limit ionizing radiation to the tumor only. The tumor temperature is raised to 41.5-42° C by exposure to the 2450 MHz applicator and maintained for one hr and monitored periodically. Rectal temperature is measured at various times during and at the end of exposure to make sure the core temperature does not rise above a physiologically acceptable level. Following the hyperthermic treatment, the animals are exposed to a "subcurative" X-ray dose. Body weight, rectal temperatures, and tumor size are recorded regularly. Growth curves and regression rates will be determined for tumors treated with hyperthermia, X-rays ("subcurative" and "curative"), and the combination of microwaves and "subcurative" X-rays. This should permit determination of the synergistic effect of the hyperthermia and X-rays on tumor growth, regression, and cures. At specific times after treatment, tumors will be removed surgically for gross and cytological examination and compared with untreated tumors. All dead animals will be necropsied. (1/76-12/76)

Supporting Agency:American Cancer Society.

0072 COMBINATION OF MODALITIES IN THE TREATMENT OF NEUROBLASTOMA. Feldman, A. (Univ. Hawaii, Cancer Center of Hawaii, 1997 East West Road, Honolulu, HI 96822).

The threefold objectives of this study are (1) to investigate the potential of microwave radiation for the hyperthermic treatment of round cell neuroblastoma implanted subcutaneously in the hind legs of A/J mice, (2) to determine if microwave radiation sensitizes tissue, thus potentiating the effectiveness of X-ray therapy, and (3) to investigate the effect of denervation plus hyperthermia on remission of tumor. To effect the first objective, the tumor-bearing limbs of the mice will be externally irradiated at x-band (a frequency of 10,000 MHz) by means of a helical coil placed around the limb. The second objective will be accomplished by using standard X-ray equipment available at Queen's Medical Center, under the direction of Dr. Paul DeMare, a radiation therapist. To effect the third objective, the gastrocnemius muscle in the hind leg will be denervated four days prior to tumor implant, and the tumor-bearing limbs will be irradiated as above. (7/76-9/76)

Supporting Agency:Univ. Hawaii

0073 QUANTIFICATION & MEASUREMENT OF INTERNAL ELECTROMAGNETIC FIELDS INDUCED IN FINITE BIOLOGICAL BODIES BY NONUNIFORM ELECTROMAGNETIC FIELDS. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, East Lansing, MI 48824).

A theoretical basis will be developed for quantification and measurement of internal electromagnetic fields induced in finite biological bodies by nonuniform electromagnetic fields. Experimental confirmation will be sought by use of implantable probes in simulated models. A theoretical study of implanted probes and their response within the medium will be made. The Army is using electromagnetic radiation to provide communication l'nks, to probe the battle environment for enemy presence, equipment, and activities, to control defensive ordnance, and to control guidance of ordnance. Individual and cumulative levels of these radiated energies are becoming a considerable concern because of their effects on the natural environment and on man. The theoretical method will be based on numerical solution of a tensor integral equation quantifying the internal electromagnetic field induced in a finite, heterogeneous biological body by an incident, nonuniform electromagnetic field. In this method the body is subdivided into a selected number of small sub-volumes, and the individual electric properties determined. Measurements with sample probes immersed in various simulant media will determine parameters for testing the theoretical derivations of probe interactions. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Army.

0074 PHARMACOLOGICAL STUDIES OF ACETYLCHOLINE TURNOVER--RADIOISOTOPIC APPROACH. Cheney, D. L.; Racagni, G.; Zsilla, G.; Costa, E. (U.S. Dept. Health, Education, Welfare, Public Health Service, Elizabeths Hosp., 2800 Nichols Ave. S.E., Washington, DC 20032).

Decapitated or microwave-killed animals were compared to determine whether changes in acetylcholine content following drug treatment might reveal indirect information concerning its turnover rate. The results suggest that changes in the turnover rate of striatal acetylcholine elicited by drugs cannot be predicted by a decrease or an increase in striatal acetylcholine content measured in rats killed by decapitation. The acetylcholine content and turnover rate were determined in rats receiving haloperidol or clozapine. Both drugs reverse the decrease in striatal turnover rate caused by apomorphine. The turnover rate of striatal acetylcholine is increased by haloperidol but not by clozapine. This difference could explain its extra-pyramidal action, while the anticholinergic action of clozapine could explain its lack of extrapyramidal side effects. (7/75-6/76)

Supporting Agency:HEW, PHS, Alcohol, Drug Abuse & Mental Health Admin., NIMH.

0075 OCULAR PATHOLOGY FROM ELECTROMAGNETIC RADIATIONS. Fine, B. S.; Hirsch, S. E.; Tso, M. O. (Univ. Association Research and Education, 9650 Rockville Pike, Bethesda, MD 20014).

It has long been known that damage to ocular tissues may occur by exposure to various wavelengths of the electromagnetic spectrum. Damage is dependent on the amount of energy absorbed. With development in recent years of a wide variety of sources

of powerful electromagnetic radiations, some of which are coherent (i.e., masers and lasers), the potential for accidental injury to the eye grows. This study will evaluate the sequence of morphologic events produced in ocular tissues by such devices in both the visible and invisible portions of the spectrum. Current methods of light and electron microscopy will be employed. This project will evaluate two important regions of the invisible spectrum using (a) an ultraviolet laser to determine effects on cornea, lens, and possibly the retina in short (days, weeks) and medium term (months to a year) experiments; (b) microwave radiations to determine mainly the effects on the lens in short, medium, and long term (i.e., years) experiments. In addition, this project will evaluate the damage to the primate fovea by coherent visible light using a continuous wave laser (Argon). The proposed studies will be used to evaluate the potential for accidental injury and to determine safety standards. (6/76-5/77)

Supporting Agency:HEW, PHS, FDA.

0076 REMOTE STIMULATION BY RADIOFREQUENCY TRANSMISSION. Glenn, W. W. (Yale Univ., Sch. Medicine, 333 Cedar St., New Haven, CT 06510).

No descriptive information is available. (10/75-9/76).

Supporting Agency:HEW, PHS, NIH, Res. Resources Div.

0077 QUANTITATIVE EFFECTS OF EM ENERGY ON HUMAN TISSUES. Guy, A. W.; Lovely, R. H.; Chou, C.; Lehmann, J. F. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

This project will investigate electromagnetic (EM) field interaction with man, experimental animals, and isolated nerve preparations to provide information for promulgating realistic exposure safety standards. Both theoretical and experimental interdisciplinary investigations will be carried out to: (1) quantitatively establish the EM field pattern within, and external to, human and animal tissues exposed to various EM sources as a function of frequency, source configuration, and source locations, (2) expose test animals to these EM sources while monitoring incident and absorbed power densities, and (3) observe physiological characteristics of animals before, during, and after exposure to both low and high power EM sources. Based on the above, safe levels of exposure of man to various EM sources as a function of frequency will be determined. In addition, the project will ascertain the hazards associated with human exposure to routine diathermy treatment and develop safe methods for the application and monitoring of EM energy in diathermy practice. (6/76-5/77)

Supporting Agency:HEW, PHS, FDA.

0078 BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. Eisenbud, M. (New York Univ., Sch. Medicine, 550 First Ave., New York, NY 10016).

This project is part of a broader program whose aim is to provide core support for a broad program in the environmental health sciences. The research under way and the proposed research concerns the adverse health effects from environmental factors. The general objectives of the research are to define the nature and extent of such effects with the aim of instituting appropriate preventive or control procedures where required. Interests range from acute to chronic health effects including, in the latter, cancer and the degenerative diseases. The research encompasses laboratory studies on the biochemical mode of action of environmental toxicants, exploratory studies aimed at improving the reliability and efficiency of predictive toxicological tests, improvement of diagnostic procedures for diseases possibly related to environmental factors, epidemiological investigations, and field studies on the distribution of pollutants. (1/76-12/76)

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

0079 PROSPECTIVE EPIDEMIOLOGICAL STUDY TO EVALUATE PERSONNEL OCCUPATIONALLY EXPOSED TO NON-IONIZING ELECTROMAGNETIC RADIATION. Blais, B. M.; Kelly, R. (U.S. Navy, Ophthalmology Dept., 17th St. & Pattison Ave., Philadelphia, PA 19145).

No descriptive information is available. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy

0080 HYPERTHERMIA AND RADIATION--X-RAYS VS. FAST NEUTRONS. Nagle, W. A.; Moss, A. J. (Univ. Arkansas, Sch. Medicine, 4301 W. Markham St., Little Rock, AR 72201).

Recent results suggest that hyperthermia combined with X or gamma radiation may simulate the effects of high linear energy transfer (LET) radiation, since radiation sensitivity of hypoxic cells is increased. If this observation is confirmed and can be exploited clinically, radiotherapy can be improved greatly. Patients may derive the expected benefits of high LET radiotherapy without the expense of constructing and maintaining sources of high LET particles. To be clinically useful, heat must be delivered to some depth in tissue while, at the same time, the skin is not heated significantly. This is necessary to maintain a therapeutic margin between the tumor and the incidentally irradiated normal tissues. Two modalities now available for heating deeply-seated lesions are ultrasound and microwaves. An in-depth study of the interaction of agents that cause heating (thermal heat, ultrasound, and microwaves) and ionizing radiations of both low (250 kVp X-rays) and high (fast neutrons) LET will be performed. Cultured cells of three different

mammalian lines will be used and cell populations will be synchronized where appropriate. The experiments will be performed under conditions of hypoxia as well as normal oxygenation. Both cellular (proliferity integrity) and molecular (production and repair of DNA single strand breaks) effects will be measured. The results will help to establish a biologic base from which rational clinical trials can be formulated. (6/76-6/77)

Supporting Agency:HEW, PHS, NIH, NCI.

0081 BIOLOGICAL EFFECTS AND HAZARDS OF MICROWAVE RADIATION. Hunt, E. L.; Larsen, L. E. (U.S. Army, Walter Reed Army Inst. Research, Washington, DC).

An attempt will be made to establish meaningful criteria for delimiting human occupancy in an electromagnetic (EM) environment to achieve maximum operational effectiveness of military personnel and eliminate health risk. The interaction of radiofrequency and microwave radiation (10 MHz-100 GHz) with biologic systems will be delineated. In addition, established EM dosimetry techniques will be evaluated and developed to measure and control incident and absorbed energy. Each major organ system and biologic process will be investigated where EM effects might occur at reasonably low power intensities. The military significance of the effects will be determined and measures necessary to obviate them will be evaluated. A multidisciplinary approach will be used including methods of experimental psychology, biophysics, physiology, and engineering. Exposure parameters will be chosen for relevance to Army radiating equipment operational requirements. In addition, a quarterly digest on the biologic effects of EM radiation will be published. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Army

0082 CELLULAR INJURY AS INDICATED BY ULTRASTRUCTURAL ALTERATIONS (MICE). Stephens, R. J. (Stanford Research Inst., 333 Ravenswood Ave., Menlo Park, CA 94025).

See CR 0084 for description of this research. (7/75-6/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Med. Sci.

0083 EFFECT OF ULTRASOUND ON REPRODUCTIVE PHYSIOLOGY (MICE). Stolzenberg, S. J. (Stanford Research Inst., 333 Ravenswood Ave., Menlo Park, CA 94025).

See CR 0084 for description of this research. (7/75-6/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Med. Sci

0084 CYTOGENETIC EVALUATION OF THE EFFECTS OF ULTRASOUND (HUMAN, MICE). Mitchell, A. D. (Stanford Research Inst., 333 Ravenswood Ave., Menlo Park, CA 94025).

This project is part of a broader program to determine the threshold conditions for selected bioeffects that are expected to be sensitive indicators of damage at many levels of biologic structure and function. Bioeffects will be sought within the exposure ranges of 1-10 MHz, continuous wave and pulsed (3-100 microsec) modes, $1\text{-}10^4$ sec, with 1-10 repetitive exposures, at 1-10 W/cm^2. Exposed Swiss-Webster mice and tissue cultures will be analyzed by histochemical micro-techniques for monitoring critical metabolites, by cytologic techniques for detecting toxicity and genetic instability, by optical and electron microscopy, and by observation of anomalies in reproductive physiology. (7/75-6/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Med. Sci.

0085 EFFECTS OF MICROWAVES ON NEURAL RESPONSE. McRee, D. I.; Wachtel, H. (U.S. Dept. Health, Education, Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

The objective of this project is to determine the effect of microwave radiation on neurologic response. Isolated neurons, such as, the abdominal ganglion of the *Aplysia*, the sciatic nerves of frogs and the saphenous nerves of cats will be exposed to continuous wave and modulated microwave radiation in the power density range of 1-10 mW/cm^2. The effects of the microwave radiation on the strength-duration of a stimulus to produce an action potential will be investigated, in addition to the amplitude of the response, and conductive velocity. (7/75-6/76)

Supporting Agency:HEW, NIH, Natl. Inst. Environmental Health Sci.

0086 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P.; Johnson, C. C. (Univ. Utah, Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The objective of this research is to determine behavioral and biologic effects of resonant electromagnetic power absorption in rats to develop realistic exposure criteria for military personnel. The parallel-plate wave guide will be used to generate plane waves for exposure of the experimental animals. Exposures will be made and biologic effects studied with the animals oriented along the E, H, and K axes. The frequency will be established based on the frequency of peak absorption; frequencies of 0.5, 0.75, 1.0, 1.25 and 1.5 times this resonant frequency will be used. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Army

0087 CUMULATIVE TERATOGENESIS FROM LOW LEVEL MICROWAVES. Rosenbaum, F. J.; Pickard, W. F. (Washington Univ., Sch. Engineering & Applied Science, 4559 Scott Ave., St. Louis, MO 63130).

It is known that prolonged exposure to low-level microwave radiation (0.5 mW for 8 hr at 9 GHz) induces putatively cumulative teratogenic damage in pupae of the darkling beetle *Tenebrio molitar*. This project will attempt to determine whether intermittent exposure to microwave energy during pupation causes like damage. An effort will be made to establish the power level for thermally induced damage and examine the distribution of types of damage below the thermal level. The influence of microwave frequency in the production of teratogenesis will be investigated to help identify possible mechanisms for the non-thermal effects already observed. (5/76-4/77)

Supporting Agency:HEW, PHS, FDA

0088 STUDY OF ELECTROMAGNETIC MODIFICATION OF DISUSE OSTEOPOROSIS. Bassett, C. A. (Columbia Univ., Sch. Medicine, 630 W. 168th St., New York, NY 10032).

No descriptive information is available. (1/76-12/76).

Supporting Agency:NASA, Organization & Management Office, Univ. Affairs Office

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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 9×10^3 M^{-1} to 300×10^3 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.)

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.)

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.)

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.)

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.)

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.)

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 respons- 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.)

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.)

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 Univeresity 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.)

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.)

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.)

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.)

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.)

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.)

4630 BIOLOGICAL THERMAL EFFECT OF MICROWAVE RADIATION ON HUMAN EYES (PROCEEDINGS ABSTRACT). (Eng.) Al-Badwaihy, 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 generation 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.)

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.)

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.; Beischer, 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.)

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.)

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-