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.)

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.)

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.)

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.)

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 from the radiation. (No refs.)

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.)

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.)

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.)

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 $\geq$ 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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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, V79-122D1, 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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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 evidance, 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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

4672 THE USE OF MAGNETIC FIELDS AND ELECTRONIC NOISE IN THE TREATMENT OF INSOMNIA AND NEUROSIS. (Cze.) Gruenner, O. (Vyzkumni 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 (I 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.)

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.)

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.)

4675 MORPHOFUNCTIONAL STATUS OF THE HYPOPHYSEOGONADAL 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.)

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.)

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.)

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.)

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.)

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.)

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.)

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.)

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-