BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

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"The views and conclusions contained in this documentation are those of the author and should not be interpreted as necessarily representing the officials’ policies, either expressed or implied, of the Office of Telecommunications Policy or of the U.S. Navy."
A theoretic investigation was conducted of the magnitude and spatial 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.)

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, 62, 52, and 62 mW/cm² were used. The animals were exposed to a 60 min and 120 min exposure time at the levels 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 radiowave power; all levels employed continuous waves. Pulsed waves were also used at 4 and 16 mW/cm² (PRF = 1 sec, P.D. = 0.1 sec). The monkeys performed the vigilance task, which is defined as the irradiation of 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/cm². Irradiation occurred; and even in these instances, behavior was only minimally and inconsistently changed. Mice body heating (0.4°C to 1.7°C) was associated with the higher density (32-62 mW/cm²), although body temperature was not related to observed behavioral changes at these same levels. (No refs.)

Eight male rats were irradiated for 3 min with 918 MHz microwaves pulse-modulated at 11 Hz, for 8 hr/day, at field strengths of 10 mW/cm². 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 pulsed-modulated microwaves on them are presented. (No refs.)

75–192


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 myelinated axon in constant temperature (6–8°C) saline solution was exposed to current densities of approximately 100 mAs/cm² corresponding to a heat deposition rate of 0.6 W/cm³. 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 0.5 msc duration did not trigger the nerve. It was found that triggering was possible only in the low frequency region between 0.5 msc pulses from direct current to 20 KHz. The giant axon of the myelinated axon in constant temperature finger solution. It was found that no effects were observed 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/cm²) associated with a temperature rise up to 39°C did, however, damage the nerve. In both cases electrode pick-up induced artifacts and may have presented a potential electromagnetic hazard. (No refs.)

75–193


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/cm² to 450 mW/cm². Microwave irradiation did not suppress their lever press rate, which suggests that the power density and times used in the experiment were not aversive to the rhesus. (No refs.)

75–194


The role of microwave frequency in the experimental induction of lens opacities was tested by irradiating the eye 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/cm². At 2.45 GHz, it was 320 mW/cm². (No refs.)

75–195


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 3H-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 Ehrlichia coli lipopolysaccharide. (No refs.)

75–196


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, lasted about 200 usec, 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 microphonics response to the microwave pulses. This cochlear microphonics response suggests that the microwave auditory effect is accompanied by a mechanical disturbance of the hair cells of the cochlea. (No refs.)

75–197


A theoretical 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 stress 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. Numerical results will indicate the magnitude of the induced stress and displacement as well as the applicability of the theory to the microwave auditory phenomenon. (No refs.)

75–198


Localized microwave exposure of the canine thyroid gland was undertaken to determine its thermal sensitivity. The experiments were conducted with a 2400 MHz utilizing a small (21 x 11) 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 wore 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-hour equilibration period. One gland was then subjected to a 2-hour 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 Th4/min) was observed in each group. The smallest increase occurred during the 39°C exposure, and successively larger increases occurred during the 42°C and 45°C heating. It is concluded that thyroid gland function can be stimulated by temperature increases at the gland of 2°C or more above normal. (No refs.)

75–199


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-
CURRENT LITERATURE

75-200


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 line worker working in very close proximity to an energized conductor. The position of the arms was varied, for example, arms extended or down at the side. The question of biologic hazards from exposure to fields of these systems is also discussed. (No refs.)

75-201


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

75-202


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 stimuli in order to depress the functional state. The result was compared with the depression state made by application of low frequency photic stimulus. The result showed that depressed functional state could be normalized to some extent by application of 90 Hz AC E.F. (No refs.)

75-203


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, hydrolyzes ribonucleic acid at the position of the pyrimidine nucleotides. Measurements were made spectrophotometrically between 240 and 300 nm using a difference spectrophotometric 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 ranged from 7.4 x 10^3 M^-1 to 3.0 x 10^3 M^-1 at pH 5.5. The solutions in the sample chamber were irradiated at a waveguide termination. Measurements were performed immediately after exposure and after exposure for 30 min. The absorbed dose rate for the irradiated samples was 40 W/kg. All experiments were carried out at 25°C, and the temperature of the sample and reference solutions was monitored continuously. No difference in the binding of ribonuclease in irradiated solutions and unirradiated controls could be detected. (No refs.)

75-204

A survey of recent selected Soviet and East European references reveals 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 consistently correlate with changes in animal behavior and organoleptic 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, Eastern European, and/or Western experimental findings, coupled with the pressure of public opinion, may have a significant effect on their unique positions with regard to the occupational exposure levels. This report represents a continuing effort to comprehensively compile the world literature on the subject and complements a 1969 review of the subject. New emphasis has been placed on experimental and theoretical research. (No refs.)

75-207

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 the heat dissipated in the body were computed to determine the maximum levels of irradiation permissible for long- and short-time exposures. Since the thermal response is strongly affected by the local sweat rate, four different models were used in which the hypothalamus, average skin and local skin temperatures, and the time rate of change of these temperatures were the controlling parameters. The best of these different models, as judged by comparison of the results with measured data, was then used in microwave simulations. (No refs.)

75-208
CURRENT LITERATURE

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 homogeneous 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, and to the thymus. Similar events have been seen with many types of normal cells extracted from animals exposed to a variety of electromagnetic fields. Another corollary, as yet unexamined in radiofrequency fields, is loss of intracellular materials from such cells. (No refs.)

75-209


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/cm² produced performances on the fixed consecutive number schedule. All power densities led to increased frequency of premature switching, with the highest power producing the most disruption of the counting discrimination. Premature switching responses due to radiation exposures were associated with pronounced reductions in the percentage of correctly performed response runs that produced reinforcements. Microwave radiation had no effects on overall or running response rates or on response variability. Performance changes were not related to induced hyperthermia. (No refs.)

75-210


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/cm² continuous wave signal. The results clearly demonstrated 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 in the 985 MHz, while large rats convulsed most quickly at 710 MHz. The frequency-vulnerability relationships were most clearly demonstrated with the E-field polarized horizontally. These data indicate the importance of considering frequency, orientation, and subject size when evaluating vulnerability to microwave exposure. (No refs.)

75-211


The high incidence of bird collisions at a 1000 ft TV tower north of Tallahassee, Florida, motivated this study of possible electromagnetic effects in bird navigation. Data collected over a 19-year period (1956 to 1975) concerning daily bird kills, number of birds, species, and position found formed the basis of a correlation study to determine factors responsible for high bird kills. Evidence indicates that bird navigation is a complicated process involving the integration of many sensory inputs including sight, pressure, smell, and magnetic field. This study investigated bird responses to (1) TV radiation from the tower, (2) disturbances
of natural magnetic and electric fields, and (3) lights of the tower. (Interference with the bird's navigation process that results in an attraction to the tower was responsible for bird kills not resulting in random incidence. The electromagnetic environment of the tower and theories of bird navigation regarding this problem are discussed. (No refs.)

75-212


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

75-213


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 $10 \pm 1 \text{ mW/cm}^2$ for 8 hr/day, 5 consecutive days a week 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 same 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 detectable weight loss. No other differences were detected between experimental and control animals. No latent effects were observed up to 2 mo post-irradiation. (No refs.)

75-214


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

75-215


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) and pulse length of 65 microns delivered 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 hydroxylase system may be stimulated. Significant inhibition of weight gain and differential development patterns in maturing male mice occurred after 30 min daily exposure for 14 days at the highest pulse frequency. Female mice showed a different weight inhibitory pattern initiated during the 14-day radiation schedule. Adult weight levels for both controls and treated mice were similar, which indicated a temporary effect in developmental gain equalized at approximately 2-4 wk. These effects appeared independent of overall effects on body temperature and were not associated with any gross alterations in organ to body weight ratios. (No refs.)

75-216


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/cm² for 15, 30, or 60 min. Plasma corticosterone levels rose in all six rats exposed to 60 mW/cm², 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/cm² for 30 or 60 min, but not in those (2/6) exposed for 15 min. One of four rats responded with an increase in plasma corticosterone to exposure to 30 mW/cm². Plasma corticosterone levels tended to plateau during exposure and, in general, began to drop sharply following termination of exposure, returning to baseline within 30 min in all cases. The data on rats exposed to thermogenic power density-time relationships demonstrate the transient nature of the response. (No refs.)

75-218


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 3-9 hr at 35°C. Exposure was conducted at far field power densities of 10 and 50 mW/cm², 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/cm², 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.)
The effects of external heating on the rabbit eye were investigated and compared with the cataleptogenic effects of microwave irradiation. The intraocular temperature of rabbits was elevated by the same amount as occurs during a cataleptogenic 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 conform 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 vascular stasis was observed as well as hemorrhage in ciliary body and iris vessels, corneal necrosis, and many instances of extensive hyphema. The few opacities that developed were in the anterior lens cortex, thereby differing in location from those induced by microwaves. (No refs.)


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 plexiglass 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 usec 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 mV/cm².

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 conditioned ability to respond at the 85-90% level. Although the results suggest an auditory component in the microwave control of this behavior, the demonstrations also indicate that stimulus control of appeti-
tive behavior can indeed be obtained with pulsed microwaves. This is in contrast to reports that such control cannot be obtained with modulated micro-
wave radiation. These findings also stand in con-
trast to, and suggest other possible interpretations of, recent reports of detection and avoidance of pulsed microwave radiation in rats. (No refs.)


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 deve-
lopment of the chick; and (3) growth of the sexually immature bird. Special equipment was con-
structed 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 CO₂ production. (No refs.)


Freshly isolated chick cerebral hemispheres were equilibrated with a calcium Ringer's solution containing 45Ca₂⁺ for 30 min. Washed tissue portions were ex-
posed to sinusoidal electric fields at either 1, 6, 16, or 32 Hz with electric gradients of 10, 20, or 50 V/m in air for each frequency for 20 min. Then 45Ca⁺ efflux was measured in 0.2 ml of supernatant and compared with efflux from unexposed control sam-

ples. All tissues were maintained at 36°C and checked for specific activity after the experiments. A frequency sensitive "tuning curve" showed sharply reduced efflux at 15-20 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 Hz. 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 fre-

quencies tested. At 10 V/m, non-significant decreases occurred at 6 and 16 Hz. It is concluded that oscillating electric low frequency fields at 6 to 30 Hz reduce Ca efflux; whereas, weak very high frequency fields amplitude modulated at the same frequencies increase efflux. A model for both effects based on cooperative interactions of Ca with fixed charges on stranded biopolymers is proposed. (No refs.)

75-2-23- 4637 MICROWAVE-INDUCED HYPERTERMIA AND RADIATION SENSITIVITY OF MOUSE INTESTINE (PRO-

Recent data show that heat applied alone both in vivo and in vitro selectively kills cancer cells and that heat plus radiation have a synergistic inter-
action. Normal tissue tolerance has been studied using only hot-water immersion of mouse skin. In this investigation, the mouse intestine was irradiated to define normal tissue response more ade-
quately. 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 epigastrum. 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 ad-
ministered and at 3 days post-treatment, the in-
testine was removed with histologic sections prepared, and the regenerative crypts counted. With heat alone (45°C for 15 min), preliminary data sug-
gested survival was reduced to less than 10% (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 radia-
tion (45°C for 2 min). Since the systemic rise in temperature related to microwaves heating may have caused the high mortality, the above technique was altered to improve survival. The subcutaneous temper-

ature 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 (428 ± 45°C for 3 min). Heating of externalized bowel resulted in the same low survival. Further studies will pursue these techniques to develop complete radiation dose-response curves and evaluate implanted tumor response. (No refs.)

75-224


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

75-225


Three separate groups of mice were exposed to high peak power (HPP) pulsed radiation over a 6-no period, 1 hr/day, 5 days/ wk to assess the effects of long-term exposure. Group I, which consisted of 53 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.)

75-226


To study the effects of nonionizing radiation exposure on brain electrical activity, continuous recordings of electrocorticogram (ECOG), electro-oculogram (EOG), and electromyogram (EMG) were obtained from adult male rabbits on a 24-hr basis following daily 2-hr microwave exposure at 5 mW/cm² for 60 days. The surgical implant assembly allowed chronic post-irradiation recording, while allowing nonmetallic elements to be associated with the subjects during microwave exposure. Log circuitry allowed the quantification of both the frequency and duration of rapid eye movement (REM) stage episodes. It is concluded that prolonged exposure of an organism to microwave radiation will decrease the frequency and duration of REM stage sleep. The sleep process is viewed as a potential index of central nervous system adaptation to prolonged electromagnetic radiation exposure. (No refs.)

75-227


Two experiments were performed to determine the ef-
flect 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 fluid crystal fiberscope temperature probe (3 cm rectally). Each rat was given 10 min exposure to RF radiation within a transversely polarized 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 1.5 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-sac reinforcement schedule while in the parallel plate waveguide. Preliminary results indicated that resonant (500 MHz) RF exposure in the electric field orientation disrupted lever-pressing behavior sooner than RF exposure at nonresonant frequencies. Future experiments will investigate RF absorption extended to 750 MHz. (No refs.)

75-229


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 14C 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 true BBB alteration and vasodilation or edema. 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/cm². The possible differences between CW and pulsed energy, molecular weight of test molecule, functional dependence of the BBB alteration with microwave parameters, and duration of BBB alteration are discussed. (No refs.)

75-229


Whole-body acute microwave (2450 MHz, continuous wave) exposure of 120 male Long Evans rats was carried out in a 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/cm² or 60 mW/cm² than they were in control rats, but there was no difference between the CC levels of rats exposed to 10 mW/cm² or 20 mW/cm² and control rats. Rats exposed to 20 mW/cm² or 40 mW/cm² showed an inconsistent tendency toward higher CC levels for exposure the longest exposure used in this study. The data suggested that for 2450 MHz exposures of up to 1 hr, the rat HHA axis was not stimulated unless incident power densities ≥ 30 mW/cm² 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 the power densities that resulted in increased CC levels also increased the rectal temperature of the rat by 1 to 3°C. (No refs.)

75-233


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 emotionality. Rats (16 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/cm². In
control animals, locomotor activity, emotionality, and vigilance decreased during the test, while exploratory activity increased. In irradiated animals, exploratory activity increased more slowly; vigilance at first increased then decreased; and locomotor activity was uniform. (No refs.)

75-231


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. Exposure 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/cm² 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 50 mW/cm² and 300 mW/cm² 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/cm² produced a highly significant reduction in audiogenic response. Nine rats showed no response following irradiation. However, these nine rats did respond following their sham treatment. Recovery of responsiveness within 4 days occurred in all rats for which the sham treatment had followed the microwave treatment. The present data show that audiogenic convulsive responses can be attenuated by a single, 30-min, continuous wave exposure. It is concluded that pulsed irradiation and repeated exposures, which have been used by previous investigators, are apparently not required to produce a decrease of central nervous system sensitivity as reflected by this measure. (No refs.)

75-232


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 (150°) 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 concentration was on the tail and abdominal regions. In addition, determining the total absorbed energy, the determination of the distribution of absorbed energy in animal bodies can be important in the interpretation of observed biologic and psychologic effects. (No refs.)

75-233


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 together with different levels of body reaction. The steady state heat diffusion equation became nonlinear when body reaction was taken into consideration. The geometry of a cylindrical layer of skin enclosing fat and muscle in suitable models was then considered. Temperature profiles were again presented for these models and for different frequencies, exposure levels, skin and fat thicknesses, blood circulation rates, and levels of body reactions. It is concluded that the results
should serve as a more accurate guide for suitable exposures for such treatments. (No refs.)

75-234


Anesthetized rats and mice were exposed to plane-wave microwaves of 100 mW/cm² 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 higher temperatures at 710 MHz. Comparing the temperature changes across the groups of subjects of different size, an interaction of frequency and size was found. At 710 MHz, a general inverse relation between temperature increase and body size was evident. At 710 MHz, the rank ordering was reversed, indicating a direct relation between temperature increase and the body size of the respective subjects. These colonic temperature changes are suggestive of differential absorption, which is complexly determined by frequency, E-field orientation, and the dimensions of the experimental subject. (No refs.)

75-236


The ability of low level 2450 MHz continuous wave microwave energy to generate avoidance behavior in the male mouse (30-36 g) was investigated. Subjects were irradiated in an environmentally controlled waveguide assembly at incident power levels of 0.8, 1.6, 2.4, 3.2, 4.0, and 4.8 W. At 1.6 W and higher, 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 1.6 W, and this decreased with increasing power to an asymptote of approximately 30% 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 positioning within the waveguide assembly. The data suggest that the subjects were capable of detecting average dose rates of as little as 28 mW/kg. Furthermore, this level of irradiation, while not producing core temperature increases of more than 0.5°C, was aversive and caused the animal to actively try to avoid the microwave radiation. (No refs.)

75-237


To study the effect of cataractogenic doses of microwave radiation on lenticular transport, the influx of L-ascorbic acid (C-14 labelling) into uninjured 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 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 (O₂ uptake/protein/min). Exposure did not affect the ability to complete either the sexual or asexual life cycle. Experiments seeking thresholds have found no significant mitotic delay in cultures exposed to 0.4, 0.6, 0.15 V/m 15 Hz fields. Experiments are in progress to determine whether these effects are due to electric, magnetic, or a combination of fields. (No refs.)
found to be the same for irradiated and unirradiated pairs. Further, the rate of influx was too slow for transport to be responsible for the early decrease in the lenticular concentration of ascorbic acid after microwave irradiation. In another experiment, using similar procedures, the transport of 3-O-methyl D-glucose, a nonmetabolized D-glucose transport analog, and thymidine was studied. Microwave radiation was found to cause changes in the rate of influx. These changes, however, occurred a significant time after irradiation. (No refs.)

75-2-38

4652 EFFECTS OF 35 AND 107 GHz MICROWAVES ON THE RABBIT EYE (PROCEEDINGS ABSTRACT).

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 disorganization 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 microwave incidence thresholds for immediate injury following an acute exposure. It is concluded that thresholds for chronic low level exposure cannot be deduced from these results but require additional work. (No refs.)

75-2-40

4654 EFFECTS OF MICROWAVE RADIATION ON HUMA-
LIAN CELLS IN VITRO (PROCEEDINGS ABSTRACT).

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

75-2-41

4655 EVALUATION OF DOMINANT LETAL TEST AND DNA STUDIES IN MEASURING MUTAGENICITY
CAUSED BY NON-IONIZING RADIATION (PROCEEDINGS AB-
STRUCT).
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/cm² for 30 min, and in the second experiment, the mice were exposed to 1.7 GHz, 10 mW/cm² for 80 min. In the first experiment of the DNA studies, the mice were exposed to 1.7 GHz, 50 mW/cm² for 30 min; in the second, 1.7 GHz, 10 mW/cm² for 80 min; and in the third, 0.985 GHz, 10 mW/cm² for 80 min. In the dominant lethal test, mice exposed to 1.7 GHz, 50 mW/cm² 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 base 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/cm² 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.)


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 VSIR 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 circuity. 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 positions. Based on 1 W input (average incident power density of 3 mW/cm²) 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 Rf, the mean absorbed power was 0.43 mW with a standard deviation of ± 0.07 mW. (No refs.)


Low level electromagnetic fields, amplitude modulated at brain wave frequencies, have been shown to influence the thresholded 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 in the surface macromolecules or by inducing small displacements of the surface-bound cations. This study examined the theoretical 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.)


The effects of microwave irradiation on the hormonal activities of rat pituitary glands were studied. Twelve 30-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/cm²). 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 aceton. 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 lutetinizing hormone (LH). NIH-FSH-57, NIH-LH-S15, and NIH-GH-5 were used as standards. The following quantities of hormones were found in yg/pituitary (x ± S.D. ± S.E.): (I) In irradiated rats - FSH: 655 ± 123 ± 50; LH: 302 ± 81 ± 33; GH: 140 ± 17 ± 11; (II) In control rats - FSH: 635 ± 84 ± 33; LH: 157 ± 34 ± 14; GH: 134 ± 41 ± 13. The amount of LH was significantly higher (at p < 0.05) in the pituitary gland of irradiated than of control rats. The results of this investigation support the findings of a previous study about the possible shifts of gonadotropic activities in pituitary gland of rats exposed to microwave radiation. (No refs.)

75-2-45


The effect of high power microwave pulses on zebra fish embryos was studied. Microwave pulses with electric field strengths between 5 and 15 kV/m 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 be responsible for damage in osmotic pressure. Low frequency data on electrically-induced bleb formation in blood plasma are presented. (No refs.)

75-2-46


The electromagnetic field perturbation technique was used to calculate the total absorbed power of monkey and human spheroidal and ellipsoid phosphorus in a near-placenta 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 placental impedance of 377 ohms, a theoretic technique was developed in which the power absorbed in the placenta spheroid phantom was calculated. This method gave the power absorbed in an irradiation field in which the E/H impedance ratio was not necessarily accurate to 377 ohms. Calculated data for power absorbed by monkey and human phantoms from 10 MHz to 50 MHz are presented and discussed. For the monkey phantoms, data are given for the three principal polarizations: electric, magnetic, and cross, but for the human phantom, data are given only for magnetic and cross polarization because the phantom was too long to allow measurements with electric polarization. (No refs.)

76-71


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 2550 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 no significant differences between the damage caused by the microwave 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.)
at 60 Hz. These fields produced a similar effect but an intermediate dose-survival curve resulted, \( D_0 = 194 \pm 24 \text{ rads}, n = 2.6 \). The HF seemed to modify the combined action of IA and x-rays on the tumor cells. No synergistic action of the HF with x-rays was found; however, the results indicate that magnetic fields may distort radiation sensitivity of cells under certain conditions. (No refs.)

76-217

4663 METABOLIC RATES IN FIVE ANIMAL POPULATIONS AFTER PROLONGED EXPOSURE TO WEAK EXTREME LOW FREQUENCY ELECTROMAGNETIC FIELDS IN NATURE.

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 Lumbriculus variegatus Hoffmeister; slug Arian 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 D\(_2\)O consumption and RQ, except for a marginal difference (0.05 > p > 0.025) in D\(_2\)O consumption of L. variegatus; 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 changes in sensitivity to the electromagnetic fields. Controls showed an annual increase in metabolic rate of wood louse and salamanders. In an experiment to determine the factors of animal transport on the metabolic rate, it was found that oxygen consumption of wood louse was significantly (p < 0.05) affected by method of shipment. There was no evidence, however, that exposed and control animals reacted differently from each other to shipment by air or by car. It was also found that short-term (1 wk) exposure of earthworms to the electromagnetic fields did not alter metabolic rate; however, confinement in nylon bags and translocation did, thereby limiting meaningful conclusions. No abnormalities in behavior, habitat selection, or external features, and pigmentation have been observed in any of the exposed populations during 4 yr of collecting and observation. (22 refs.)

75-249


Simple rectal temperature measurements in rats exposed to strong magnetic fields (40 amp meter-1) at 19 MHz in the USAF/AM 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 Hz 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 Hz with a field impedance of 337 ohms, in the near field synthesizer with field impedances of 1000 ohms and 1000 ohms, as well as at 1600 Hz with field impedances of 337 ohms. It was found that eddy current-induced heating at 19 Hz varied with the aspect to the field and that, even in a uniform ellipsoid, distinctly non-uniform heating patterns were produced in electric and magnetic fields. (No refs.)

75-775


Proposed mechanisms of the human auditory system response to lower power densities, 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 psychophysical data. Several alternate possibilities were then considered that were consistent with the body of experimental data. For each, the site specific physical phenomena, which may explain the energy-biologic tissue interaction, are discussed, and experimentation, which should provide an understanding of the RF sound mechanism, is suggested. (No refs.)

76-74


A case is described in which infarction of a fallopian tube occurred after tubal diathermy in a 38-year-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 infarcted end of the right fallopian tube was black and infarcted distal to the distal mesentery. 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 salpingectomy was performed to prevent a similar occurrence in the opposite tube. Signs of paralytic ileus developed postoperatively but resolved within 48 hr with nasogastric suction and intravenous fluids. Histology confirmed that the tube was hemorrhagic and infarcted at the fimbriated end. No other abnormality was noted. This case is the first of its kind to be reported in the literature. (No refs.)

76-75


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/cm²) for 60 min, 3 times/day at 5 day/week intervals for 4 mo. Changes in the respiratory process during brain mitochondrial oxidation of succinate and a-ketoglutarate were observed. The changes included reductions in the rates of phosphorylative respiration and AOP phosphorylation (at 50 mW/cm² and higher for α-ketoglutarate and at 50 mW/cm² and higher for succinate), an increased respiratory quotient, and a decrease in respiratory control values (at 25 mW/cm² and higher for both substrates). A mechanism of oxaloacetic acid inhibition of phosphorylation was observed. No decrease in the AOP/D ratio was noted during succinate oxidation, but decreases in this ratio during α-ketoglutarate oxidation (at 50 mW/cm² and higher) indicated damage to the respiratory chain at the lipase-NAD flavoprotein section. Since power flux densities of 10 mW/cm² were without effect, this value should be considered in the design and production of apparatus using microwave radiation of a 12 cm wavelength. (4 refs.)

76-76


Forty-two male rats were exposed to superhigh frequency radiation (wavelength = 12 cm, vertically polarized waves) of various power flux densities (10, 25, 50, 100, 500, 1000 mW/cm²) for 60 min, 3 times/day at 5 day/week intervals for 4 mo. Densities of less than 50 mW/cm² had no effect, but respiratory processes in the liver mitochondria were altered during nonsuphorylative respiration at densities of 50 mW/cm² and higher, and then during phosphorylative respiration at densities of 100 mW/cm² 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 radiosensitive and was associated with greater values of ADP phosphorylation than that α-ketoglutarate oxidation. Apparently there was a block in the respiratory chain substrate NAD+/flavoprotein + cytochrome Q to flavoproteins, the pathway for α-ketoglutarate oxidation. These results should be considered in the development of superhigh frequency apparatus. (4 refs.)

75-75
A formula for determining the power flux density of microwave radiation is proposed. Examples of the applied calculation methods based on this formula indicate their simplicity and the close correlation of their results with those of instrumental measurements. The calculation methods are recommended for use in the hygienic supervision of the radiation effect from radio-location stations on the surrounding area and population. (No refs.)

76-77
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 insomnia were then conducted to determine the effects of electronic noise and of a constant homogeneous magnetic field, with results evaluated on the basis of changes in skin electroconductivity (SEC), skin electroresistance (SER), and subjective and objective descriptions of alertness. Tests on 21 neurotics revealed no significant differences between the effects of 1 hr of electronic noise superimposed on a constant uniform component or an impulse current superimposed on a constant uniform component, but both caused significant reductions in alertness and SEC in comparison with placebo control tests. When pure electronic noise (1 ef = 5 mA) was applied to a group of 23 neurotics, its effects were significantly greater than those of both the other tests. Longitudinal analysis (treatment every other day for 3 wk) in 10 patients showed that superimposed electronic noise caused a significant reduction in alertness and increase in SER compared with controls. In 59 neurotics, the head was placed in the center of a constant homogeneous magnetic field (0.73 Gc) for 2 hr. SER increased in 50 neurotics, decreased in 8, and remained unchanged in 1, while in control experiments it increased in 21, decreased in 35, and was unchanged in 3. The results indicate that electronic noise and a constant homogeneous magnetic field have a tranquilizing effect and may be of value in the treatment of insomnia and neurosis. (43 refs.)

76-78
A graphic method was used to determine the boundaries of hazardous regions caused by powerful microwave radiation. The peak and mean power radiated, the size and gain of the antenna were used in these determinations. The "biological hazard region" (10 W/m² mean power) and the "ignition hazard region" (3000 W/m² peak power, f=frequency in GHz) were found first by a theoretical 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 apertures are presented. For circular apertures it was necessary to determine the power flux in a near-field and a far-field region. For elliptical or rectangular apertures, the area 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 communication installation and a radar height finder. Methods of avoiding hazards were also considered. (9 refs.)

76-79
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 were observed for 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. Cho-
lesterol and triglyceride levels of subjects exposed
to both electric and magnetic fields did not fluctu-
ate from the norm. Electrocardiograms and electro-
encephalograms of subjects exposed to the electromagnet-
ic fields also remained normal as did arterial blood
pressure. In addition, no subject expressed any sub-
jective discomfort. The effects of exposure to the
above fields for periods lasting up to 3 hr seemed to
be limited to a stimulation effect and a nonspecific
excitation effect, neither of which was pathologic.
(9 refs.)

76-80

4675 MORPHOFUNCTIONAL STATUS OF THE HYPOPHYSE-
GONADAL SYSTEM DURING EXPOSURE OF THE ORGA-
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magnetic field (7 kHz, 72 kA/m, pulse duration 1.3
msec, pulse interval 10 sec) (Group 1) and the
electric component of high-frequency electromagnetic
field (41 Hz, 1 kV/m) (Group 2) on the hypophysego-
 nadal function of male albino rats was studied. Ex-
posure of Group 1 to the pulsed electromagnetic field
over 3 hr each for 15 days had a direct effect on Ley-
dig cells, and caused a sharp depression of the andro-
genic function of the testicles. The testosterone level
in the blood draining the testicles dropped from
1.23±0.35 μg/L to 0.23±0.01 μg/L 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 se-
cretion and release of gonadotropins. The total go-
 nadotropin level in the pituitary gland decreased.
The findings indicate that pulsed and high-frequency
emagnetic fields directly affect Leydig cells
resulting in a reduction of the blood androgen
level, which provokes intensified gonadotropin secre-
tion and release in the pituitary gland. (6 refs.)

76-81

4676 PROLONGED EFFECT OF A CONSTANT AND ALTERNA-
TING MAGNETIC FIELD OF 1,000 OERSTED ON THE
MITOTIC ACTIVITY. (Russ.) Strakhovskova, A. D. (No
affiliation given); Galaktionova, G. V. Kozm. Biol.

The prolonged effect of permanent magnetic field of
1,000 Oe on the mitotic activity of cells of the cor-
neal epithelium and of bone marrow cells was studied
in C57B1 mice. Exposure to the permanent magnetic
field over a 15-day period caused an increased decrease
in the mitotic activity of epithelial and bone marrow
cells, which was followed by increased mitotic activi-
ity and hyperregeneration. The cell count of the tis-
sues showed only slight changes, and it rapidly norm-
alized after the field was switched off. Daily alter-
nation of the field direction with respect to the
body position of the animals caused no additional
changes in the mitotic 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 chromo-
somal aberrations, which indicates the absence of
mutagenic effect. (6 refs.)

76-82

4677 EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON
LIVING ORGANISMS AND IN PARTICULAR ON MAN:
GENERAL REVIEW OF THE LITERATURE. (Eng.) Cabanes, J.
(International Association on Occupational Medicine).
Rev. Gen. Electrostat. (Janvier Speciale) 82: 19-26; 16

The literature dealing with the effects of low fre-
quency (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 kW substi-
tions revealed neurologic, cardiovascular, and digesti-
ve disturbances. However, studies in the United
States involving the repetitive exposure of linemen
working on 345 kW high voltage lines failed to re-
veal 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. Stud-
ies 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 fre-
quency. Contradictory results have also been reported
for studies involving the effects of low fre-
quency 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 proce-
dures and reporting in some instances, and the use of
an insufficient number of subjects in other cases.
(No refs.)

76-83

4678 THE EFFECT OF A DISCHARGE OF A HIGH-VOLTAGE
CONDENSER ON THE OPTIC PROPERTIES OF THE
FROG CARDIAC MUSCLE. (Russ.) Arleevsky, I. P. (Kazan
Advanced Training Medical Inst., Kazan, USSR); Bezug-
81(5): 531-533; 1976

A high-voltage condenser discharge, with a duration
of 3-5 nsec, 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 lumi-
nescence was 15-100 nsec at a discharge voltage of 500
V and 100-350 nsec at 1,000 V. The increase in the
light flux under the effect of high-voltage discharge
CURRENT LITERATURE

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

76-84


General physical and therapeutic characteristics of magnetic field therapy, which employ 'Jonomodulator' and 'Eictherm' apparatus, are described. Magnetic field therapy experiments, in which the patient is located inside a magnetic coil, have not been proven therapeutically valuable. Dynamical 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 'Eictherm' apparatus, including a combination of light orange and UV light sources, is used in the treatment of cervical and lumbar syndromes. (No refs.)

76-85

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

The catecholamine and dioxophenylalanine 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 dioxophenylalanine 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 decreased epinephrine levels in the adrenals. The catecholamine levels dropped both in the blood and the adrenals in a third phase. Normalization of the hormone levels was observed 14 days after exposure. The findings illustrate the powerful stress effect of alternating magnetic field on the neuroendocrine system. (16 refs.)

76-86


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 disintegration and destruction of normal tissue has not been observed in over 20 inoperable cases of cancer that were treated with dielectric radiofrequency heating and immunotherapy. (5 refs.)

76-87


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 regeneration of the corneal epithelium decreased with increasing duration of the exposure. No increase was observed in the number of aberrant mitoses in the cells of the corneal epithelium under the effect of the permanent magnetic field. The findings indicate the possibility of the therapeutic use of permanent magnetic fields. (7 refs.)

75-257


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-
traplate to human beings. Among populations of working people exposed to microwave fields there is a wealth of clinical opportunity for research, but the problem is, as always, what to look for. Much work has been concentrated on discovering the threshold of specific macroscopic damage to discrete organs such as the formation of cataracts in eye lenses. It was upon such work that the present 10 mW/cm² safety level has been based. The Russian standards, which are not based on such heating effects, cause much heart-searching among occupational health physicians. Instead of seeking gross pathologic changes resulting from microwave exposure, we should be on guard against the occurrence of more subtle effects, which detract from industrial comfort or an individual's efficiency. For instance, recent work has shown that protracted exposure to low power microwave fields can cause small vacuole formation and abnormal striation in the eye lens. While this causes no discernible opacity, it would cause impairment of the lens elasticity. The focusing capacity is therefore impaired, and the usual onset of presbyopia in middle life occurs at an earlier age. Investigations into changes of this degree in human populations are advocated, and preventive measures are discussed.

75-254


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

76-89


Transcerebral electrotherapy (TCET) was tested for its ability to relieve anxiety in 24 (23 men and 1 woman, aged 21-59 yr) psychiatric inpatients. Subjects completed the State Anxiety Inventory (SAI). On the basis of the Harvard Group Scale of Hypnotic Susceptibility scores the patients were assigned to a high or low suggestibility group (12/group). These subjects were again assigned to an active TCET or placebo condition (6/group). The TCET group received a burst of current at a rate of 100 Hz/sec with a width of 2 msec for 30 min for five sessions on consecutive days. Controls received no electrical stimulation other than that delivered at an initial adjustment and 15 min readjustment period. Six to nine days following the last treatment each subject again completed the SAI. These scores indicated that for the low and high suggestibility groups the pre- and post-scores changed from 58.33 to 43.50 and from 57.66 to 50.66 respectively. Subjects in the active TCET condition showed significantly greater anxiety reduction than the control group (p < 0.01, F=8.26). There was no overall effect of suggestibility, nor was there a significant interaction between suggestibility and type of treatment (p=0.10, F=2.85). Likewise there was no differential response between the low- and high-suggestible control subjects (F=1). (14 refs.)

75-254


The criteria for design and performance of a facility utilized for studying microwave biologic effects in rats weighing up to 500 g were investigated. The results of using a 1.2 x 1.2 x 1.2 m semi-enclosed anechoic exposure chamber including field measurement techniques, material selection, environmental control, and biologic experimental design are discussed, with an analysis of the problems encountered in its use. The problems were related to certain biologic parameters studied in a finite experiment dealing primarily with environmental control, field measurements, and the simultaneous use of several subjects in the enclosure. Using the same basic design and performance criteria as the first experimental chamber, a second larger and more sophisticated semi-enclosed anechoic chamber, 1.8 x 1.8 x 1.8 m in size was constructed. This chamber addressed environmental control and microwave field parameters at its inception. Absolute requirements included: (1) a 2450 MHz microwave reference field located in the far field of a 15 dB standard gain horn showing no greater than 1.0 dB variation over a 100 cm² working area; (2) an absolute temperature control of the environment where the experimental animals were located, in a range of 12.5 to 45°C, and control of the air temperature at each selected control point; and (3) a uniform air flow over the experimental animals with provision for dumping chamber air rather than recirculating it. Using the NBS XD-1 and EMD-IC microwave sensors, the field pattern alterations induced by polyurethane foam products used in the construction of animal enclosures was studied along with a standardized
method of measuring exposure levels. Using analogous techniques, field amplitude patterns around single and multiple experimental animals were derived along with energy absorption estimates made from standing wave patterns created by the animals. (No refs.)

75-255


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

75-256


Experimental results are described for whole-body absorption of a series of saline-filled and biologic-phantom figurines of major lengths (L) that varied from 0.4 to 1.5 L. Measurements are also reported of parameter values (ratio of mV/kg of absorbed energy to mW/cm² of incident field energy) for different regions of the body. The energy distribution was measured for 12.1 and 18.4 cm tall figurines under free space irradiation at both 285 and 2450 MHz using the liquid crystal temperature probe. These results were compared to those obtained in the transverse electromagnetic mode parallel plate chamber, namely, of whole-body values for the 220-750 MHz frequency range with 12.1 and 18.4 saline-filled figurines and prolate spheroids of a/b=6. The highest intensity of energy deposition was observed for the neck region of the body in both free space and parallel plate exposure conditions. The for the neck region was approximately 30 times that observed for the whole-body average. The values for other parts of the body, in descending order of magnitude, were reported for the thighs, shins, chest, pudendal region, and the eye region. For figurines with the feet touching the ground plate of the parallel-plate chamber, maximum energy deposition was observed for the shins, with w=12 at 240 MHz (Lx = 0.15). A monopole-above-ground chamber is presently under construction to permit assessment of ground effects and measurements of w values. (No refs.)

75-257


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

76-89

The impact of microwave radiation on the human body is discussed. Human exposure limits regarded as safe are 0.03 W/cm² for frequencies below 0.5 GHz and 0.02 W/cm² at frequencies higher than 3 GHz. An examination of the absorption of microwave energy by various human tissues in the frequency range of 0.15-30 GHz reveals that at 0.15 GHz the penetration is much deeper; whereas, at 10 GHz the energy is absorbed in or near the skin. Parts of the body that do not have blood vessels (chambers of the eye and the hollow viscera) are particularly vulnerable to electromagnetic radiation because the heat can dissipate only by conduction to the surrounding vascular tissues. A case of bilateral cataracts has been reported for a person subjected to an intermittent exposure of about 0.005 W/cm² at 1.7-3.4 GHz for 3 days and to a level of 0.12 W/cm² for a total of 2 hr. Precautions for avoiding the hazards associated with occupational exposure to electromagnetic radiation include increasing the height of microwave antennae, the use of reflective clothes and protective goggles, and field strength monitoring in potential exposure areas. (6 refs.)

76-90

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

75-258

The biologic consequences of exposure to electromagnetic fields below frequencies of 30 MHz are reviewed. Data obtained from triple-layer models of the human body indicated that electromagnetic absorption increased linearly with frequency in the region below 100 MHz. Differences in absorption for the various chinoesises typical of the human body were insignificant in the radiofrequency region, and calculations indicated an absorption of about 15% at 30 MHz. It is suggested that personnel working with electromagnetic pulse simulators be restricted to 1440 pulses over any 6-min period; 1 pulse/min produces a power density of 0.044 mW/cm², which is about 1/200 of the acceptable dose. The increase in body temperature for such exposures is estimated at 0.00009°C. Since the threshold of temperature increase sensation on the surface receptors of humans is about 0.05°C, the thermal effects produced in humans by electromagnetic pulses are probably incapable of even generating sensations of warmth. Biologic effects of nonthermal origin resulting from human exposure to electromagnetic fields below 30 MHz include: vascular conditioned reflexes (static frequency, field intensity of 10,000 V/m); diurnal rhythmical (10 Hz, 2.5 V/m); brachycardia (static, 2600 V/m); changes in reaction time (less than 12 Hz, about 2 V/m), and interference with cardiac pacemakers (0.5-1.0 Hz or 10-30 Hz at high-frequency communications levels for the latter frequency range). (39 refs.)

76-91
4693 A MICROWAVE APPLICATOR FOR IN VIVO RAPID INACTIVATION OF ENZYMES IN THE CENTRAL NERVOUS SYSTEM. (Eng.) Lenox, R. H. (Dept. Neuroendocrinology, Div. Neuropsychiatry, Walter Reed Army Inst. Res., Washington, DC 20012); Gandhi, G. P.; Meyerhoff, J. L.; Grove, H. M. Appl., 1976 (available through Inst. of Electrical and Electronics Engineers, Inc., New York, N.Y., No. 601MT1014). A microwave applicator for the in vivo rapid inactivation of rat brain enzymes is described. The applicator includes a WR 430 waveguide test cell and a 2450 MHz pulsed power source that delivers 3.5 kW of microwave power, which is matched to the coaxial load (rat's head) by a double screw tuner. The rat is placed in a Plexiglas tube, which is wrapped with copper screening that acts as a cylindrical waveguide, and the shielded tube is inserted into the waveguide chamber. Uniformity of fields along the width of the waveguide (ear to ear of the animal) is obtained as a result of the symmetrical dielectric loading achieved with the rat head in that dimension. Improved uniformity of heating the brain is achieved in the rostral to caudal dimensions by attaching tapered aluminum shields to the broad faces of the waveguide. In the vertical plane, a slight heating gradient exists that apparently is due to the overheating of the abundant muscle on the ventral side of the brain. The exposure time required for enzyme inactivation is 2.8 sec. Measurements of cyclic adenosine monophosphate in the microwave-treated brain indicate rapid enzyme inactivation and the prevention of post-mortem changes in enzyme activity associated with more conventional methods of sacrifice. Measurements of cyclic adenosine monophosphate and cyclic guanosine monophosphate have been made in 13 distinct re-
CURRENT LITERATURE


The effects of small electrical currents on soluble collagen solutions made up from rat tail tendon were investigated. When a direct current of 15 μA was passed through a 400 μg/ml collagen solution (pH 6.60) via vertically placed stainless steel electrodes, a brown-colored interface denoting a boundary between two regions of apparently differing viscosity was observed. On the cathode side of the band, the solution appeared more viscous, indicating the presence of collagen. The phenomenon appeared to be one of collagen molecule aggregation rather than polymerization, and electron micrographs of the viscous band revealed no fibers. The passage of a 10-μA direct current through a 160 μg/ml collagen solution (pH 4.70) via vertically placed stainless steel wire electrodes did not produce a band-like structure, and there was no evidence of collagen molecule aggregation. When a 5-μA direct current was passed through an 80-μg/ml collagen solution (pH 6.50) via horizontal platinum electrodes, polymerization of the collagen molecules into well-characterized fibers was observed in the form of a whitish band that formed concave to the cathode in a horizontal plane. Thus, different effects were observed for different current gradients and different collagen solutions. (8 refs.)


The cerebral electric activity was studied in 76 menopausal women before, after 5, 10, 15, 20 and 35 pulse current treatment sessions, and 4-6 mo after the treatment. The current intensity was 0.5-0.8 mA, at a frequency of 300-600 Hz, and a pulse duration of 0.5 msec. The current contained an additional galvanic component. The electrodes were placed in the frontal-striatal region. The pulse current therapy resulted in an improvement of the general well-being, in normalization of the arterial pressure, reduced irritability, and disappearance of congestion. Normalization of the electroencephalogram (EEG) was observed in most abnormal cases. Regardless of the original EEG pattern before the therapy, the pulse current treatment caused steretotypical changes in the EEG; appearance of alpha-waves when

they had been absent, increase in the alpha-wave amplitude and duration, irradiation of the alpha-waves into the temporal regions of the cerebral and its synchronization in all regions. Correlation was established between the clinical improvement and the normalization of the EEG. The therapeutic effect of pulse current on menopausal symptoms is thought to be due to its direct action on the neuroendocrine and vascular systems. (15 refs.)


Periodic medical examination data and absenteeism rates were analyzed for 84 workers exposed to electric fields at transformer stations or near high voltage lines (up to 400 kV) and 9 women working on low voltage overhead lines. The first group showed a higher incidence of digestive, nervous, and locomotor system disorders; however, differences in the working habits of these two groups might also explain the different rates. Absenteeism due to illness was greater for the second group, thus confirming the significance of the above findings. It is concluded that electromagnetic fields caused no lasting pathologic effects in the workers, since no biochemical changes were observed. (No refs.)


The effects of high voltage electric field exposures on experimental animals were investigated. Anesthetized rabbits were exposed to 60 kV/m electric fields at a frequency of 50 Hz for periods varying from a few minutes to about 500 hr. No significant alterations in cardiac output, heart rate, or arterial blood pressure during acute exposures were observed, although the last cardiovascular parameter tended to be elevated in animals receiving chronic exposures. Increases in heart rate were observed in a conscious dog exposed to 25 kV/m during the first 10 sec after a change in electric field. Slight changes in the total and differential white cell count were observed in rats and dogs exposed to electric fields of 100 and 25 kV/m, respectively; the dogs also showed a fall in hemoglobin concentration and red cell count. Male rats exposed to an electric field of 100 kV/m for acute exposures of 30 min/day and chronic exposures of 8 hr/day over a total period corresponding to the complete maturation cycle of the germ cells showed no change in gonadal function; however, diminished libido was observed during acute exposures. No embryotoxic or teratogenic effects were observed in the first generation progeny of male rats subjected to acute (30 min/day) or chronic (8 hr/day) exposures of 100 kV/m. Likewise, no changes in the macro- or microscopic structure of the liver, kid-
exposure. The changes in the enzyme activity were dependent on field intensity, exposure time, and the specific anatomical sites. (10 refs.)

76-96


The effect of magnetic and electric fields on the mutation rate and growth of the bacterium Escherichia coli and the fungus Penicillium chrysogenum was investigated. Electric fields ranging from 10-200 kV/m were generated between two circular metal plates situated in an incubator. The magnetic field experiments involved exposing the above microorganisms to 50-hz alternating magnetic fields ranging from 10-350 times the earth’s magnetic field. The exposure time was 24 hr. A higher mutation rate was observed in the case of the above organisms compared to changes during exposure to magnetic or electric fields, even at the maximum dosages applied. (No refs.)

76-97


Results from experiments investigating the effects of high voltage fields on humans and animals are reviewed. Studies in the Soviet Union on 319 men working in 220, 330, and 500 kV switchyards revealed no specific central nervous system disturbances. Similar observations were reported from Spain where 8 or 9 switchyard workers were transferred to a new 500 kV station and several of them complained of headaches, drowsiness, fatigue, and nausea. In contrast, a review of seven studies performed in the U.S. and Western Europe reveals no adverse effects in humans exposed to fields as high as 20 kV/m (50 Hz) for 45 min. These studies also revealed no adverse effects in humans exposed to 60 Hz fields from 755 kV lines. Laboratory studies with animals involving exposures as high as 160 kV/m (60 Hz) over 1500 hr also have revealed no adverse effects. However, the progeny of mice exposed to the above field strength showed a slightly slower growth rate than controls, which could have been due to differences in weather availability and temperature. Research in the U.S. and Western Europe has not reproduced the adverse effects noted in Soviet and Spanish studies. (19 refs.)

76-100

The effect of cardioversion, using a 4,700 V defibrillator, on the indices of central hemodynamics was studied in 23 patients with left atrial fibrillation. The patients were administered phenobarbital and anesthetized with hexanal. The minute volume showed no change 25-30 min after the restoration of the sinus rhythm. However, the frequency of the cardiac contractions decreased and the systolic volume increased after cardioversion. The reduction in the Sonnenblick-fergut contractility indices was believed to be due to the adverse effect of the electro discharge on the myocardium, and partly to the hexanal anesthesia. (18 refs.)

75-259


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

76-101


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

76-102

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

The effect of electrical stimulation (100 V and 5 mA maximum) on protein synthesis in skeletal muscle cell cultures established from 12- to 13-day embryonic chick breast muscle was investigated. When the muscle cultures were 4-5 days old, they were stimulated for 15-48 hr with a 0.6-sec train of 10- to 15-msec biphasic pulses delivered every 4 sec by way of agar saline bridges. The quantity of protein extracted from the cultures with pyrophosphate buffer was increased by a mean of 21% over that of unstimulated control cultures, and the amount of radioactive leucine in myosin heavy chain protein was increased by a mean of 39% over controls. A 25% increase in the pyrophosphate-extractable protein as compared with only a 7% increase in total cellular protein indicated that the electrical stimulation affected greater on contractile proteins, such as myosin. A comparison of the deoxyribonucleic acid content of stimulated and nonstimulated cultures revealed that the protein enhancement in stimulated cultures was due to increased protein synthesis rather than cell proliferation. Thus, direct electrical stimulation of the contraction of skeletal muscle cells in vitro enhances the amount of protein produced by myotubes, and this increase is greater for the contractile proteins. (26 refs.)

76-103


Transient electric birefringence measurements on poly (L-lysine hydrobromide) in methanol-water mixtures were carried out at various solvent compositions in the vicinity of the helix-coil transition region (from 87 to 98 vol % methanol). The electric field was applied to the solution in a Kerr cell in the form of single rectangular pulses of up to 6 kV amplitude. Anomalous birefringence transients were observed between 50 and 95 vol % methanol above a threshold field strength. A distinct difference between the responses to weak and strong electric fields was noticed over a narrow range of the solvent composition. The effects of polymer concentration and temperature on the field-strength dependence of the birefringence were studied at a solvent composition of 90 vol % methanol where the anomalous transients
appeared most clearly. The double logarithmic plots of the steady-state specific birefringence versus the square of field strength for different concentrations and temperatures could be superimposed by shifting them horizontally along the abscissa. The threshold field strength, which was determined from the shift factor, decreased with decreasing concentration. The results provide further evidence that strong electric fields can cause a helix-coil transition in this system under favorable conditions. (17 refs.)

76-109


The tensor integral equation was used to calculate the induced electric field inside a biologic body illuminated by a simple plane wave. Simulated biologic bodies made of plexiglas were filled with saline and put into an anechoic chamber and illuminated by electromagnetic waves with frequencies ranging from 1.7-3.1 GHz radiated from a horn antenna. The induced electric field inside the solution was measured by a dipole-type probe loaded with a microwave detector diode at the terminal. Model sizes were 6x6x1 cm, 12x12x1 cm, 16x16x1 cm, and 12x12x2 cm. Results of the theoretic and experimental values of the dissipated power (DP) are presented graphically. The distribution of the DP was shown to change significantly when frequency, conductivity and permeability changed only slightly. In the model 2 cm deep (two 1 cm layers) the DP in the first layer was several decibels higher than that in the second layer, as was theoretically predicted. The patterns of the DP indicated the complexity of the induced field in the models. (10 refs.)

76-105


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

76-106


The dielectric constant (ε), conductivity (σ), and penetration depth (ρ) of millimeter waves in fat and muscle tissue were measured over the frequency bands 40-54 GHz and 85-90 GHz. Fat from recently slaughtered cattle, and muscle tissue from Sprague-Dawley rats, were used for measurements. The measured σ of fat at 40-54 GHz and 85-90 GHz ranged from approximately 1.8-2.5 cm (peak at 55 GHz) and from approximately 1.2-1.3 mm (peak at 90 GHz), respectively. The σ for muscle in the two frequency bands ranged from approximately 0.4 to 0.27 nm (peak at 40 GHz) and from approximately 0.22 to 0.21 nm (peak at 85 GHz). A phase-lock technique was used to determine the relative ε and σ for the tissues. A substantial shift in the characteristic of fat was determined by these values. The initial values for ε and σ increased from 8.4 and 15 m−1 m−1 respectively, for about 1.5 hr, after which they shifted downward to 4 and 7 m−1 m−1. This shift did not seem to be affected by temperature. The results indicate that millimeter wave irradiation of human body tissue similar to that investigated has to be considered for microwave hazard studies. (11 refs.)

76-107


The use of pulsed electromagnetic fields for peripheral nerve and spinal cord regeneration in laboratory animals was investigated. The apparatus used was a diapulse machine that is capable of delivering field strengths of from 5-120 mV/cm. In the form of 65-microsec pulses over frequencies of 80-600 pulses/sec. Peripheral nerve section and suture (median-ulnar nerve in the upper forelimb) was performed on 132 rats, and postoperatively half of the rats were treated for 15 min/day with diapulse therapy (dosage not given). The diapulse-treated animals demonstrated a return of nerve conduction 12 days after division and suture of the nerve, although a 10-fold increase in stimulus strength (0.5-5.0 V) was required for the response. No responses to the 5.0-V stimulation were observed in control animals. Histologic sections distal to the point of suture in the treated animals 30 days after surgery showed
that the nerve contained abundant regenerating nerve fibers but of reduced diameter. Comparable sections from untreated animals 60 days after division and suture also showed regeneration, but the degree of recovery was not as great as that in treated animals at 30 days postoperative. Studies of spinal cord regeneration following hemi section in cats were also performed. Exposures to diapulse therapy were for 0.5 hr each day for 1 mo using an average field strength of 50 mV/cm² and a frequency of 400 pulses/sec. When the animals were sacrificed 3 mo after hemi section, electromagnetic-induced nerve fiber regeneration across the scar region was observed. (6 refs.)

75-260


To investigate the effects of radiofrequency radiation on the central nervous system of rats, power distribution was thermographically determined in rats exposed to 1.6 GHz radiation at a measured power density of 80 mW/cm² for 10 min. Rectal temperature rise was 4°C. Serotonin and its metabolite 5-hydroxyindole acetic acid, dopamine and its metabolite homovanillic acid, and norepinephrine were measured in the hypothalamus, corpus striatum, midbrain, hippocampus, cerebellum, medulla-pons, and cortex. Parallel hyperthermal and normothermal controls were also examined. The hyperthermal controls were maintained in a 75°C environment for 10 min which resulted in a rectal temperature rise of 4°C. A significant decrease in hypothalamic norepinephrine content was noted in the irradiated and hyperthermal groups compared to the normothermal controls. The hippocampal content of serotonin was decreased in the irradiated but not the hyperthermal animals. Conversely, cerebellar and cortical serotonin concentrations were decreased in the hyperthermal but not the irradiated rats. The dopamine content of the corpus striatum was significantly lower in the irradiated group but not in the hyperthermal animals. The decrease in hypothalamic norepinephrine supports other data suggesting that neurotransmitter subserves a neuronal system to lower body temperature. The other changes agree with thermographic imagery of rats exposed to 1.6 GHz radiation. The results indicate that the effects on the neurotransmitters are a result of radiofrequency radiation induced hyperthermia and not a direct effect on innervated tissue. (No refs.)

75-261


Experiments were performed to test the hypothesis that changes in the earth's electromagnetic field can act as a zeitgeber for birds that normally demonstrate pronounced circadian rhythms. Two identical Helmholtz coils were constructed, each containing eight non-magnetic cages arranged symmetrically within the computed field-free space. The birds' activity was monitored with an event recorder. The experiment was conducted in a soundproof room at a constant temperature. Oscillations in background noise from the power supply and recording apparatus were masked by a white noise generator. Eight birds (one bird/cage) were placed in each cell. Each group consisted of four House Sparrows and four Song Sparrows. All birds were entrained to an LD 9:15 cycle. The experimental group was placed on an electromagnetic field 9:15 cycle (3 hr free space; 15 hr earth's electromagnetic field) that coincided with the LD cycle. All birds were maintained at the LD 9:15 cycle. After several weeks, all birds were placed in constant darkness. The electromagnetic field 9:15 cycle was maintained for the experimental group, and all activity was tested for periodicity. (No refs.)
75-263

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

76-108

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