected for sensitivity to a noise signal (105 dB, 11-14 kHz, 60 sec), which was presented twice weekly during the growth period of 3-5 weeks of age. Experimentation began at 6 weeks of age. Individual exposures occurred in a plane-wave field with the E-vector parallel to the long axis of the rat. The effects of exposure at 50 mW/cm^2 were evaluated in 12 rats. Seven of the subjects were irradiated initially, and five were given a sham treatment. A second treatment was given 4 days later with the conditions reversed for each rat. The effects of a 50 mW/cm^2, 30-min exposure were not significant. Only 2 of the 12 rats failed to respond to the sound challenge following their irradiation. A second study was conducted in a similar manner with 11 new subjects. Exposure for 30 min at 75 mW/cm^2 produced a highly significant reduction in audiogenic response. Nine rats showed no response following irradiation. However, these nine rats did respond following their sham treatment. Recovery of responsiveness within 4 days occurred in all rats for which the sham treatment had followed the microwave treatment. The present data show that audiogenic convulsive responses can be attenuated by a single, 30-min, continuous wave exposure. It is concluded that pulsed irradiation and repeated exposures, which have been used by previous investigators, are apparently not required to produce a decrease of central nervous system sensitivity as reflected by this measure. (No refs.)

75-232

4646 DEPENDENCE OF TOTAL AND DISTRIBUTED ABSORBED MICROWAVE ENERGY UPON SIZE, SHAPE, AND ORIENTATION OF RAT PHANTOMS IN WAVEGUIDE (PROCEEDINGS ABSTRACT). (Eng.) Leicher-Preka, A. (Inst. Physiological Biochemistry, Medical Faculty, Sarajevo, Yugoslavia); Ho, H. S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 136; 1975.

The relationship between the total and distributed absorbed energy in rat phantoms and their sizes and orientations in a waveguide exposed to 2450 MHz microwave radiation was investigated. Six models of tissue-equivalent materials were used to simulate the sizes and shapes of rats that were 1, 4, 10, 23, 30, and 60 days old. The measurements were made with all models at the center of the waveguide oriented facing (0°) and opposite to (180°) the direction of the incident wave. For the two smaller models, the orientation was also varied stepwise from 0° to 180°. The patterns of absorbed energy in the cross sections of the phantoms were studied using a thermographic camera. The result indicated that changes in size, shape, and orientation of exposed animal models produced changes in total and distributed absorbed energy. Although the total absorbed energy changed only slightly between the 0° and 180° orientation, large differences existed in the distribution of absorbed energy in the animal phantoms. With the phantom head facing the incident radiation, in most cases, the head area (including the brain) absorbed the most microwave energy. In the opposite orientation, the maximum absorption concentrated on the tail and abdominal regions. In addition to determining the total absorbed energy, the determination of the distribution of absorbed energy in animal bodies can be important in the interpretation of observed biologic and psychologic effects. (No refs.)

75-233

4647 STEADY STATE TEMPERATURE PROFILES IN MICROWAVE DIATHERMY (PROCEEDINGS ABSTRACT). (Eng.) Al-Badwaihy, K. A. (Dept. Electrical Engineering, Cairo Univ., Cairo, Egypt); Youssef, A-B. A. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 90; 1975.

Body reaction and heat transfer are important factors in predicting steady state temperature profiles in microwave diathermy and hence in determining safe doses of microwaves. This study investigated how to include such effects both in the formulation and numeric solution of steady state temperature profiles. Microwave irradiation of stratified skin, fat, and muscle layers was first considered. Steady state temperature profiles were calculated by solving the heat diffusion equation and the electromagnetic transmission equation. The metabolic heat generation and blood cooling effects were included in the analysis. Body reaction in the form of increased blood circulation as a result of local microwave heating was then considered for different levels of body reaction. The steady state heat diffusion equation became nonlinear when body reaction was taken into consideration. The geometry of a cylindrical layer of skin enclosing fat and muscle in suitable models was then considered. Temperature profiles were again presented for these models and for different frequencies, exposure levels, skin and fat thicknesses, blood circulation rates, and levels of body reactions. It is concluded that the results

should serve as a more accurate guide for suitable exposures for such treatments. (No refs.)

75-234

4648 COLONIC TEMPERATURE CHANGES DURING MICROWAVE EXPOSURE (PROCEEDINGS ABSTRACT). (Eng.) Githens, S. H. (Dept. Microwave Research, Walter Reed Army Inst. Research, Washington, DC); Hawkins, T. D.; Schrot, J. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 232; 1975.

Anesthetized rats and mice were exposed to plane-wave microwaves of 100 mW/cm^2 for exactly 4 min to assess changes in colonic temperature. Changes in colonic temperature were determined from pre-exposure and post-exposure temperature measurements and were compared to those of comparable sham-irradiated subjects. Exposures during which the E-vector was parallel to the long axis of the subject consistently resulted in higher temperatures than did exposures with a vertical E-vector. For each type of animal, differential frequency effects were most pronounced during exposures with a parallel E-vector. Mice (25-30 g) showed larger temperature increases at 1700 and 2450 MHz than at 710 MHz. Small rats (100-125 g) and large rats (380-420 g) exhibited highest temperatures at 710 MHz. Comparing the temperature changes across the groups of subjects of different size, an interaction of frequency and size was indicated. At 1700 and 2450 MHz, a general inverse relation between temperature increase and body size was evident. At 710 MHz, the rank ordering was reversed, indicating a direct relation between temperature increase and the body size of the respective subjects. These colonic temperature changes are suggestive of differential absorption, which is complexly determined by frequency, E-field orientation, and the dimensions of the experimental subject. (No refs.)

75-235

4649 LONG-TERM EFFECTS OF WEAK 45-75 Hz ELECTROMAGNETIC FIELDS ON THE SLIME MOLD, *PHYSARUM POLYCEPHALUM* (PROCEEDINGS ABSTRACT). (Eng.) Greenebaum, B. (Div. Science, Univ. Wisconsin-Parkside, Kenosha, WI); Goodman, E. M.; Marron, M. T. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 267-268; 1975.

Cultures of the slime mold, *Physarum polycephalum*, were continuously exposed to weak (2.0 G, 0.7 V/m) 75, 60, and 45 Hz electric and magnetic fields, applied simultaneously to simulate electromagnetic radiation. Exposure to this radiation caused mitotic delay. The onset of the effect appeared to be frequency dependent; the time for two cell cycles (normally 14-16 hr) was increased by 1-2 hr after 90-120 days of exposure at 75 Hz and after shorter exposure times at 60 and 45 Hz. When cultures showing the delay were removed from the fields, the mitotic delay slowly diminished, becoming indistinguishable from the control after about 30 days. Other effects induced by exposure to electromagnetic fields included a slowing of reversible protoplasmic streaming and a depression in the rate of respiration (O_2 uptake/mg protein/min). Exposure did not affect the ability to complete either the sexual or asexual life cycles. Experiments seeking thresholds have found no significant mitotic delay in cultures exposed to 0.4 G, 0.15 V/m 75 Hz fields. Experiments are in progress to determine whether these effects are due to electric, magnetic, or a combination of fields. (No refs.)

75-236

4650 MICROWAVE-INDUCED AVOIDANCE BEHAVIOR IN THE MOUSE (PROCEEDINGS ABSTRACT). (Eng.) Monahan, J. C. (Bureau of Radiological Health, Rockville, MD); Ho, H. S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 197; 1975.

The ability of low level 2450 MHz continuous wave microwave energy to generate avoidance behavior in the male mouse (30-34 g) was investigated. Subjects were irradiated in an environmentally controlled waveguide assembly at incident power levels of .84, 1.6, 2.4, 3.2, 4.0, and 4.8 W. At 1.6 W and higher, the percent absorption decreased after the initial 5 min and remained lower for the duration of exposure. Subjects exhibited an average maximum of 57% absorption at .84 W, and this decreased with increasing power to an asymptote of approximately 35% at 3.2, 4.0, and 4.8 W. Although no visual observations were possible during irradiation, it was assumed that the subjects were actively decreasing their potential dose of microwave energy by altering both their orientation and their position within the waveguide assembly. The data suggest that the subjects were capable of detecting average dose rates of as little as 28 mW/g. Furthermore, this level of irradiation, while not producing core temperature increases of more than 0.5°C, was aversive and caused the animal to actively try to avoid the microwave radiation. (No refs.)

75-237

4651 THE EFFECT OF CATARACTOGENIC DOSES OF MICROWAVE RADIATION ON LENTICULAR TRANSPORT (PROCEEDINGS ABSTRACT). (Eng.) Rabinowitz, J. R. (New York Univ. Medical Center, Inst. Environmental Medicine, New York, NY). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 41-42; 1975.

To study the effect of cataractogenic doses of microwave radiation on lenticular transport, the influx of L-ascorbic acid (C-14 labelled) into unirradiated and irradiated (cataractogenic doses) rabbit lenses was measured. The lenses were removed and cultured at various times after irradiation and the rate of influx (1.2 µg/hr lens) was

found to be the same for irradiated and unirradiated pairs. Further, the rate of influx was too slow for transport to be responsible for the early decrease in the lenticular concentration of ascorbic acid after microwave irradiation. In another experiment, using similar procedures, the transport of 3-O-methyl D-glucose, a nonmetabolized D-glucose transport analog, and thymidine was studied. Microwave radiation was found to cause changes in the rate of influx. These changes, however, occurred a significant time after irradiation. (No refs.)

75-238

4652 EFFECTS OF 35 AND 107 GHz CW MICROWAVES ON THE RABBIT EYE (PROCEEDINGS ABSTRACT). (Eng.) Birenbaum, L. (Polytechnic Inst. of New York, Brooklyn, NY); Kaplan, I. T.; Metlay, W.; Rosenthal, S. W.; Zaret, M. M. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 40; 1975.

The eyes of anesthetized rabbits were irradiated (56 animals at 35 GHz, 46 at 107 GHz, and 11 sham exposures) with continuous wave microwaves using a circular horn applicator. By this means, the nature of the threshold injury following a single exposure was defined, and the corresponding power levels and exposure times observed. Effect on the corneal stroma, as seen by slit lamp, was found to be a valid indicator of threshold injury. Although 107 GHz power was more effective in producing immediate stromal damage, it was generally gone by the next day. On the other hand, 35 GHz effects were persistent, almost always present the next day, and associated with high levels of epithelial injury. Fluorescein staining was employed to detect epithelial damage. Power levels were principally 50 mW and below. Exposure times ranged from 15-80 min. The degree of stromal injury seen with the slit lamp correlated well with the degree of derangement of the collagen fibers within the corneal layers, as seen with the electron microscope. Threshold levels of power dissipated in the eye, measured in the closed-waveguide experiment, were used to estimate free-field planewave incidence thresholds for immediate injury following an acute exposure. It is concluded that thresholds for chronic low level exposure cannot be deduced from these results but require additional work. (No refs.)

75-239

4653 MICROWAVE PERTURBATION ON CELLULAR ENZYMATIC REACTIONS (PROCEEDINGS ABSTRACT). (Eng.) Hsieh, S. T. (Tulane Univ., New Orleans, LA); Seto, Y. J. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 131-132; 1975.

An attempt was made to account for the microwave-induced cellular growth effect in the facultative non-photosynthetic micro-organism observed in previous experiments. To establish theoretical data, a three-dimensional spherical cell model for extra- and intra-cellular nutrient transports was used. An externally applied electromagnetic field interacting with the transport process of charged nutrient substrates was examined using a perturbation approach and Green's function technique. Solutions correct to second order were obtained. Taking into consideration the localization of respiratory enzymatic systems, a microwave-induced radiofrequency-diffusion effect on substrates was found to modify the nutrient consumption rate. The modified Michaelis-constant in the Monod growth rate equation was shown to alter the batch growth pattern at the deceleration phase isothermally. Analytical results were found to have good agreement with the observed changes of growth pattern in *Escherichia coli* under low intensity microwave perturbation. (No refs.)

75-240

4654 EFFECTS OF MICROWAVE RADIATION ON MAMMALIAN CELLS *IN VITRO* (PROCEEDINGS ABSTRACT). (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI); Chen, K. C. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 132-133; 1975.

A bioengineering approach was developed to differentiate the thermal and non-thermal factors of microwaves acting on mammalian cells in culture. Cells of a Chinese hamster somatic cell line, V79-12201, derived originally from the lung of a male animal, were synchronized by treating cells with a suitable concentration of hydroxymen in conjunction with the mitotic shake-off technique. The synchronized cell populations were then exposed to 2450 MHz radiation of both low and high intensities in a wave-guide chamber. The biologic effects of microwave radiation on these cells were shown to be a function of incident and absorbed power densities and duration of exposure. The possibility of non-thermal involvement in the radiation effect at the cellular level is discussed. It is concluded that this experiment could provide a model system for future studies of the molecular mechanisms of microwave-induced biologic effects in living systems. (No refs.)

75-241

4655 EVALUATION OF DOMINANT LETHAL TEST AND DNA STUDIES IN MEASURING MUTAGENICITY CAUSED BY NON-IONIZING RADIATION (PROCEEDINGS ABSTRACT). (Eng.) Varma, M. M. (Dept. Bio-Environmental Engineering and Sciences, Howard Univ., Washington, DC); Trabculay, E. A., Jr. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 133-134; 1975.

Two dominant lethal tests and three DNA studies were conducted on fifty-six day old Swiss mice exposed to microwave radiation. In the first experiment of the dominant lethal test, the mice were exposed to 1.7 GHz, 50 mW/cm^2 for 30 min, and in the second experiment, the mice were exposed to 1.7 GHz, 10 mW/cm^2 for 80 min. In the first experiment of the DNA studies, the mice were exposed to 1.7 GHz, 50 mW/cm^2 for 30 min; in the second, 1.7 GHz, 10 mW/cm^2 for 80 min; and in the third, 0.985 GHz, 10 mW/cm^2 for 80 min. In the dominant lethal test, mice exposed to 1.7 GHz, 50 mW/cm^2 showed that mutagenicity was significant at the 99% level in the third week and at the 95% level in the fourth, fifth, and sixth weeks. The parallel DNA study showed a change in the temperature from 87°C in the control to 85°C in the irradiated group, with subsequent changes in the based composition and asymmetry ratio. In the second dominant lethal test, mutagenicity was significant at the 99% level in the fifth week and at the 95% level in the first, second, third, and sixth weeks. The parallel DNA study showed changes in the temperature (86°C), base composition, and asymmetry ratio. A third DNA study was performed at 0.985 GHz, 10 mW/cm^2 for 80 min and similar changes in the temperature (85.5°C), base composition, and asymmetry were observed. The change in the optical density of the irradiated DNA supports the possibility that irradiation causes strand separation and reflects a decrease in hydrogen bonding. A point mutation would then result, if there is imprecise base matching. (No refs.)

75-242

4656 CHRONIC EXPOSURE OF A RAT POPULATION BY CIRCULARLY POLARIZED GUIDED WAVES (PROCEEDINGS ABSTRACT). (Eng.) Guy, A. W. (Bioelectromagnetics Research Lab., Univ. Washington, Sch. Medicine, Seattle, WA); Chou, C. K.; Lovely, R. H. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 138; 1975.

A system was developed for economically exposing a large number of rodents on a long-term basis without disturbing their normal laboratory living patterns. The use of separate cells consisting of cylindrical wave-guide excited with circularly polarized guided waves provided relatively constant and easily quantifiable coupling of the fields to each animal, regardless of the animal's position, posture, and moving patterns. The VSWR to each cell was sufficiently low that any number of cells could be coupled to a single source through a power splitter without the need for isolation circuitry. Tests made on ellipsoidal phantom models of a 333 g rat exposed in various possible shapes and positions in a 20 cm diameter exposure chamber operating at 918 MHz indicated that the subjects absorbed approximately one-quarter of the input power to the cell, regardless of position. Based on a net 1 W input (average incident power density of 3 mW/cm^2) the average absorbed power density varied from 0.79 to 0.92 W/kg and the peak absorbed power density varied from 1.06 to 1.42 W/kg in the phantoms. Measurements were made for the total power absorption as a function of time in a 323 g live rat exposed for a number of hours in the chamber. With an incident input power of 1 mW to terminal R_F, the mean absorbed power was 0.43 mW with a standard deviation of ± 0.07 mW. (No refs.)

75-243

4657 INTERACTION OF MODULATED ELECTROMAGNETIC FIELDS WITH NERVOUS STRUCTURES (PROCEEDINGS ABSTRACT). (Eng.) Wu, C. -L. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI); Lin, J. C. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 226-227; 1975.

Low level electromagnetic fields, amplitude modulated at brain wave frequencies, have been shown to influence the conditioned and spontaneous electroencephalographic patterns in cats and to increase the calcium efflux from isolated brains of neonatal chicks. One hypothesis offered was that the electric fields induced in the brain were modifying the membrane characteristics of neurons either by triggering configurational changes on the surface macromolecules or by inducing small displacements of the surface-bound cations. This study examined the theoretic considerations for the induced fields immediately surrounding the central neurons. By using a "greater membrane model" as a basis, the possibility of the interaction of impinging low level electromagnetic fields with the central nervous system was investigated. A comparison between the effects of amplitude modulated and continuous wave radiations is presented. (No refs.)

75-244

4658 MICROWAVE-INDUCED SHIFTS OF GONADOTROPIC ACTIVITY IN ANTERIOR PITUITARY GLAND OF RATS (PROCEEDINGS ABSTRACT). (Eng.) Mikolajczy, H. (Inst. Occupational Medicine, Lodz, Poland). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 225; 1975.

The effects of microwave irradiation on the hormonal activities of rat pituitary glands were studied. Twelve 35-day-old male rats (I) were exposed 6 hr daily for 6 days weekly for 6 weeks to microwaves (2860-2880 MHz, continuous wave, 10 mW/cm^2). Each day the animals were caged randomly in a perforated polyvinyl box spaced for pairs of animals, and the box was placed in an anechoic chamber before horn antenna in far field. At the same time 12 control rats (II), manipulated and caged in comparable manner, were placed in a separate anechoic chamber without radiation source. Microwave-irradiated and control rats were killed on the day after last exposure, and separated anterior pituitaries were stored for 48 hr in cold acetone. The saline extracts of individual pituitary homogenates were tested separately; the extract from each pituitary

was tested in a single immature hypophysectomized rat. Six pituitaries of each group of animals (I and II) were tested for follicle stimulating hormone (FSH) and for gonadotropic hormone (GH) and the other six pituitaries were tested for luteinizing hormone (LH). NIH-FSH-S7, NIH-LH-S15, and NIH-GH-S were used as standards. The following quantities of hormones were found in μg/pituitary ($\bar{X}$ ± S.D. ± S.E.): (I) in irradiated rats - FSH: 655 ± 123 ± 50; LH: 302 ± 81 ± 33; GH: 140 ± 37 ± 11; (II) in control rats - FSH: 635 ± 84 ± 33; LH: 197 ± 34 ± 14; GH: 134 ± 41 ± 13. The amount of LH was significantly higher (at $p < 0.05$) in the pituitary gland of irradiated than of control rats. The results of this investigation support the findings of a previous study about the possible shifts of gonadotropic activities in pituitary gland of rats exposed to microwave radiation. (No refs.)

75-245

4659 ELECTRIC DIPOLE INTERACTIONS FOR MICROWAVE PULSES AND DAMAGE TO EMBRYOS (PROCEEDINGS ABSTRACT). (Eng.) Pyle, S. D. (Dept. Electrical Engineering, Univ. Colorado, Boulder, CO); Hu, C. L.; Caldwell, R.; Barnes, F. S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 204-205; 1975.

The effect of high power microwave pulses on zebra fish embryos was studied. Microsec pulses with electric field strengths between 5 and 15 kV/cm at 2.7 GHz were used to kill fish embryos in a temperature-controlled environment. A partial temperature independence for damage was found, and the orientation of asymmetric dielectric bodies may have been responsible for death by changes in osmotic pressure. Low frequency data on electrically-induced birefringence changes in blood plasma are presented. (No refs.)

75-246

4660 THEORETICAL CALCULATIONS OF POWER ABSORBED BY MONKEY AND HUMAN SPHEROIDAL AND ELLIPSOIDAL PHANTOMS IN AN IRRADIATION CHAMBER (PROCEEDINGS ABSTRACT). (Eng.) Massoudi, H. (Univ. Utah, Salt Lake City, UT); Durney, C. H.; Johnson, C. C.; Allen, S. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 199; 1975.

The electromagnetic field perturbation technique was used to calculate the total absorbed power of monkey and human spheroidal and ellipsoidal phantoms in a near-planewave irradiation chamber to compare experimental and theoretic values. The measured values of electric and magnetic field strength in the empty irradiation chamber were used to calculate the absorbed power. Since the measured values of E and H did not have the planewave impedance of 377 ohms, a theoretic technique was developed in which the power absorbed in the prolate spheroid phantoms in the presence of two oppositely traveling planewaves was calculated. This method gave the power absorbed in an irradiation field in which the E/H impedance ratio was not necessarily equal to 377 ohms. Calculated data for power absorbed by monkey and human phantoms from 10 MHz to 50 MHz are presented and discussed. For the monkey phantoms, data are given for the three principal polarizations: electric, magnetic, and cross, but for the human phantom, data are given only for magnetic and cross polarization because the phantom was too long to allow measurements with electric polarization. (No refs.)

76-71

4661 THE THERMAL, NON-THERMAL AND THERAPEUTIC EFFECTS OF 2450 MHz RADIATION ON MAMMALIAN CELLS (MEETING ABSTRACT). (Eng.) Key, M. (Radiation Therapy Div., Univ. Miami Sch. Medicine, Miami, FL 33152); Charyulu, K. K. N. *Radiat. Res.* 67(3): 549; 1976.

Chinese hamster cells were grown *in vitro* and raised to various temperatures, between 34°C and 45°C for periods up to 5 hr, by exposure to 2450 MHz radiation or immersion in a warm water bath. Indices of cell damage were measured. Effects at temperatures below 37°C were classified as non-thermal, and in most of the experiments these effects were not significant. At given temperatures above 37°C there were only slight differences between the damage caused by the microwaves and by the water bath immersion. No effect, other than thermal, could be clearly determined at these higher temperatures. The therapeutic effect of the microwave radiation was assessed by using it to locally heat Ehrlich ascites cells grown intraperitoneally in mice. A temperature of 42.5°C for a period of 30 min was the best compromise treatment consistent with mouse survival and tumor cell death. Several daily treatments generally produced extended survival times but very few total cures. Tumor cell viability was measured by the dye exclusion technique following either *in vivo* or *in vitro* irradiation. (No refs.)

76-72

4662 EFFECTS OF IODOACETAMIDE, X-RAYS, AND MAGNETIC FIELDS ON LYMPHOMA CELLS *IN VIVO* (MEETING ABSTRACT). (Eng.) Feola, J. M. (Univ. Kentucky, Dept. Radiation Medicine, Lexington, KY 40506). *Radiat. Res.* 67(3): 550; 1976.

Lymphoblastic ascites tumor (LSA) of the C57BL mouse was treated *in vivo* and assayed for tumor-forming ability (TD_{50}) in normal 10-12 wk old recipients. Seven-day-old tumors were used throughout; they were initiated by the intraperitoneal (ip) injection of 10^4 cells. A survival curve obtained by irradiation with x-rays had a D_0 = 369 ± 50 rads and n = 1.7. Simultaneous experiments were done in which 0.185 mg of iodoacetamide (IA) were injected ip 10 min before irradiation. It gave a survival curve with D_0 = 243 ± 35 rads and n = 0.54, showing an independent as well as a sensitizing effect, with a dose-modifying factor DMF = 1.52 ± 0.32. The combined action of IA and x-rays was studied in a magnetic field (MF) of 100 G, used either as a constant MF or alternating

at 60 Hz. These fields produced a similar effect but an intermediate dose-survival curve resulted, D_0 = 194 ± 24 rads, n = 2.8. The MF seemed to modify the combined action of IA and x-rays on the tumor cells. No synergistic action of the MF with x-rays was found; however, the results indicate that magnetic fields may distort radiation sensitivity of cells under certain conditions. (No refs.)

76-73

4663 METABOLIC RATES IN FIVE ANIMAL POPULATIONS AFTER PROLONGED EXPOSURE TO WEAK EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS IN NATURE. (Eng.) Greenberg, B. (Dept. Biological Sciences, Univ. Illinois at Chicago Circle, Chicago, IL 60680); Ash, N. *Radiat. Res.* 67(2): 252-265; 1976.

Soil-dwelling animals were collected under or some distance from the Navy's Project Sanguine extremely low frequency experimental antenna in September 1974 and in summer 1975, and their oxygen consumption and respiratory quotient (RQ) were tested and compared. The antenna generated a 42-76 Hz electromagnetic field. The species included earthworms, *Lumbricus terrestris L.* and *Lumbricus rubellus* Hoffmeister; slug *Arion* sp.; wood louse, *Oniscus asellus L.*; and redbacked salamander, *Plethodon cinereus cinereus* (Green). Controls were collected on the same or next day, 6-13 miles from the nearest antenna. Test and control animals were tested simultaneously. In September 1974 there were no significant differences in O_2 consumption and RQ, except for a marginal difference ($0.05 > p > 0.025$) in O_2 consumption of *L. rubellus;* in 1975, there were no significant differences. Comparisons of metabolic rates between exposed and control groups in fall of 1974 and between fall and summer (1973 and 1975) populations revealed no seasonally linked change in sensitivity to the electromagnetic fields. Controls showed an autumnal increase in metabolic rate of wood lice and salamanders. In an experiment to determine the effect of mode of animal transport on the metabolic rate, it was found that oxygen consumption of wood lice was significantly ($p < 0.05$) affected by method of shipment. There was no evidence, however, that exposed and control animals reacted differently from each other to shipment by air or by car. It was also found that short-term (1 wk) exposure of earthworms to the electromagnetic fields did not alter metabolic rate; however, confinement in nylon bags and translocation did, thereby limiting meaningful conclusions. No abnormalities in behavior, habitat selection, or external features, and pigmentation have been observed in any of the exposed populations during 4 yr of collecting and observation. (22 refs.)

75-247

4664 ELECTROMAGNETIC FIELD EFFECTS ON ISOLATED NERVE TISSUE (PROCEEDINGS ABSTRACT). (Eng.) Sandler, S. S. (Bioelectromagnetics Lab., Dept. Electrical Engineering, Northwestern University, Boston, MA). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 322-323; 1975.

A technique was developed for exposing isolated nerve tissue to a known electric field. Freshly dissected frog brains were placed in a coaxial exposure chamber and subjected to a known electric field. Both thermal and nonthermal field effects are possible. In previous experiments, in which large motor neurons of the spinal cord were exposed to high-voltage subnanosec pulses, which produce negligible thermal heating, no gross histologic damage was found. New experiments have been performed to determine whether there is any field effect that can be seen with the electron microscope. A series of thermal heating studies have also been initiated to correlate tissue damage to the specific local electric field and to the local power density in the tissue. (No refs.)

75-248

4665 MECHANISM OF MICROWAVE CATARACTOGENESIS IN RABBITS (PROCEEDINGS ABSTRACT). (Eng.) Kramer, P. (Bioelectromagnetics Research Lab., Univ. Washington Sch. Medicine, Seattle, WA); Harris, C.; Guy, A. W.; Emery, A. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 40-41; 1975.

The possible existence of a specific non-thermal factor in microwave cataractogenesis was investigated by raising the retrolental temperature to a level known to be associated with cataract formation (42°C or above for at least 30 min) by means other than microwaves. If cataracts develop under these conditions, heat itself is responsible for the lens damage. Rabbits were exposed to conditions of general hyperthermia and their retrolental temperatures maintained above 42°C for over 30 min. The animals were allowed to recover, and their eyes were examined periodically thereafter. To date no detectable lens abnormalities have been found. Differences and similarities between the two methods of elevating the retrolental temperature are presented. (No refs.)

75-249

4666 MODELS OF BIOLOGIC INTERACTION WITH ELECTROMAGNETIC FIELDS (PROCEEDINGS ABSTRACT). (Eng.) Frazer, J. W. (U.S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX); MacDougal, J.; Webb, M.; Guy, A. W. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 201-202; 1975.

Simple rectal temperature measurements in rats exposed to strong magnetic fields (40 amp meter-1) at 19 MHz in the USAFSAM near-field synthesizer demonstrated qualitative agreement with theoretic power deposition predictions. An increase in diameter was accompanied by more rapid heating over a narrow range of animal radii. Distribution of absorbed energy was measured at frequencies of 19 MHz and

1600 MHz in rats sectioned along their long axis and in two specially designed head inactivators at 2450 MHz using electric and magnetic field concepts. In addition, energy distribution in prolate ellipsoids was measured at 19 MHz with a field impedance ~337 ohms, in the near field synthesizer with field impedance of ~100 ohms and ~1000 ohms, as well as at 1600 MHz with field impedances of ~377 ohms. It was found that eddy current-induced heating at 19 MHz varied with the aspect to the field and that, even in a uniform ellipsoid, distinctly non-uniform heating patterns were produced in electric and magnetic fields. (No refs.)

75-250

4667 RF SOUND: POSSIBLE MECHANISMS AS DEFINED BY RECENT RESEARCH (PROCEEDINGS ABSTRACT). (Eng.) Eichert, E. S. (Randomline, Inc., Huntingdon Valley, PA); Frey, A. H. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 38; 1975.

Proposed mechanisms of the human auditory system response to low power density, pulse modulated, electromagnetic energy were considered. It was found that previously proposed radiofrequency (RF) sound mechanisms were derived from model studies and were inconsistent with the recently obtained physiologic and psychophysic data. Several alternate possibilities were then considered that were consistent with the body of experimental data. For each, the site specific physical phenomena, which may explain the energy-biologic tissue interaction, are discussed, and experimentation, which should provide an understanding of the RF sound mechanism, is suggested. (No refs.)

76-74

4668 INFARCTION OF FALLOPIAN TUBE AFTER TUBAL DIATHERMY (LETTER TO EDITOR). (Eng.) Cordiner, J. W. (Dept. Gynecology, Western Infirmary, Glasgow G11 6NT, Scotland); Carty, M. J.; Mackay, C. *Lancet* 1(7970): 1178; 1976.

A case is described in which infarction of a fallopian tube occurred after tubal diathermy in a 38-yr-old para 2 + 0 on whom laparoscopic sterilization was performed. The diathermy was applied at three separate places on each tube. The pelvic organs were normal, and the appendix had been removed previously. Twenty hr after the procedure, the patient complained of severe lower abdominal pain. The abdomen was rigid, and there was generalized rebound tenderness. Bowel sounds were present and excitation tenderness was noted on pelvic examination. Pulse, blood-pressure, and temperature were normal. Laparotomy was performed through a right lower paramedian incision. The small and large bowel were normal throughout their lengths. The fimbriated end of the right fallopian tube was black and infarcted distal to the diathermied areas. There was no evidence of torsion, and both ovaries were healthy. The infundibulopelvic ligaments were normal, and the fimbriated end of the left tube was healthy distal to the points of diathermy. Bilateral partial salpingectomy was performed to prevent a similar occurrence in the opposite tube. Signs of paralytic ileus developed postoperatively but resolved within 48 hr with nasogastric suction and intravenous fluids. Histology confirmed that the tube was hemorrhagic and infarcted at the fimbriated end. No other abnormality was noted. This case is the first of its kind to be reported in the literature. (No refs.)

76-75

4669 THE INFLUENCE OF SUPERHIGH FREQUENCY RADIATION ON BRAIN MITOCHONDRIAL OXIDATIVE PHOSPHORYLATION. (Rus.) Rudichenko, V. F. (Kiev Research Inst. General and Communal Hygiene, Kiev, USSR). *Gig. Sanit.* (4): 108-109; 1976.

Forty-two male rats were exposed to microwave radiation (wavelength = 12 cm, vertically polarized waves) of various power flux densities (10, 25, 50, 100, 500, 1000 mW/cm^2) for 40 min, 3 times/day at 5 day/wk intervals for 4 mo. Changes in the respiratory process during brain mitochondrial oxidation of succinate and α-ketoglutarate were observed. The changes included reductions in the rates of phosphorylative respiration and ADP phosphorylation (at 25 mW/cm^2 and higher for α-ketoglutarate and at 50 mW/cm^2 and higher for succinate), an increase in nonphosphorylative respiration, and a decrease in respiratory control values (at 25 mW/cm^2 and higher for both substrates). A mechanism of oxalacetic acid inhibition of phosphorylation was observed. No decrease in the ADP/O ratio was noted during succinate oxidation, but decreases in this ratio during α-ketoglutarate oxidation (at 50 mW/cm^2 and higher) indicated damage to the respiratory chain at the lipoate-NAD-flavoprotein section. Since power flux densities of 10 mW/cm^2 were without effect, this value should be considered in the design and production of apparatus using microwave radiation of a 12 cm wavelength. (4 refs.)

76-76

4670 THE DEPENDENCE OF THE FUNCTIONAL ACTIVITY OF LIVER MITOCHONDRIA ON SUPERHIGH FREQUENCY RADIATION. (Rus.) Dumanskii, Yu. D. (Kiev Research Inst. General and Communal Hygiene, Kiev, USSR); Rudichenko, V. F. *Gig. Sanit.* (4): 16-19; 1976.

Forty-two male rats were exposed to superhigh frequency radiation (wavelength = 12 cm, vertically polarized wave) of various power flux densities (10, 25, 50, 100, 500, 1000 mW/cm^2) for 40 min, 3 times/day at 5 day/wk intervals for 4 mo. Densities of less than 50 mW/cm^2 had no effect, but respiratory processes in the liver mitochondria were altered during nonphosphorylative respiration at densities of 50 mW/cm^2 and higher, and then during phosphorylative respiration at densities of 100 mW/cm^2 and higher. Nonphosphorylative oxidation of Krebs cycle metabolites (succinate and α-ketoglutarate was intensified and the rate of oxygen consumption during

phosphorylative respiration was reduced. The reduction in phosphorylative respiration and the partial reduction in the ADP/O ratio (during α-ketoglutarate oxidation) led to a decrease in the rate of ADP phosphorylation. Respiratory chain oxidation of succinate was more radioresistant and was associated with greater values of ADP phosphorylation than of α-ketoglutarate oxidation. Apparently there was a block in the respiratory chain substrate→lipoate→NAD→flavoprotein→cytochromes→O to flavoproteins, the pathway for α-ketoglutarate oxidation. These results should be considered in the development of superhigh frequency apparatus. (4 refs.)

75-251

4671 PREDICTING THE INTENSITY OF SUPER HIGH FREQUENCY RADIATION. (Rus.) Sorochkin, A. I. (No affiliation given). *Voen. Med. Zh.* (7): 49-52; 1975.

A formula for determining the power flux density of microwave radiation is proposed. Examples of the applied calculation methods based on this formula indicate their simplicity and the close correlation of their results with those of instrumental measurements. The calculation methods are recommended for use in the hygienic supervision of the radiation effect from radio-location stations on the surrounding area and population. (No refs.)

76-77

4672 THE USE OF MAGNETIC FIELDS AND ELECTRONIC NOISE IN THE TREATMENT OF INSOMNIA AND NEUROSIS. (Cze.) Gruenner, O. (Vyzkumnl ustav balneologicky, Prague, Czechoslovakia). *Cesk. Neurol. Neurochir.* 39(1): 1-11; 1976.

Preliminary experiments showed that, on the basis of subjective evaluation, neurotic symptoms were significantly influenced by atmospheric pressure and geomagnetic activity. Further preliminary studies on the effect of electronic noise (5 Hz-30 kHz) on rabbits suggested the existence, primarily in the deep structures of the brain, of a mechanism sensitive to such noise. A series of four clinical experiments with neurotic insomniacs were then conducted to determine the effects of electronic noise and of a constant homogeneous magnetic field, with results evaluated on the basis of changes in skin electroconductivity (SEC), skin electroresistance (SER), and subjective and objective descriptions of alertness. Tests on 21 neurotics revealed no significant differences between the effects of 1 hr of electronic noise superimposed on a constant uniform component or an impulse current superimposed on a constant uniform component, but both caused significant reductions in alertness and SEC in comparison with placebo control tests. When pure electronic noise (1 ef = 5 mA) was applied to a group of 23 neurotics, its effects were significantly greater than those of both the other tests. Longitudinal analysis (treatment every other day for 3 wk) in 10 patients showed that superimposed electronic noise caused a significant reduction in alertness and increase in SER compared with controls. In 59 neurotics, the head was placed in the center of a constant homogeneous magnetic field (0.73 Oe) for 1 hr. SER increased in 50 neurotics, decreased in 8, and remained unchanged in 1, while in control experiments it increased in 21, decreased in 35, and was unchanged in 3. The results indicate that electronic noise and a constant homogeneous magnetic field have a tranquilizing effect and may be of value in the treatment of insomnia and neurosis. (43 refs.)

76-78

4673 AVOIDANCE OF RADIATION HAZARDS FROM MICROWAVE ANTENNAS. (Eng.) Shinn, D. H. (Marconi Research Lab., GEC-Marconi Electronics Ltd., West Hanningfield Rd., Great Baddow, Essex, England). *Marconi Rev.* 39(201): 61-80; 1976.

A graphic method was used to determine the boundaries of hazardous regions caused by powerful microwave radiation. The peak and mean power radiated, and the size and gain of the antenna were used in these determinations. The "biological hazard region" (100 W/m^2 mean power) and the "ignition hazard region" (3000 f^2 W/m^2 peak power, f=frequency in GHz) were found first by a theoretic prediction, followed by actual measurement if a potential hazard appeared to exist. Theories for computing the power flux for antennas with circular, elliptical, or rectangular aperatures are presented. For circular aperatures it was necessary to determine the power flux in a near-field and a far-field region. For elliptical or rectangular aperatures, where the width was greater than the vertical extent, or vice versa, a near-field, far-field, and intermediate region had to be determined. The appropriate power flux values were calculated for a tropospheric scatter communications installation and a radar height finder. Methods of avoiding hazards were also considered. (9 refs.)

76-79

4674 INFLUENCE OF 50 HZ ALTERNATING ELECTRIC AND MAGNETIC FIELDS ON HUMAN BEINGS. (Eng.) Hauf, R. (Research Inst. Electropathology, Freiburg in Brisgau, W. Germany). *Rev. Gen. Electricite (Numero Special)* 85: 31-49; July, 1976.

The effects of 50 Hz alternating electric and magnetic fields on healthy human volunteers (average age 25 yr) were investigated in a laboratory setting simulating the field conditions of high voltage installations. Electric field intensities of up to 20 kV/m at 1.50 m above the ground (undisturbed field) were used alone or in combination with a magnetic field of 0.3 mT. The latter field was also used alone in some experiments. A displacement current of 200 μA was also generated during some experiments. Test periods lasted for a maximum of 3 hr. The electric field experiments resulted in an improvement in subject reaction time, which was considered to be a stimulation effect. During the magnetic field and displacement current tests, no changes in reaction time with respect to control values were noted. No differences in erythrocyte count or hemoglobin content were observed during any of the tests in relation to control values. However, absolute neutrophils and reticulocytes increased markedly with re-

spect to controls, although the values were within physiologic limits. These changes were considered to be related to a non-specific excitation effect. Cholesterol and triglyceride levels of subjects exposed to both electric and magnetic fields did not fluctuate from the norm. Electrocardiograms and electroencephalograms of subjects exposed to the electromagnetic fields also remained normal as did arterial blood pressure. In addition, no subject expressed any subjective discomfort. The effects of exposure to the above fields for periods lasting up to 3 hr seemed to be limited to a stimulation effect and a nonspecific excitation effect, neither of which was pathologic. (9 refs.)

76-80

4675 MORPHOFUNCTIONAL STATUS OF THE HYPOPHYSEO-GONADAL SYSTEM DURING EXPOSURE OF THE ORGANISM TO ELECTROMAGNETIC FIELDS WITH DIFFERENT CHARACTERISTICS. (Rus.) Evtushenko, G. I. (Inst. Industrial Hygiene and Occupational Diseases, Kharkov, USSR); Kolodub, F. A.; Ostrovskaia, I. S.; Timchenko, A. N.; Chernysheva, O. N. *Gig. Tr. Prof. Zabol.* (6): 52-54; 1976.

The effect of the magnetic component of pulsed electromagnetic field (7 kHz, 72 kA/m, pulse duration 1.3 msec, pulse interval 10 sec) (Group 1) and of the electric component of high-frequency electromagnetic field (41 MHz, 1kV/m) (Group 2) on the hypophyseogonadal function of male albino rats was studied. Exposure of Group 1 to the pulsed electromagnetic field over 3 hr each for 15 days had a direct effect on Leydig cells, and caused a sharp depression of the androgenic function of the testicles. The testosterone level in the blood draining the testicles dropped from 1.23±0.35 µg% to 0.23±0.01 µg% in the controls. Exposure of Group 2 to the high-frequency field over 3 hr daily for 15 days caused ultrastructural changes in the hormone-producing cells of the posterior lobe of the pituitary gland, causing an activation of the secretion and release of gonadotropins. The total gonadotropin level in the pituitary gland decreased. The findings indicate that pulsed and high-frequency electromagnetic fields directly affect Leydig cells resulting in a reduction of the blood androgen level, which provokes intensified gonadotropin secretion and release in the pituitary gland. (6 refs.)

76-81

4676 PROLONGED EFFECT OF A CONSTANT AND ALTERNATING MAGNETIC FIELD OF 1,000 OERSTED ON THE MITOTIC ACTIVITY. (Rus.) Strzhizhovsky, A. D. (No affiliation given); Galaktionova, G. V. *Kosm. Biol. Aviakosm. Med.* 10(2): 63-67; 1976.

The prolonged effect of permanent magnetic field of 1,000 Oe on the mitotic activity of cells of the corneal epithelium and of bone marrow cells was studied in C57Bl mice. Exposure to the permanent magnetic field over a 15-day period caused an initial decrease in the mitotic activity of epithelial and bone marrow cells, which was followed by increased mitotic activity and hyperregeneration. The cell count of the tissues showed only slight changes, and it rapidly normalized after the field was switched off. Daily alternation of the field direction with respect to the body position of the animals caused no additional changes in the mitotic activity, but it caused an appreciable decrease in the effectiveness of the adaptive process. The exposure did not cause chromosomal aberrrations, which indicates the absence of mutagenic effect. (6 refs.)

76-82

4677 EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON LIVING ORGANISMS AND IN PARTICULAR ON MAN: GENERAL REVIEW OF THE LITERATURE. (Eng.) Cabanes, J. (International Association on Occupational Medicine). *Rev. Gen. Electricite (Numero Special)* 85: 19-26; 76. July, 1976.

The literature dealing with the effects of low frequency (50 Hz) electric and magnetic fields on man and other biologic organisms is reviewed. Studies of workers in the Soviet Union who were exposed to low frequency electric fields at 400 and 500 kV substations revealed neurologic, cardiovascular, and digestive disturbances. However, studies in the United States involving the repetitive exposure of linemen working on 345 kV high voltage lines failed to reveal any biologic changes. Soviet studies involving the exposure of volunteers to low frequency electric fields ranging from 0-30 kV/m revealed hematologic changes in addition to neurologic and cardiovascular disturbances at field values exceeding 5 kV/m. Studies in Italy involving the long-term exposure of mice, rats, and guinea pigs to strong electric fields (100 kV/m) showed statistically significant modifications in polynuclear neutrophil and lymphocyte numbers along with electrocardiogram changes; however, these changes were within the physiologic range of values. Genetic studies in France involving the exposure of bacteria to electric fields of 10, 50 and 200 kV/m failed to demonstrate alterations in mutation frequency. Contradictory results have also been reported for studies involving the biologic effect of low frequency magnetic fields (50 Hz) ranging in strength to as high as 9 G. It is concluded that the disparity of these results is possibly due to vague study procedures and reporting in some instances, and the use of an insufficient number of subjects in other cases. (No refs.)

76-83

4678 THE EFFECT OF A DISCHARGE OF A HIGH-VOLTAGE CONDENSER ON THE OPTIC PROPERTIES OF THE FROG CARDIAC MUSCLE. (Rus.) Arlevsky, I. P. (Kazan Advanced Training Medical Inst., Kazan, USSR); Bezuglov, V. K.; Buzukin, V. G. *Biull. Eksp. Biol. Med.* 81(5): 531-533; 1976

A high-voltage condenser discharge, with a duration of 3-5 msec, caused a sharp increase in the intensity of a flux of plane-polarized light passing through a strip of frog myocardium. The duration of the luminescence was 15-100 msec at a discharge voltage of 500 V and 100-350 msec at 1,000 V. The increase in the light flux under the effect of high-voltage discharge

is believed to be due to conformation changes in the membrane proteins. The configuration changes in the cell membrane proteins are probably due to the direct effect of the electric discharge on the hydrogen bonds of hydrate layers stabilizing the steric structure of the macromolecules and to an indirect change in the physicochemical parameters of the medium in the immediate vicinity of the protein molecules. (7 refs.)

76-84

4679 MAGNETIC FIELD IRRADIATION, "JONOMODULATOR" AND "EICHOTHERM" APPARATUS. (Ger.) Ott, V. R. (Klinik und Institut fur Physikalische Medizin und Balneologie, Universitat Giessen, 6350 Bad Nauheim, Ludwigstr. 37-39, W. Germany); Rusch, D. *Dtsch. Med. Wochenschr.* 101(33): 1236-1237; 1976.

General physical and therapeutic characteristics of magnetic field therapy, which employ "Jonomodulator" and "Eichotherm" apparatus, are described. Magnetic field therapy experiments, in which the patient is located inside a magnetic coil, have not been proven therapeutically valuable. Dyadynamic electrotherapy using frequency-modulated impulse current with 50-100 Hz frequency (Jonomodulator) is valuable in controlling pains and disorders of arterial blood circulation. Its effect is based upon neurophysiologic principles. The "Eichotherm" apparatus, including a combination of light orange and UV light sources, is used in the treatment of cervical and lumbar syndromes. (No refs.)

76-85

4680 HORMONAL REACTION OF THE SYMPATHICOADRENAL SYSTEM ON SINGLE EXPOSURE TO ALTERNATING MAGNETIC FIELD. (Rus.) Sakharova, S. A. (No affiliation given); Ryzhov, A. I.; Udintsev, N. A. *Biol. Nauki* (1): 40-44; 1976.

The catecholamine and dioxyphenylalanine levels of the blood and adrenals were studied in male albino rats following a 24-hr exposure to an alternating magnetic field (200 Oe, 50 Hz). Considerable increase in the catecholamine and dioxyphenylalanine levels of the blood and adrenals was observed during the first 12 hr after exposure. Dilatation of the lacunae in the medulla and hyperemia of the adrenal gland were observed. A second phase was characterized by high norepinephrine and epinephrine levels in the blood and by reduced epinephrine level in the adrenals. The catecholamine levels dropped both in the blood and the adrenals in a third phase. Normalization of the hormone levels was observed 14 days after exposure. The findings illustrate the powerful stress effect of alternating magnetic field on the neuroendocrine system. (16 refs.)

76-86

4681 TUMOR ERADICATION BY RADIOFREQUENCY THERAPY [Letter to Editor]. (Eng.) Le Veen, H. H. (Veterans Admin. Hosp., Brooklyn, NY). *JAMA* 236(15): 1691; 1976.

Tumor eradication by radiofrequency therapy is discussed in terms of tumor temperature measurement and the association between preferential tumor heating and tumor blood flow. Criticism that radiofrequency therapy causes heating of temperature sensors and leads to erroneous tumor temperature measurements is valid only for inductive type heating by radiofrequency application. Dielectric type radiofrequency heating, which is accomplished by placing the part to be heated between two plates of a condenser, results in the heating of only poorly conductive substances and does not directly affect the temperature sensors. Impedance measurements of cancer and normal tissues during radiofrequency therapy experiments proved to be similar, indicating that the amount of heat captured by each type of tissue was similar. The only explanation for an observed preferential heating of cancer tissue is that cancer cools more slowly than normal tissue. The rate of cooling depends on the rapidity of blood flow. Criticism that blood flow in some tumors may not be reduced is not supported, and sluggish blood flow in brain tumors has been confirmed by computerized scanning. Radiofrequency-induced cancer dissemination and destruction of normal tissue has not been observed in over 20 inoperable cases of cancer that were treated with dielectric radiofrequency heating and immunotherapy. (5 refs.)

76-87

4682 PHYSIOLOGICAL REGENERATION OF THE CORNEAL EPITHELIUM EXPOSED TO SUPERSTRONG CONSTANT MAGNETIC FIELDS. (Rus.) Strzhizhovsky, A. D. (Inst. Biochemical Problems, Ministry of Public Health of the USSR, Moscow, USSR); Galaktionova, G. V. *Tsitologiia* 18(3): 330-335; 1976.

The effect of permanent magnetic field of 9.9-39.4 kOe over 0.5-24 hr on the corneal epithelium of mice was studied. Exposure to a permanent magnetic field with an intensity of 39.4 kOe over 3 hr caused a reduction of the mitotic index, while exposure to the same field over 8-24 hr stimulated the mitotic activity. The changes in the mitotic activity decreased as the field potential was decreased. The rate of the regeneration of the corneal epithelium decreased with increasing duration of the exposure. No increase was observed in the number of aberrant mitoses in the cells of the corneal epithelium under the effect of the permanent magnetic field. The findings indicate the possibility of the therapeutic use of permanent magnetic fields. (7 refs.)

75-252

4683 HEALTH HAZARDS IN MICROWAVE FIELDS (PROCEEDINGS ABSTRACT). (Eng.) Woolas, K. D. (Medical Officer, MOD, United Kingdom). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 313; 1975.

The use of rats, rabbits, and other small animals for experiments has the advantage of strictly controlled conditions and the great disadvantage that the results of such work do not always clearly ex-

trapolate to human beings. Among populations of working people exposed to microwave fields there is a wealth of clinical opportunity for research, but the problem is, as always, what to look for. Much work has been concentrated on discovering the threshold of specific macroscopic damage to discrete organs such as the formation of cataracts in eye lenses. It was upon such work that the present 10 mW/cm^2 safety level has been based. The Russian standards, which are not based on such heating effects, cause much heart-searching among occupational health physicians. Instead of seeking gross pathologic changes resulting from microwave exposure, we should be on guard against the occurrence of more subtle effects, which detract from industrial comfort or an individual's efficiency. For instance, recent work has shown that protracted exposure to low power microwave fields can cause small vacuole formation and abnormal striation in the eye lens. While this causes no discernible opacity, it would cause impairment of the lens elasticity. The focusing capacity is therefore impaired, and the usual onset of presbyopia in middle life occurs at an earlier age. Investigations into changes of this degree in human populations are advocated, and preventive measures are discussed.

75-253

4684 A TRIAL INVOLVING THE USE OF PULSED ELECTRO-MAGNETIC THERAPY ON CHILDREN UNDERGOING ORCHIDOPEXY. (Eng.) Bentall, R. H. C. (Dept. Applied Physiology, Royal Coll. Surgeons, Lincoln's Inn Fields, London, England); Eckstein, H. B. *Z. Kinderchir.* 17(4): 380-389; 1975.

The effect of postoperative non-thermal pulsed high frequency electromagnetic therapy on bruise healing and edema formation was evaluated during a double blind trial involving 50 paired boys undergoing orchidopexy. Electromagnetic therapy was given 3 times a day for the first 4 postoperative days and consisted of the local administration of 500 pulses/sec at a penetration of 5 for 20 min followed by a second application of 500 pulses/sec at a penetration of 4 to the epigastrium for 10 min. Patients so treated showed a significant increase in bruise resolution rate as well as a trend toward increased rate of reduction of scrotal circumferential measurement. No side effects were observed, nor was there any difficulty experienced in the application of this nonthermal therapy. It is concluded that previously reported beneficial effects of this therapy on bruise resolution and edema reduction were confirmed. (33 refs.)

76-88

4685 EFFECTS OF TRANSCEREBRAL ELECTROTHERAPY (ELECTROSLEEP) ON STATE ANXIETY ACCORDING TO SUGGESTIBILITY LEVELS. (Eng.) Ryan, J. J. (Psychology Service, Veterans Admin. Hosp., North Little Rock, AR); Souheaver, G. T. *Biol. Psychiatry* 11(2): 233-237; 1976.

Transcerebral electrotherapy (TCET) was tested for its ability to relieve anxiety in 24 (23 men and 1 woman, aged 21-59 yr) psychiatric inpatients. Subjects completed the State Anxiety Inventory (SAI). On the basis of the Harvard Group Scale of Hypnotic Susceptibility scores the patients were assigned to a high or low suggestibility group (12/group). These subjects were again assigned to an active TCET or placebo condition (6/group). The TCET group received a burst of current at a rate of 100 Hz/sec with a width of 2 msec for 30 min for five sessions on consecutive days. Controls received no electrical stimulation other than that delivered at an initial adjustment and 15 min readjustment period. Six to nine days following the last treatment each subject again completed the SAI. These scores indicated that for the low and high suggestibility groups the pre- and post-scores changed from 58.33 to 43.50 and from 57.66 to 50.66 respectively. Subjects in the active TCET condition showed significantly greater anxiety reduction than the control group ($p < 0.01$, $F=8.26$). There was no overall effect of suggestibility, nor was there a significant interaction between suggestibility and type of treatment ($p>0.10$, $F=2.89$). Likewise there was no differential response between the low- and high-suggestible control subjects ($F<1$). (14 refs.)

75-254

4686 CONSIDERATIONS OF CHAMBER DESIGN, ENVIRONMENTAL CONTROL, AND MICROWAVE FIELD INTERACTIONS IN SMALL ANIMAL EXPERIMENTATION. (PROCEEDINGS ABSTRACT). (Eng.) Houk, W. M. (Naval Aerospace Medical Research Lab., Pensacola, FL); Grissett, J. D.; Longacre, A., Jr. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 137; 1975.

The criteria for design and performance of a facility utilized for studying microwave biologic effects in rats weighing up to 500 g were investigated. The results of using a 1.2 x 1.2 x 1.2 m semi-enclosed anechoic exposure chamber including field measurement techniques, material selection, environmental control, and biologic experimental design are discussed, with an analysis of the problems encountered in its use. The problems were related to certain biologic parameters studied in a finite experiment dealing primarily with environmental control, field measurements, and the simultaneous use of several subjects in the enclosure. Using the same basic design and performance criteria as the first experimental chamber, a second larger and more sophisticated semi-enclosed anechoic chamber, 1.8 x 1.8 x 1.8 m in size was constructed. This chamber addressed environmental control and microwave field parameters from its inception. Absolute requirements included: (1) a 2450 MHz microwave reference field located in the far field of a 15 dB standard gain horn showing no greater than ±1.0 dB variation over a 100 cm^2 working area; (2) an absolute temperature control of the environment where the experimental animals were located, in a range of 12.5 to 45°C, and control of ±0.5°C at the selected control point; and (3) a uniform air flow over the experimental animals with provision for dumping chamber air rather than recirculating it. Using the NBS XD-1 and EMD-1C microwave sensors, the field pattern alterations induced by polystyrene foam products used in the construction of animal enclosures was studied along with a standardized

method of measuring exposure levels. Using analogous techniques, field amplitude patterns around single and multiple experimental animals were derived along with energy absorption estimates made from standing wave patterns created by the animals. (No refs.)

75-255

4687 NUMERICAL STUDY OF ELECTROMAGNETIC POWER DEPOSITION IN BIOLOGICAL TISSUE BODIES (PROCEEDINGS ABSTRACT). (Eng.) Barber, P. W. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 229; 1975.

The extended boundary condition method (EBCM) was applied to the problem of obtaining quantitative power absorption information for a homogeneous prolate spheroid model of man. It is known that this technique can readily be applied to power deposition calculations for man at relatively low frequencies. The EBCM and the long wavelength analysis method give exactly the same results at 10 MHz. This study was concerned with making calculations at higher frequencies to determine the frequencies of maximum absorption, i.e., the resonant frequencies of man. Extension of the numeric work to bodies that are electrically larger required the consideration of various numeric problems, including the solution of an unusual set of simultaneous equations. Although the matrix involved was not ill-conditioned, the wide variation in the amplitude of the elements could result in appreciable error in the solution because of the finite precision arithmetic of the computer. This behavior, which is a consequence of the large dielectric constant of the muscle tissue used in the model, appeared to limit the application of the EBCM to frequencies below 100 MHz. This, however, did permit a determination of the first resonance. The numeric results gave the average power absorption and peak power absorption for man as a function of frequency, polarization, and orientation through the first resonance. (No refs.)

75-256

4688 DISTRIBUTION OF ELECTROMAGNETIC ENERGY DEPOSITION IN MODELS OF MAN WITH FREQUENCIES NEAR RESONANCE (PROCEEDINGS ABSTRACT). (Eng) Gandhi, O. P. (Dept. Electrical Engineering and Bioengineering, Univ. Utah, Salt Lake City, UT); Sedigh, K.; Beck, G. S.; Hunt, E. L. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 201; 1975.

Experimental results are described for whole-body absorption of a series of saline-filled and biologic-phantom figurines of major lengths (L) that varied from 0.4 to 1.5 λ. Measurements are also reported of α parameter values (ratio of mW/g of absorbed energy to mW/cm^2 of incident field energy) for different regions of the body. The energy distribution was measured for 12.1 and 18.4 cm tall figurines under free space irradiation at both 985 and 2450 MHz using the liquid crystal temperature probe. These results were compared to those obtained in the transverse electromagnetic mode parallel plate chamber, namely, of whole-body values for the 220-750 MHz frequency range with 12.1 and 18.4 saline-filled figurines and prolate spheroids of a/b=6. The highest intensity of energy deposition was observed for the neck region of the body in both free space and parallel plate exposure conditions. The α for the neck region was approximately 30 times that observed for the whole-body average. The α values for other parts of the body, in descending order of magnitude, were reported for the thighs, shins, chest, pudendal region, and the eye region. For figurines with the feet touching the ground plate of the parallel-plate chamber, maximum energy deposition was observed for the shins, with α=12 at 240 MHz ($L/\lambda \approx 0.15$). A monopole-above-ground chamber is presently under construction to permit assessment of ground effects and measurements of α values. (No refs.)

75-257

4689 CRITICAL ASPECTS OF HUMAN VERSUS TERRESTRIAL ELECTROMAGNETIC SYMBIOSIS (PROCEEDINGS ABSTRACT). (Eng.) Maxey, E. S. (Research Div., Miami Heart Inst., Miami, FL). *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 314; 1975.

Man's terrestrial electrical environment includes electrostatic fields, magnetic fields, field modulations, and aerion (positive and negative) concentrations. Nature imposes harmonious variations in these four factors. Laboratory studies often attribute biologic changes to variations in a single factor without adequate consideration of the remaining variables. Humans exhibit revealing electric characteristics. Brain waves physiologically present at frequencies paralleling the terrestrial Schumann resonance and sferics, and states of conciousness and decision making abilities are correlatable to cerebral alpha, beta, and theta frequencies. Can brains be entrained to terrestrial field modulations in the same way that mammalian hearts become synchronized to external rotating magnets? Positive and negative aerions affect numerous biologic responses including blood pH and serotonin fluctuations, changes in pulmonary oxygen exchange efficiency, and variations in the degree of left/right electroencephalographic synchronization. The travel of all charged particles is influenced by both electrostatic and magnetic field factors. Currents induced into the human organism by earth's electric forces are subtle but biologically significant. It is recommended that working spaces such as aircraft cockpits, where rapid response and precise decision making are critical, be conditioned with regard to aerion concentrations, magnetic fields, electrostatic fields, and field modulations. (No refs.)

76-89

4690 IMPACT OF RADAR IRRADIATION ON HUMAN SYSTEMS. (Eng.) Natarajan, K. (No affiliation given); Jagannathan, N. *J. Inst. Electronics Telecommunication Eng.* 22(5): 326-329; 1976.

The impact of microwave radiation on the human body is discussed. Human exposure limits regarded as safe are 0.03 W/cm^2 for frequencies below 0.5 GHz and 0.02 W/cm^2 at frequencies higher than 3 GHz. An examination of the absorption of microwave energy by various human tissues in the frequency range of 0.15-10 GHz reveals that at 0.15 GHz the penetration is much deeper; whereas, at 10 GHz the energy is absorbed in or near the skin. Parts of the body that do not have blood vessels (chambers of the eye and the hollow viscera) are particularly vulnerable to electromagnetic radiation because the heat can dissipate only by conduction to the surrounding vascular tissues. A case of bilateral cataracts has been reported for a person subjected to an intermittent exposure of about 0.005 W/cm^2 at 1.7-3.4 GHz for 3 days and to a level of 0.12 W/cm^2 for a total of 2 hr. Precautions for avoiding the hazards associated with occupational exposure to electromagnetic radiation include increasing the height of microwave antennae, the use of reflective clothes and protective goggles, and field strength monitoring in potential exposure areas. (6 refs.)

76-90

4691 EXPERIMENTAL DEVELOPMENT OF SIMULATED BIOMATERIALS FOR DOSIMETRY STUDIES OF HAZARDOUS MICROWAVE RADIATION. (Eng.) Cheung, A. Y. (Dept. Radiology, Section Radiation Physics and Radiation Biology, Univ. Maryland at Baltimore, Baltimore, MD); Koopman, D. W. *IEEE Trans. Microwave Theory Techniques* MTT-24(10): 669-673; 1976.

Simulated biotissues for microwave radiation dosimetry studies at X-band frequencies and for S-band modeling experiments, which use miniature phantoms at X-band frequencies, were developed. The influence of material composition on the dielectric and heat properties of the materials was studied at frequencies of 8.5 and 10.0 GHz for two types of materials: one corresponding to tissues of high water content (muscle) and the other for bone and fat tissues. Based on measured dielectric properties using a short-circuit waveguide technique, a simulated bone material consisting of Laminac 4110 (a polyester resin), acetylene black, and aluminum powder was chosen. A muscle composition simulated by combining a gelling plastic Super Stuff (Whamo Manufacturing) with water, polyethylene powder, and sodium chloride was similarly chosen. Formulations for the properties of high-water-content materials are valuable for identifying phantom materials for many parts of the human body that have a wide range of dielectric properties. (8 refs.)

75-258

4692 EFFECTS OF ELECTROMAGNETIC FIELDS BELOW 30 MHz ON ANIMAL BIOLOGY. (Eng.) Pierluissi, J. H. (Lawrence Livermore Lab., Univ. California, Livermore, CA 94550). *Prepared by Lawrence Livermore Laboratory for ERDA under Contract No. W-7405-Eng-48.* (UCRL-51880): 14 pages; August, 1975.

The biologic consequences of exposure to electromagnetic fields below frequencies of 30 MHz are reviewed. Data obtained from triple-layer models of the human body indicated that electromagnetic absorption increased linearly with frequency in the region below 100 MHz. Differences in absorption for the various thicknesses typical of the human body were insignificant in the radiofrequency region, and calculations indicated an absorption of about 15% at 30 MHz. It is suggested that personnel working with electromagnetic pulse simulators be restricted to 1440 pulses over any 6-min period; 1 pulse/min produces a power density of 0.044 mW/cm^2, which is about 1/200 of the acceptable dose. The increase in body temperature for such exposures is estimated at 0.00009°C. Since the threshold of temperature-increase sensation on the surface receptors of humans is about 0.05°C, the thermal effects produced in humans by electromagnetic pulses are probably incapable of even generating sensations of warmth. Biologic effects of nonthermal origin resulting from human exposure to electromagnetic fields below 30 MHz include: vascular conditioned reflexes (static frequency, field intensity of 10,000 V/m); diurnal rhythmicity (10 Hz, 2.5 V/m); brachycardia (static, 2600 A/m); changes in reaction time (less than 12 Hz, about 2 V/m), and interference with cardiac pacemakers (0.5-1.0 Hz or 10-30 Hz at high-frequency communications levels for the latter frequency range). (39 refs.)

76-91

4693 A MICROWAVE APPLICATOR FOR *IN VIVO* RAPID INACTIVATION OF ENZYMES IN THE CENTRAL NERVOUS SYSTEM. (Eng.) Lenox, R. H. (Dept. Neuroendocrinology, Div. Neuropsychiatry, Walter Reed Army Inst. Res., Washington, DC 20012); Gandhi, O. P.; Meyerhoff, J. L.; Grove, H. M. 4pp., 1976 (available through Inst. of Electrical and Electronics Engineers, Inc., New York, N.Y., No. 601MT1014).

A microwave applicator for the *in vivo* rapid inactivation of rat brain enzymes is described. The applicator includes a WR 430 waveguide test cell and a 2450 MHz pulsed power source that delivers 3.5 kW of microwave power, which is matched to the complex load (rat's head) by a double screw tuner. The rat is placed in a plexiglas tube, which is wrapped with copper screening that acts as a cylindrical waveguide, and the shielded tube is inserted into the waveguide chamber. Uniformity of fields along the width of the waveguide (ear to ear of the animal) is obtained as a result of the symmetrical dielectric loading achieved with the rat head in that dimension. Improved uniformity of heating the brain is achieved in the rostral to caudal dimensions by attaching tapered aluminum shims to the broad faces of the waveguide. In the vertical plane, a slight heating gradient exists that apparently is due to the overheating of the abundant muscle on the ventral side of the brain. The exposure time required for enzyme inactivation is 2.8 sec. Measurements of cyclic adenosine monophosphate in the microwave-treated brain indicate rapid enzyme inactivation and the prevention of postmortem changes in enzyme activity associated with more conventional methods of sacrifice. Measurements of cyclic adenosine monophosphate and cyclic guanosine monophosphate have been made in 13 distinct re-

glons of the rat brain: cerebellum, brainstem, midbrain, substantia nigra, thalamus, hypothalamus, hippocampus, amygdala-pyriform cortex, septal nuclei, nucleus accumbens, olfactory tubercle, striatum, and cortex. (15 refs.)

76-92

4694 EFFECTS OF SMALL ELECTRICAL CURRENTS ON COLLAGEN IN SOLUTION. (Eng.) Eriksson, C. (Inst. Stomatology, Sch. Dentistry, Univ. Pretoria, P.O. Box 1266, Pretoria, 0001, South Africa); Jones, S. *S. Afr. J. Sci.* 72: 114-116; 1976.

The effects of small electrical currents on soluble collagen solutions made up from rat tail tendon were investigated. When a direct current of 15 μA was passed through a 400 μg/ml collagen solution (pH 6.80) via vertically placed stainless steel electrodes, a brown-colored interface denoting a boundary between two regions of apparently differing viscosity was observed. On the cathode side of the band, the solution appeared very viscous, indicating the presence of collagen. The phenomenon appeared to be one of collagen molecule aggregation rather than polymerization, and electron micrographs of the viscous band revealed no fibers. The passage of a 10-μA direct current through a 160 μg/ml collagen solution (pH 4.70) via vertically placed stainless steel wire electrodes did not produce a band-like structure, and there was no evidence of collagen molecule aggregation. When a 5-μA direct current was passed through an 80-μg/ml collagen solution (pH 6.50) via horizontal platinum electrodes, polymerization of the tropocollagen molecules into well-characterized fibers was observed in the form of a whitish band that formed concave to the cathode in a horizontal plane. Thus, different effects were observed for different current gradients and different collagen solutions. (8 refs.)

76-93

4695 DYNAMICS IN CHANGES OF THE CEREBRAL ELECTRIC ACTIVITY IN MENOPAUSAL PATIENTS DURING THE TREATMENT OF PULSE CURRENT. (Rus.) Persianinov, L. S. (All-Union Scientific Research Inst. Obstetrics and Gynecology, USSR Ministry of Public Health, Moscow, USSR); Tkachenko, I. M.; Smetnik, V. P.; Verulashvili, Ya. V. *Akush. Ginekol.* (2): 8-14; 1976.

The cerebral electric activity was studied in 76 menopausal women before, after 5, 10, 15, 20 and 25 pulse current treatment sessions, and 4-6 mo after the treatment. The current intensity was 0.5-0.8 mA, at a frequency of 300-600 Hz, and a pulse duration of 0.5 msec. The current contained an additional galvanic component. The electrodes were placed in the frontomastoidal region. The pulse current therapy resulted in an improvement of the general well-being, in normalization of the arterial pressure, reduced irritability, and disappearance of congestion. Normalization of the electroencephalogram (EEG) was observed in most abnormal cases. Regardless of the original EEG pattern before the therapy, the pulse current treatment caused stereotypical changes in the EEG; appearance of alpha-waves when they had been absent, increase in the alpha-wave amplitude and duration, irradiation of the alpha-waves into the temporal regions of the cerebrum, and its synchronization in all regions. Correlation was established between the clinical improvement and the normalization of the EEG. The therapeutic effect of pulse current on menopausal symptoms is thought to be due to its direct action on the neuroendocrine and vascular systems. (15 refs.)

76-94

4696 MEDICAL CONTROL OF MEN WORKING WITHIN ELECTROMAGNETIC FIELDS. (Eng.) Malboysson, E. (Hidroelectrica Espanola S.A.). *Rev. Gen. Electricite (Numero Special)* 85: 75-80; July, 1976.

Periodic medical examination data and absenteeism rates were analyzed for 84 workers exposed to electric fields at transformer stations or near high voltage lines (up to 400 kV) and 94 linemen working on low voltage overhead lines. The first group showed a higher incidence of digestive, nervous, and locomotor system disorders; however, differences in the living and working habits of these two groups might also explain the different rates. Absenteeism due to illness was greater for the second group, thus confounding the significance of the above findings. It is concluded that electromagnetic fields caused no lasting pathologic effects in the workers, since no biochemical changes were observed. (No refs.)

76-95

4697 RESEARCH CARRIED OUT IN ITALY BY ENEL ON THE EFFECTS OF HIGH VOLTAGE ELECTRIC FIELDS. (Eng.) Cerretelli, P. (Inst. Human Physiology, Univ. Milan, Milan, Italy); Malaguti, C. *Rev. Gen. Electricite (Numero Special)* 85: 65-74; July, 1976.

The effects of high voltage electric field exposures on experimental animals were investigated. Anesthetized rabbits were exposed to 80 kV/m electric fields at a frequency of 50 Hz for periods varying from a few minutes to about 500 hr. No significant alterations in cardiac output, heart rate, or arterial blood pressure during acute exposures were observed, although the last cardiovascular parameter tended to be elevated in animals receiving chronic exposures. Increases in heart rate were observed in a conscious dog exposed to 25 kV/m during the first 10 sec after a change in electric field. Slight changes in the total and differential white cell count were observed in rats and dogs exposed to electric fields of 100 and 25 kV/m, respectively; the dogs also showed a fall in hemoglobin concentration and red cell count. Male rats exposed to an electric field of 100 kV/m for acute exposures of 30 min/day and chronic exposures of 8 hr/day over a total period corresponding to the complete maturation cycle of the germinal cells showed no change in gonadal function; however, diminished libido was observed during acute exposures. No embryotoxic or teratogenic effects were observed in the first generation progeny of male rats subjected to acute (30 min/day) or chronic (8 hr/day) exposures of 100 kV/m. Likewise, no changes in the macro- or microscopic structure of the liver, kid-

neys, lungs, heart, spleen, pituitary gland, thyroid gland, adrenal glands, prostate, seminal vesicles, testicles, cervical lymph nodes, or stomach were observed in rats subjected to acute and chronic exposures of 100 kV/m. (6 refs.)

76-96

4698 BIBLIOGRAPHIC STUDY ON THE ELECTRIC AND MAGNETIC FIELD EFFECT ON LIVING ORGANISMS. (Eng.) Cabanes, J. (30, avenue de Wagram, 75008 Paris, France). *Rev. Gen. Electricite (Numero Special)* 85: 27-30; July, 1976.

A bibliography of 145 documents dealing with the effects of electric and magnetic fields on living organisms is presented. Specific topics covered include: occupational exposures to electric fields, the ecologic influence of electric fields, the dynamics of low frequency magnetic fields, the effects of electromagnetic fields on patients with cardiac pacemakers, the development of safe working procedures for persons occupationally exposed to electromagnetic radiation, central nervous system effects in animals exposed to extremely low frequency magnetic fields, the locomotor activity of animals exposed to high tension alternating fields, the effects of low frequency electric fields on plant growth, devices for measuring the intensity of alternating current electric fields, the interaction of extremely low frequency electromagnetic fields with brain organelles, the effects of electrical currents on *Escherichia coli* growth rates, displacement currents to the human body resulting from dielectric fields under overhead lines, the absorption of electromagnetic energy in body tissues, the mechanism of the behavior of cells in an alternating electric field, and the influence of weak electromagnetic fields on human circadian periodicity. (145 refs.)

76-97

4699 CHANGES OF THE ACTIVITY OF SUCCINATE DEHYDROGENASE IN CELLS OF VARIOUS BRAIN STRUCTURES UNDER THE EFFECT OF UHF FIELD OF LOW INTENSITY. (Rus.) Belokrinitsky, V. S. (A. N. Marzeev Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR); Nikitina, N. G. *Vrach. Delo* (3): 127-131; 1976.

Changes in the succinate dehydrogenase activity of cells of the archipallium, paleopallium, neocortex, subcortical structures, vascular plexes of the ventricles, ependyma and pia mater of the brain were studied in 99 sexually mature male rats during 1- to 4-mo exposure to low-intensity UHF electromagnetic field with 10-1,000 mW/cm^2. The animals were exposed to the electromagnetic field on work days more than three times daily for 40 min. Considerable field intensity-dependent increase was observed in the succinate dehydrogenase activity following a 30-day exposure in all brain structures. The smallest increase was in the nucleus caudatus and subiculum, and the field intensity had little effect on the activity increase in Ammon's horn. The enzyme activity decreased at the end of a 60-day exposure to show increased values again at the end of the 4-mo exposure. The changes in the enzyme activity were dependent on field intensity, exposure time, and the specific anatomic sites. (10 refs.)

76-98

4700 EFFECT OF MAGNETIC AND ELECTRIC FIELDS ON THE GROWTH AND RATE OF MUTATIONS OF VARIOUS MICRO-ORGANISMS. (Eng.) Riviere, J. (Natl. Agricultural Coll., Paris-Grignon, France). *Rev. Gen. Electricite (Numero Special)* 85: 98-101; July, 1976.

The effect of magnetic and electric fields on the mutation rate and growth of the bacterium *Escherichia coli* and the fungus *Penicillium chrysogenum* was investigated. Electric fields ranging from 10-200 kV/m were generated between two circular metal plates situated in an incubator. The magnetic field experiments involved exposing the above microorganisms to 50-Hz alternating magnetic fields ranging from 10-350 times the earth's magnetic field. The exposure time was 48 hr. Neither mutation rate nor growth rate of the above organisms changed during exposure to magnetic or electric fields, even at the maximum dosages applied. (No refs.)

76-99

4701 BIOLOGICAL EFFECTS OF ELECTRIC FIELDS. (Eng.) Kornberg, H. A. (Electric Power Research Inst., Palo Alto, CA 94303). *Rev. Gen. Electricite (Numero Special)* 85: 51-64; July, 1976.

Results from experiments investigating the effects of high voltage fields on humans and animals are reviewed. Studies in the Soviet Union on 319 men working in 220, 330, and 500 kV switchyards revealed nonspecific central nervous system disturbances. Similar observations were reported from Spain where 8 or 9 switchyard workers were transferred to a new 500 kV station and several of them complained of headaches, drowsiness, fatigue, and nausea. In contrast, a review of seven studies performed in the U.S. and Western Europe reveals no adverse effects in humans exposed to fields as high as 20 kV/m (50 hz) for 45 min. These studies also revealed no adverse effects in humans exposed to 60 Hz fields from 765 kV lines. Laboratory studies with animals involving exposures as high as 160 kV/m (60 Hz) over 1500 hr also have revealed no adverse effects. However, the progeny of mice exposed to the above field strength showed a slightly slower growth rate than controls, which could have been due to differences in water availability and temperature. Research in the U.S. and Western Europe has not reproduced the adverse effects noted in Soviet and Spanish studies. (19 refs.)

76-100

4702 IMMEDIATE EFFECT OF ELECTRIC CARDIOVERSION ON THE INDICES OF HEMODYNAMICS AND MYOCARDIUM CONTRACTILITY IN PATIENTS WITH AURICULAR FIBRILLATION. (Rus.) Bogoslovsky, V. A. (A. L. Miasnikov Inst. Cardiology, USSR Acad. Medical Sciences, Moscow, USSR); Kukharchuk, V. V.; Mazaev, A. V.; Plchugin, V. N. *Ter. Arkh.* 47(4): 100-104; 1976.

The effect of cardioversion, using a 4,700 V defibrillator, on the indices of central hemodynamics was studied in 29 patients with left atrial fibrillation. The patients were administered phenobarbital and anesthetized with hexenal. The minute volume showed no change 25-30 min after the restoration of the sinus rhythm. However, the frequency of the cardiac contractions decreased and the systolic volume increased after cardioversion. The reduction in the Sonnenblick-Feragut contractility indices was believed to be due to the adverse effect of the electric discharge on the myocardium, and partly to the hexenal anesthesia. (18 refs.)

75-259

4703 CERVICAL ENDOMETRIOSIS AS A COMPLICATION AFTER DIATHERMIC COAGULATION OF THE UTERINE CERVIX. (Bul.) Karagiosov, I. (Medical Acad., Maternity and Pediatric Center, Bulgaria); Makaveeva, V. *Akush. Ginekol. (Sofia)* 14(3): 203-208; 1975.

A study of the incidence and colposcopic morphology of cervical endometriosis as a complication of diathermic coagulation (not described) of the uterine cervix is presented. Of 5,531 women examined colposcopically, 40 (.72%) showed evidence of cervical endometriosis. All cases occurred in patients in whom diathermal coagulation had been performed (40/636 patients, 6.28%). Pseudotumors, flat, ulcerous and pseudoectopic forms of cervical endometriosis were distinguished colposcopically. (14 refs.)

76-101

4704 CONFORMATIONAL EFFECTS ON THE ACTIVATION FREE ENERGY OF DIFFUSION THROUGH MEMBRANES AS INFLUENCED BY ELECTRIC FIELDS. (Eng.) Offner, F. F. (Technological Inst., Northwestern Univ., Evanston, IL 60201); Kim, S. H. *J. Theor. Biol.* 61: 97-112; 1976.

The influence of an electric field on the permeability of biologic membranes to potassium and sodium ions is theoretically analyzed. Permeability changes in membranes are explained by simple electrostatically induced conformational changes at the mouths of membrane pores, which result from the deflection of long-chain molecules having ionized polar groups near the interface. The deflection of such a chain increases approximately as the cube of the number of deflecting atoms in the chain increases. Such a molecule will suffer a considerable deflection if subjected to a component of an electric field normal to its axis. For example, a 20-atom chain would deflect 1.0 Angstrom as a result of a normal field component of 100,000 V/cm acting on a single electron charge. A conformational change requiring a low free energy for its production may result in a large change in the free energy of activation. This difference is due to the time scale of the two processes: the electrical displacement can occur over a relatively long time (fraction of a msec), while the process affecting activation energy occurs over a time scale on the order of 10^{-12} sec. Thus the activation energy for diffusion through pores should be highly sensitive to the boundary electric field, provided that the pore opening is of a suitable form and carries charges at the interface. The energy required to partially dehydrate sodium and potassium ions plays an essential role in the process. (22 refs.)

76-102

4705 MYOSIN SYNTHESIS INCREASED BY ELECTRICAL STIMULATION OF SKELETAL MUSCLE CELL CULTURES. (Eng.) Brevet, A. (Dept. Medicine, Stanford Univ. Medical Center, Stanford, CA 94305); Pinto, E.; Peacock, J.; Stockdale, F. E. *Science* 193(4258): 1152-1154; 1976.

The effect of electrical stimulation (100 V and 5 mA maximum) on protein synthesis in skeletal muscle cell cultures established from 12- to 13-day embryonic chick breast muscle was investigated. When the muscle cultures were 4-5 days old, they were stimulated for 14-48 hr with a 0.6-sec train of 10- to 25-msec biphasic pulses delivered every 4 sec by way of agar saline bridges. The quantity of protein extracted from the cultures with pyrophosphate buffer was increased by a mean of 21% over that of unstimulated control cultures, and the amount of radioactive leucine in myosin heavy chain protein was increased by a mean of 39% over controls. A 29% increase in the pyrophosphate-extractable protein as compared with only a 7% increase in total cellular protein indicated that the electrical stimulation effect was greater on contractile proteins, such as myosin. A comparison of the deoxyribonucleic acid content of stimulated and unstimulated cultures revealed that the protein enhancement in stimulated cultures was due to increased protein synthesis rather than to cell proliferation. Thus, direct electrical stimulation of the contraction of skeletal muscle cells *in vitro* enhances the amount of protein produced by myotubes, and this increase is greater for the contractile proteins. (26 refs.)

76-103

4706 ELECTRIC FIELD-INDUCED CONFORMATIONAL CHANGE OF POLY(L-LYSINE) STUDIED BY TRANSIENT ELECTRIC BIREFRINGENCE. (Eng.) Kikuchi, K. (Dept. Chemistry, Coll. General Education, Univ. Tokyo, Meguroku, Tokyo, Japan); Yoshioka, K. *Biopolymers* 15(9): 1669-1676; 1976.

Transient electric birefringence measurements on poly (L-lysine hydrobromide) in methanol-water mixtures were carried out at various solvent compositions in the vicinity of the helix-coil transition region (from 87 to 98 vol % methanol). The electric field was applied to the solution in a Kerr cell in the form of single rectangular pulses of up to 6 kV amplitude. Anomalous birefringence transients were observed between 90 and 95 vol % methanol above a threshold field strength. A distinct difference between the responses to weak and strong electric fields was noticed over a narrow range of the solvent composition. The effects of polymer concentration and temperature on the field-strength dependence of the birefringence were studied at a solvent composition of 90 vol % methanol where the anomalous transients

appeared most clearly. The double logarithmic plots of the steady-state specific birefringence versus the square of field strength for different concentrations and temperatures could be superimposed by shifting them horizontally along the abscissa. The threshold field strength, which was determined from the shift factor, decreased with decreasing concentration. The results provide further evidence that strong electric fields can cause a helix-coil transition in this system under favorable conditions. (17 refs.)

76-104

4707 EXPERIMENTAL AND THEORETICAL STUDIES ON ELECTROMAGNETIC FIELDS INDUCED INSIDE FINITE BIOLOGICAL BODIES. (Eng.) Guru, B. S. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., East Lansing, MI 48824); Chen, K-M. *IEEE Trans. Microwave Theory Tech.* MTT-24(7): 433-440; 1976.

The tensor integral equation was used to calculate the induced electric field inside a biologic body illuminated by a simple plane wave. Simulated biologic bodies made of plexiglas were filled with saline and put into an anechoic chamber and illuminated by electromagnetic waves with frequencies ranging from 1.7-3.0 GHz radiated from a horn antenna. The induced electric field inside the solution was measured by a dipole-type probe loaded with a microwave detector diode at the terminal. Model sizes were 6x6x1 cm, 12x12x1 cm, 16x16x1 cm, and 12x12x2 cm. Results of the theoretic and experimental values of the dissipated power (DP) are presented graphically. The distribution of the DP was shown to change significantly when frequency, conductivity and permittivities changed only slightly. In the model 2 cm deep (two 1 cm layers) the DP in the first layer was several decibels higher than that in the second layer, as was theoretically predicted. The patterns of the DP indicated the complexity of the induced field in the models. (10 refs.)

76-105

4708 TUMOR ERADICATION BY RADIOFREQUENCY THERAPY [Letter to Editor]. (Eng.) Selker, R. G. (Univ. Pittsburgh, Pittsburgh, PA); Wolfson, S. K. *JAMA* 236(15): 1690-1691; 1976.

A report of tumor eradication by radiofrequency therapy is questioned because of problems associated with tumor temperature measurement and the assumption that all tumors have decreased blood flow. Most temperature measuring devices are directly heated in the radiofrequency field and give false readings of intratumoral events; therefore, special thermistors must be used to prevent distortion of the absolute temperature values produced. A review of the conflicting reports in the literature concerning the effect of radiofrequency therapy on tumor eradication illustrates the importance of the above temperature measurement precautions. At 40°C, for example, enhanced tumor growth with metastatic implants and rapid death occur in experimental animals. That the results of radiofrequency-induced tumor eradication are totally related to tumor blood flow is doubtful, and in the absence of data outlining intratumoral temperatures, necrosis related to high temperatures seems more reasonable. Total tumor necrosis can occur within minutes after the application of radiofrequency heat. (5 refs.)

76-106

4709 COMPLEX PERMITTIVITY AND PENETRATION DEPTH OF MUSCLE AND FAT TISSUES BETWEEN 40 AND 90 GHz. (Eng.) Edrich, J. (Dept. Electrical Engineering, Univ. Denver, Denver, CO 80210); Hardee, P. C. *IEEE Trans. Microwave Theory Tech.* MTT-24(5): 273-275; 1976.

The dielectric constant (ε), conductivity (σ), and penetration depth (δ) of millimeter waves in fat and muscle tissue were measured over the frequency bands 40-54 GHz and 85-90 GHz. Fat from recently slaughtered cattle, and muscle tissue from Sprague-Dawley rats, were used for measurements. The measured δ of fat at 40-54 GHz and 85-90 GHz ranged from approximately 1.8-2.5 mm (peak at 45 GHz) and from approximately 1.2-1.3 mm (peak at 90 GHz), respectively. The δ for muscle in the two frequency bands ranged from approximately .4 to .27 mm (peak at 40 GHz) and from approximately .22 to .21 mm (peak at 85 GHz). A phaseless technique was used to determine the relative ε and the σ for the tissues. A substantial shift in the characteristics of fat was determined by these values. The initial values for ε and σ increased from 8.4 and 15 Ω^{-1} m^{-1} respectively, for about 1.5 hr, after which they shifted downward to 4 and 7 Ω^{-1} m^{-1}. This shift did not seem to be affected by temperature. The results indicate that millimeter wave irradiation of human body tissue similar to that investigated has to be considered for microwave hazard studies. (11 refs.)

76-107

4710 EXPERIMENTAL REGENERATION IN PERIPHERAL NERVES AND THE SPINAL CORD IN LABORATORY ANIMALS EXPOSED TO A PULSED ELECTROMAGNETIC FIELD. (Eng.) Wilson, D. H. (Accident and Emergency Dept., General Infirmary at Leeds, Leeds, England); Jagadeesh, P. *Paraplegia* 14: 12-20; 1976.

The use of pulsed electromagnetic fields for peripheral nerve and spinal cord regeneration in laboratory animals was investigated. The apparatus used was a Diapulse machine that is capable of delivering field strengths of from 5-120 mW/cm^2 in the form of 65-microsec pulses over frequencies of 80-600 pulses/sec. Peripheral nerve section and suture (median-ulnar nerve in the upper forelimb) was performed on 132 rats, and postoperatively half of the rats were treated for 15 min/day with diapulse therapy (dosage not given). The diapulse-treated animals demonstrated a return of nerve conduction 12 days after division and suture of the nerve, although a 10-fold increase in stimulus strength (0.5-5.0 V) was required for the response. No responses to the 5.0-V stimulation were observed in control animals. Histologic sections distal to the point of suture in the treated animals 30 days after surgery showed

chat the nerve contained abundant regenerating nerve fibers but of reduced diameter. Comparable sections from untreated animals 60 days after division and suture also showed regeneration, but the degree of recovery was not as great as that in treated animals at 30 days postoperative. Studies of spinal cord regeneration following hemicordotomy in cats were also performed. Exposures to diapulse therapy were for 0.5 hr each day for 1 mo using an average field strength of 50 mW/cm^2 and a frequency of 400 pulses/sec. When the animals were sacrificed 3 mo after hemicordotomy, electromagnetic-induced nerve fiber regeneration across the scar region was observed. (6 refs.)

75-260

4711 THE EFFECT OF 1.6 GHz RADIATION ON NEUROTRANSMITTERS IN DISCRETE AREAS OF THE RAT BRAIN. (Eng.) Merritt, J. H. (Radiobiology Div., U.S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX); Hartzell, R.; Frazer, J. H. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 227-228; 1975.

To investigate the effects of radiofrequency radiation on the central nervous system of rats, power distribution was thermographically determined in rats exposed to 1.6 GHz radiation at a measured power density of 80 mW/cm^2 for 10 min. Rectal temperature rise was 4°C. Serotonin and its metabolite 5-hydroxyindole acetic acid, dopamine and its metabolite homovanillic acid, and norepinephrine were measured in the hypothalamus, corpus striatum, midbrain, hippocampus, cerebellum, medulla-pons, and cortex. Parallel hyperthermal and normothermal controls were also exmained. The hyperthermal controls were maintained in a 75°C environment for 10 min which resulted in a rectal temperature rise of 4°C. A significant decrease in hypothalamic norepinephrine content was noted in the irradiated and hyperthermal groups compared to the normothermal controls. The hippocampal content of serotonin was decreased in the irradiated but not the hyperthermal animals. Conversely, cerebellar and cortical serotonin concentrations were decreased in the hyperthermal but not the irradiated rats. The dopamine content of the corpus striatum was significantly lower in the irradiated group but not in the hyperthermal animals. The decrease in hypothalamic norepinephrine supports other data suggesting that neurotransmitter subserves a neuronal system to lower body temperature. The other changes agree with thermographic imagery of rats exposed to 1.6 GHz radiation. The results indicate that the effects on the neurotransmitters are a result of radiofrequency radiation induced hyperthermia and not a direct effect on innervated tissue. (No refs.)

75-261

4712 THE EFFECT OF 1.6 GHz CW FIELDS ON TRACE METAL CONTENT OF SPECIFIC REGIONS OF RAT BRAIN. (Eng.) Chamness, F. (U.S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX); Scholes, H.; Sexauer, S.; Frazer, J. W. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 226; 1975.

To study the effects of radiofrequency radiation on the trace metal content of specific regions of the rat brain, rats were exposed to 80 mW/cm^{-2} plane wave fields at 1.6 GHz in the USAFSAM anechoic chamber. Companion studies were made on the brains of animals exposed to an environment of 80°C in a warm air oven for an equivalent period of time. Brain areas analyzed included the cortex, corpus striatum, hippocampus, hypothalamus, midbrain, cerebellum, and medulla. Metals analyzed were Na, K, Ca, Mg, Fe, Cu, and Zn, all by atomic absorption. Major differences from controls were found in the magnesium content of the hypothalamus in both hyperthermal and radiofrequency exposed rats. If the iron changes are interpreted as due primarily to alterations in blood distribution, then it appears that intracerebral circulatory changes were produced by hyperthermal environments which were not produced by radiofrequency exposure. Previous studies have found decreases in zinc content in liver and increases in the zinc content in brain cortex of animals exposed to high frequency band radiation. The present results are similar to the latter findings and show that some cerebral effects are produced indirectly as a result of primary effects on other organs. (No refs.)

75-262

4713 EFFECTS OF THE FIELD FREE SPACE ON THE CIRCADIAN RHYTHM OF THE HOUSE SPARROW, *PASSER DOMESTICUS*, AND OF THE SONG SPARROW, *MELOSPIZA MELODIA*. (Eng.) Bliss, V. (Dept. Zoology, Univ. Rhode Island, Kingston, RI); Heppner, F. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 268; 1975.

Experiments were performed to test the hypothesis that changes in the earth's electromagnetic field can act as a Zeitgeber for birds that normally demonstrate pronounced circadian rhythms. Two identical Helmholtz coils were constructed, each containing eight nonmagnetic cages arranged symmetrically within the computed field-free space. The birds' activity was monitored with an event recorder. The experiment was conducted in a soundproof room at a constant temperature. Oscillations in background noise from the power supply and recording apparatus were masked by a white noise generator. Eight birds (one bird/cage) were placed in each coil. Each group consisted of four House Sparrows and four Song Sparrows. All birds were entrained to an LD 9:15 cycle. The experimental group was placed on an electromagnetic field 9:15 cycle (9 hr field-free space: 15 hr earth's electromagnetic field) that coincided with the LD cycle. All birds were maintained at the LD 9:15 cycle. After several weeks, all birds were placed in constant darkness. The electromagnetic field 9:15 cycle was maintained for the experimental group, and all activity was tested for periodicity. (No refs.)

75-263

4714 BROADCAST RADIATION: A SECOND LOOK. (Eng.) Tell, R. A. (Environmental Protection Agency, Washington, DC); Janes, D. E. *In: Proceedings of the 1975 Annual Meeting of the International Union of Radio Science Held at the University of Colorado, Boulder, Colorado, 20-23 October, 1975.* USNC/URSI. (Washington, D.C.): 312-313; 1975.

As part of its program to determine the health and environmental effects of exposure to nonionizing radiation, the Environmental Protection Agency is gathering and analyzing information on sources that produce radiation levels in the environment. This paper extends the results of a previous project that studied broadcast stations as environmental sources of nonionizing radiation. This investigation was developed around vertical radiation patterns and data supplied by the Federal Communications Commission regarding the heights of transmitting antennas above ground and above supporting structures, such as, building roofs. In particular, power densities at roof and ground level were calculated for areas very near FM broadcast installations using recent information on steep depression angle radiation from commonly used FM transmitting antennas. Associated field measurement data are also discussed and the overall implications of this analysis are examined in terms of present radiofrequency exposure standards and philosophy. (No refs.)

76-108

4715 EIGHTH SUPPLEMENT TO BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO-FREQUENCY RADIATION. (Eng.) Glaser, Z. R. (Naval Medical Research Inst. Detachment at Naval Surface Weapons Center, Dahlgren Lab., Dahlgren, VA 22448); Brown, P. F. *Prepared by Dahlgren Laboratory for the Naval Medical Research & Development Command, Bethesda, MD.* AD 734-391: 19 pages, August, 1976.

Approximately 350 references on the biological responses to radiofrequency and microwave radiation are included in this continuing bibliography of the world literature. Citations include such topics as biomedical studies using electromagnetic pulse radiation, biological dosimetry, effects of electromagnetic radiation on implanted electronic cardiac pacemakers, microwave exposure limits, regulations and standards, and electroanesthesia. Particular attention is paid to the effects of nonionizing radiation on man. Soviet and East European literature is included in detail. (331 refs.)