4910 MICROWAVE IRRADIATION, BEHAVIORAL AND OCULAR EFFECTS ON RHESUS MONKEYS (MEETING ABSTRACT). (Eng.) McAfee, R. (Res. Dept., Veterans Admin. Hosp., New Orleans, LA 70146); Cazenavette, L.; Shubert, H.; May, J.; Elder, S. T.; Gordon, R. *Biophys. J.* 17(2): 145a; 1977.

The behavioral and ocular effects of 9.3 GHz pulsed microwave radiation on four adult rhesus monkeys were investigated. The monkeys were trained to lever press for fruit juice from a plastic tube delivered on a 20% variable schedule. During a 20-min session, the monkeys were allowed to respond for 5 min without being irradiated and were then irradiated over the face and eyes when drinking from the plastic tube. Each irradiation session lasted 15 min. The animals were allowed to cease lever pressing and withdraw from the radiation if they so desired. Infrared irradiation sessions were interspersed with microwave sessions for comparison. Although the lever press rate was suppressed as the dose of infrared radiation increased, microwave irradiation up to an intensity of 495 mW/cm^2 for 15 min had no effect on the animal's behavioral response. Ocular effects, such as, lenticular opacity formation, were not seen after 2 yr of observation. (No refs.)

4911 LONG-WAVELENGTH ANALYSIS OF ELECTROMAGNETIC POWER ABSORPTION BY PROLATE SPHEROIDAL AND ELLIPSOIDAL MODELS OF MAN. (Eng.) Massoudi, H. (Ph.D. dissertation, Univ. Utah, 1976) 218 pp.; 1976. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 76-15,57^].

An electromagnetic (EM) field perturbation technique is used to obtain the induced fields and associated power deposition in both prolate spheroidal and ellipsoidal models of man and experimental animals irradiated by an EM plane wave (the wavelength is long compared with the major axis of the spheroid or ellipsoid). Calculations of the power absorbed by both spheroidal and ellipsoidal models of man and animals are given for different frequencies and orientations of the models with respect to the incident field vectors. The results show that the induced fields and the absorbed power in the two models are strong functions of frequency, size, and orientation with respect to the incident EM field vectors. In the ellipsoidal model, for a given plane wave, the strongest absorption was found when the incident electric field vector was parallel to the longest axis and when the incident magnetic field vector was parallel to the shortest axis of the ellipsoid. The validity of the perturbation theory was checked by comparison of the data obtained by it with data obtained from the extended boundary condition method (EBCM) and with data obtained from Mie solutions for spheres. Within the long wavelength range, the data obtained from the perturbation technique were in excellent agreement with those from both the EBCM and the Mie solutions. Comparisons of the calculated data with preliminary experimental data on monkeys also showed good agreement. An investigation of the effects of tissue anisotropy on power absorption in planar and spherical models revealed that marked differences in tissue absorbed power can occur due to tissue anisotropy at frequencies below 10 MHz. The quantitative data from this study are useful for estimating tissue EM power absorption in experimental animals and man and for extrapolating EM induced effects measured in animals to those expected in man. (93 refs.)

4912 BIOLOGICAL RISKS IN THE ELECTROMAGNETIC ENVIRONMENT OF AEROSPACE ACTIVITIES. (Fre.) Martin, A. V. J. (Dept. Development and Technology, European Space Res. Technology Center, Noordwijk, Netherlands). *L'Aeronautique et l' Astronautique* (61): 53-72; 1976.

In the aerospace research environment, personnel are exposed to sources of electromagnetic radiation ranging from 30 kHz to 30 GHz. Equations and graphs are presented that establish the hazard limits for exposure to various types of antennae, telecommunication and radiodiffusion emitters, televisions, and radar present in the aerospace research environment. Damaging effects to humans can be either thermal, consisting of overheating of body tissue; or biological, consisting of biochemical, morphological, genetical, and psychological alterations. Thermal effects only are studied here. The electric macroscopic properties of biologic tissue, such as, muscle, fat, bone, and blood are described. The propagation and absorption of electromagnetic waves in biologic tissue and the transmission and reflection of the waves at the interface, which separates two media of different electromagnetic characteristics, are discussed, and the amount of absorbed energy presented graphically. Values for all parameters involved in tissue-radiation interactions are presented graphically for the frequency range of 25 MHz to 8,500 MHz and for various angles of incidence. (8 refs.)

4913 TWO MICROWAVE BIOLOGICAL EFFECTS EXPERIMENTS: HEART RATE AND MYOTATIC REFLEX OF FROGS. (Eng.) Piontek, G. E. (Ph.D. dissertation, Univ. Michigan, 1976); 109 pp. [available through Xerox University Microfilms, Ann Arbor, MI 48106, Document No. 76-19,217].

To study the effects and mechanisms of action of microwaves and the nervous and cardiovascular system the heart rates of six pithed or anesthetized leopard frogs (*Rana pipiens*) were exposed to 2.45 GHz microwave energy. The heart rate data were reduced to time interval histograms, and separate histograms were obtained for the microwave on and off data. These histograms revealed no consistent changes in heart rate during radiation. The myotatic reflex of frog's gastrocnemius muscle was also studied in 20 frogs irradiated with 1.2 GHz. Alternate 5-min off and on irradiation periods were administered over a total experimental time span of 55 min. In each 5-min period ten reflexes were elicited. The power density was calculated to be about 13 mW/cm^2. The reflex parameters analyzed were the peak reflex tension and the latency to one-half peak reflex tension. The results from the paired t-test indi-

cated that both peak and latency decreased significantly (0.05 level) during microwave exposure. The effects observed are consistent with those expected from heating. Two sham experiments were also performed. These data, when contrasted with the irradiated data, enforce the view that the effects observed were due to the radiation. (52 refs.)

4914 BIOLOGICAL EFFECTS OF HIGH VOLTAGE ELECTRIC FIELDS: BIBLIOGRAPHY AND SURVEY OF ONGOING WORK, 1975. (Eng.) Bridges, J. E. (IIT Res. Inst., Chicago, IL). 320 pp.; 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB 247 455].

A bibliography and survey of ongoing research concerning the biologic effects of electric fields from overhead high-voltage power transmission lines is presented. Approximately 800 citations are noted, some with abstracts, and about 80 ongoing research efforts are identified. The following subject areas are emphasized: the biologic effects of alternating current (AC) power line fields between frequencies of 45-75 Hz, the biologic effects of direct current electrostatic fields, and the influence of AC power line fields and radiofrequency wave fields on patients with implanted cardiac pacemakers. (800 refs.)

4915 PERTURBATION EFFECT OF ANIMAL RESTRAINING MATERIALS ON MICROWAVE EXPOSURE. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Bassen, H. I.; Wu, C.-L. *IEEE Trans. Biomed. Engineering* BME-24(1): 80-83; 1977.

Theoretic and experimental studies of the scattered fields produced by rectangular Plexiglas slabs of the thickness and width found in animal restrainers, which are used in research on microwave biologic effects, are reported. In the theoretic studies, the incident microwave radiation was assumed to be a uniform plane wave, and the slabs were taken to be infinitely long. The theoretic solution involved obtaining a set of linear equations for the induced fields inside the slab; the equations were solved using a large digital computer to give the field outside the Plexiglas slab. During the experimental part of the study, a good approximation of a plane wave field was generated in a high-performance anechoic chamber containing a 2,450 MHz source driving a 200-W amplifier, which was fed into a truncated pyramidal horn antenna. A Plexiglas sheet of 6 mm x 0.13 m x 1.21 m was used to simulate the basic components of an animal holder; the 1.21-m length was chosen to approximate an infinitely long slab. It was experimentally demonstrated that the perturbation produced by a slab paralled to the direction of propagation is at least as great as that for the normal alignment case. Moreover, the maxima for the parallel case always occur alongside the slab's widest surface rather than in front of the slab, as is the case with the normal orientation. Good agreement was obtained between the theoretic model and the experimental results. It appears that for minimal perturbation by an animal holder, constructed with Plexiglas or equivalent materials, the longest and broadest face of the holder should be oriented normal to the direction of propagation. (5 refs.)

4916 ON EMP SAFETY HAZARDS. (Eng.) Guy, A. W. *In: AGARD Lecture Series No. 78 on Radiation Hazards*, 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A015200].

Possible criteria for setting electromagnetic pulse (EMP) safety standards are theoretically evaluated. The only two quantitative criteria presently available for setting EMP safety standards are the ANSI C95.1 safety standard based on limiting thermal insult at microwave frequencies and the thresholds for the stimulation of excitable membranes by electric current, i.e., guidelines pertaining to electrical shock. The first criterion is not realistic for application to EMP, since the induced currents and energy deposition in exposed tissue is not based on an applied field amplitude and duration relationship but is related only to the rise and fall time of the applied field pulse. The induced currents in the tissues of man exposed to impulsive electromagnetic fields do not appear to be sufficient for stimulating action potentials. For impulsive fields such as EMP, it is recommended that more attention be given to the rate of change of the field rather than to the width or peak amplitude of the field in establishing safety standards. (9 refs.)

4917 LONG-WAVELENGTH ANALYSIS OF PLANE WAVE IRRADIATION OF AN ELLIPSOIDAL MODEL OF MAN. (Eng.) Massoudi, H. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Durney, C. H.; Johnson, C. C. *IEEE Trans. Microwave Theory Techniques* MTT-25(1): 41-46; 1977.

A long-wavelength analysis of electromagnetic (EM) plane wave (perturbation technique) is applied to analyze the internal fields in an ellipsoid for each of the six major orientations of the incident fields with respect to the ellipsoid. Expressions for average absorbed power and power distributions inside the ellipsoid are given. Expressions for the internal fields and specific absorbed power as well as the curves of specific absorbed power versus frequency showed that the internal electric fields and the specific absorbed power depended on the body's dielectric properties and geometry as well as on the frequency and polarization of the incident wave. A comparison of the theoretic specific absorbed power in prolate spheroidal and ellipsoidal models with corresponding experimental data on live monkeys indicated that the prolate spheroidal models were not adequate for primates; however, they might be adequate for rodents, since the cross sections taken normal to the long axis for these primates appeared to be approximately circular. For primates with approximately elliptical cross sections, the ellipsoidal model offered a superior representation. The results of this analysis showed marked differences

in electromagnetic absorption characteristics between man and animals at the same frequency and same incident field level; therefore it will be necessary to relate the biologic effects to the internal fields or power absorption and then relate the internal fields or power absorption to the incident fields in extrapolating animal effects to man. (9 refs.)

4918 ELECTROMAGNETIC FIELDS INDUCED INSIDE ARBITRARY CYLINDERS OF BIOLOGICAL TISSUE. (Eng.) Wu, T.-K. (Dept. Electrical Engineering, Univ. Mississippi, University, MS 38677); Tsai, L. L. *IEEE Trans. Microwave Theory Techniques* MTT-25(1): 61-65; 1977.

The electromagnetic field induced inside arbitrarily shaped cross-sectioned cylinders of biologic tissue is analyzed by surface integral equations and moment method techniques. A TM or TE plane wave was the illumination source, and the cylinders consisted of bone or muscle, which might be multilayered. The integral equations were of the surface type and were derived via Maxwell's equations, Green's theorem, and boundary conditions. Surface and interior fields for both a one-layer and two-layer circular cylinder were found to have excellent agreement with the exact eigenfunction expansion results, thus validating the numeric method. Results are presented for arbitrary cross-sectioned cylinders, including an arm model composed of an elliptical outer muscle layer and a circular bone at the center. The field plots throughout the cylinder interior are useful in microwave hazard diagnostics. (20 refs.)

4919 MIGRATING BIRDS RESPOND TO PROJECT SEAFARER'S ELECTROMAGNETIC FIELD. (Eng.) Larkin, R. P. (Rockefeller Univ., New York, NY 10021); Sutherland, P. J. *Science* 195(4280): 777-779; 1977.

Radar tracking of individual migrating birds flying at night over a large alternating current antenna system showed that the birds turned or changed altitude more frequently when the antenna system was operating than when it was not. The alternating current source was a sinusoidal oscillator (72-80 Hz) connected to two orthogonal dipole antennas oriented approximately north-south and east-west. At distances of 100-400 m from the antenna system, the calculated electric field generated by the antenna was about 0.07 V/m in air. The calculated magnetic field at these distances ranged from about 0.1-0.5 μtesla. The birds were tracked at low altitudes ranging from 80-300 m above the ground. When the antenna system was not operating, a total of 157 linear flights and six nonlinear flights were recorded. In contrast, when the antenna system was turned on, there were 204 linear and 28 nonlinear flights recorded. When the antenna system was operating in a condition involving current changes (from 0-75 A or 75-0 A), the percentage of nonlinear flights (28%) increased still further, with 21 nonlinear and 53 linear flights being recorded. Neither wind condition nor cloud cover appeared to account for the occurrence of responses on at least some of the nights when the birds were tracked. The results imply that some birds can sense low-intensity, alternating-current electromagnetic fields during nocturnal migratory flight. (14 refs.)

4920 COCHLEAR MICROPHONICS GENERATED BY MICROWAVE PULSES. (Eng.) Chou, C.-K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington, Sch. Medicine, Seattle, WA 98195); Galambos, R.; Guy, A. W.; Lovely, R. H. *J. Microwave Power* 10(4): 361-367; 1975.

Oscillations at a frequency of 50 kHz were recorded from the round window of guinea pigs exposed to irradiation by 918-MHz pulsed microwaves (1-10 μsec pulse duration, 100-Hz pulse repetition rate). Five anesthetized guinea pigs were placed into cylindrical circular waveguides (standing wave ratio of 1.04) and were irradiated intermittently for durations of 1.5 min at various peak power levels below 10 kW. The average absorbed energy per pulse was 1.33 J/kg. After a 3-5 hr experiment, the animals were killed, and the response recording was continued until the physiologic potentials disappeared completely. The 50-kHz oscillations promptly followed the stimulus, outlasted it by about 200 μsec, and measured 50 μV in amplitude. The threshold energy for producing the microwave auditory effect was 20 mJ/kg, which is of the same order of magnitude as the threshold energy of 16 mJ/kg for the human head. The induced oscillations preceded the auditory nerve's response and disappeared with death; they were interpreted to be a cochlear microphonic. Since the cochlear microphonic elicited by microwave irradiation was followed by auditory nerve activity after an interval of time that closely resembled that seen in the acoustically stimulated ear, it is reasonable to assign this event to activation of the cochlear hair cells. (11 refs.)

4921 METAL ION CONTENT OF SPECIFIC AREAS OF THE RAT BRAIN AFTER 1600 MHZ RADIOFREQUENCY IRRADIATION. (Eng.) Chamness, A. F. (Radiobiology Div., USAFSAM, Brooks Air Force Base, TX 78235); Scholes, H. R.; Sexauer, S. W.; Frazer, J. W. *J. Microwave Power* 11(4): 333-338; 1976.

Changes in brain metal ion content were studied in male Sprague Dawley rats who were exposed to either a hyperthermal environment (80°C for 10 min) or 1,600 MHz radiation (80 mW/cm^2 for 10 min) to achieve an equivalent rectal temperature of 4°C. Increased iron levels were found in several brain areas of both experimental groups of animals. The levels (in μmoles/g dry tissue) in the hypothalamus, corpus striatum, midbrain, hippocampus, cerebellum, medulla, and cortex of irradiated animals were 3.55 ± 1.33, 1.75 ± 0.22, 2.51 ± 0.62, 1.78 ± 0.21, 1.84 ± 0.20, 1.58 ± 0.18, and 1.98 ± 0.56, respectively; the corresponding values for rats in the hyperthermal environment were 2.41 ± 0.48, 1.74 ± 0.26, 2.12 ± 0.25, 1.63 ± 0.15, 1.91 ± 0.26, 1.66 ± 0.19, and 1.97 ± 0.41, respectively. Control levels were 1.87 ± 0.38,

1.41 ± 0.24, 1.67 ± 0.21, 1.41 ± 0.22, 1.60 ± 0.19, 1.35 ± 0.18, and 1.63 ± 0.27, respectively. Copper was increased in the cortex of both groups: 0.207 ± 0.024 for irradiated rats and 0.210 ± 0.029 for hyperthermal rats as compared with a control value of 0.195 ± 0.024. Zinc was decreased in the hypothalamus of the hyperthermal group, being 0.716 ± 0.174 as compared with 0.918 ± 0.080 for controls and 0.806 ± 0.137 for irradiated rats. Sodium was decreased in the cortex of the hyperthermal rats, being 227.5 ± 18.0 as compared with a control value of 242.6 ± 29.5 and a value of 248.2 ± 9.59 for irradiated rats. Magnesium was increased in the cortex (33.0 ± 1.2) and medulla (26.7 ± 1.3) of irradiated rats; the corresponding control values were 31.8 ± 2.1 and 25.4 ± 1.2, respectively, while those for hyperthermal rats were 31.6 ± 2.6 and 26.0 ± 1.3, respectively. The increases in metal ions observed, especially in the case of iron, suggest vascular changes that occur in response to physiologic adjustments to an imposed heat load. The decrease in zinc seen in the hypothalamus of the hyperthermal group may signal an increase in protein synthesis. Overall, the changes in metal ion distribution observed after exposure to 1,600 MHz radiation are probably the result of concomitant hyperthermia, since most of the alterations observed in irradiated rats were also observed in rats exposed to the hyperthermal environment. (9 refs.)

4922 RF FIELD INTENSITY MEASUREMENTS IN SELECTED BROADCAST FACILITIES. (Eng.) Wang, J. C.; Linthicum, J. M. (Technical Memorandum, Federal Communications Commission, 1976) 7 pp. [available through Research and Standards Div., Federal Communications Commission, Washington, DC 20554].

Power density and field strength measurements were made in or near four typical transmitting stations licensed by the Federal Communications Commission to obtain information concerning the highest levels of electromagnetic radiation that exist in such areas, particularly near human activity. Power density measurements made near a television translater, operating at a frequency of 704-710 MHz and radiating 1,000 W through a parabolic dish, ranged from 0.3 mW/cm^2 near the front of the transmitter to more than 10 mW/cm^2 at 1 foot below the front of the dish. At the site of a television transmitter (Empire State Building) operating on channel 31 with a visual power of 890 kW, power density readings ranged from negligible inside the transmitter room to more than 10 mW/cm^2 near the antenna. Readings as high as 0.5 mW/cm^2 were obtained on an observation deck (102nd floor) used by the general public. Field strength readings taken at a radio station broadcasting on 1,500 kHz (power not specified) ranged from 8.64 V/m at a distance of 50 feet from one of the antenna towers to 945.0 V/m at the base of two towers and at a distance of about 2 feet from the output transmission line. Field strength measurements at a 50-kW radio station broadcasting on 1,090 kHz ranged from 4.4 V/m near the front panel of the transmitter cabinet to 5,440 V/m about 2 feet from the antenna loading coil. (5 refs.)

4923 POWER DENSITY IN NEAR FIELD OF SMALL LINEAR ANTENNAS. (Eng.) Wang, J. C. (Technical Memorandum, Federal Communications Commission, 1976) 13 pp. [available through Applied Propagation Branch, Federal Communications Commission, Washington, DC 20554].

A theoretic analysis of the power density in the vicinity of a small linear antenna emitting nonionizing radiation is presented, with emphasis on the near field. Equations are derived for the time-average power density in the near and far fields and for the maximum possible power density in the near field. The theoretic results are compared with measurements made on a walkie-talkie operating on a frequency of 415 MHz, which radiates 1.26 W of power from an antenna 4.57 cm in height. The calculated and measured results agreed quite well in the far field (less than 1 dB apart) and reasonably well in the outer part of the near field (about 3 dB apart). However, agreement became progressively worse as the field radius decreased. This increasing inaccuracy resulted from the fact that the latest commercially available power density meter was better when used in the far field and also to the fact that as the radius approaches 0, the antenna could no longer be considered small. (10 refs.)

4924 INDUCED EM FIELD AND ABSORBED POWER DENSITY INSIDE HUMAN TORSOS BY 1 TO 500 MHZ EM WAVES. (Eng.) Chen, K.-M. (Div. Engineering Res., Michigan State Univ., East Lansing, MI 48824) 184 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-254 247].

Numeric results on the internal electromagnetic field and absorbed power density inside a human torso induced by electromagnetic waves of frequencies ranging from 1-500 MHz are presented. The numeric results were based on a recently developed tensor integral equation and on the assumption that a heterogeneous body could be partitioned into a number of electrically small and parametrically similar subvolumes or cells. If the size of the cells was kept smaller than 1/4 of the free-space wavelength, sufficiently accurate results were obtained in terms of quantifying the induced electromagnetic field inside an arbitrarily shaped biologic body, such as the human torso. After the validity and accuracy of the tensor integral equation method were confirmed experimentally by measuring the induced electric field inside boxes containing saline solution, the numeric method was applied to quantify the induced electric field and absorbed power density inside human torsos. The following specific cases were considered: induced electromagnetic field and absorbed power density in an adult torso by both vertically and horizontally polarized electromagnetic waves, induced electromagnetic field and absorbed power in a child's torso by vertically polarized waves, and electromagnetic field and absorbed power density induced by vertically and horizontally polarized electromagnetic waves in human torsos as functions of the frequency of radiation and torso geometry. (14 refs.)

4925 X-RAY DIFFRACTION FROM CHLOROPLAST MEMBRANES ORIENTED IN A MAGNETIC FIELD. (Eng.) Sadler, D. M. (H. H. Wills Physics Lab., Univ. Bristol, Royal Fort, Tyndall Ave., Bristol BS8 1TL, UK). *FEBS Lett.* 67(3): 289-293; 1976.

X-ray diffraction signals were obtained from chloroplast membranes oriented in a magnetic field of approximately 10 kG. A chloroplast suspension from spinach leaves, which corresponded to about 5 mg chlorophyll/ml, was placed in a glass capillary, which was mounted between the poles of an electromagnet on a low angle x-ray camera. A photographic recording of low angle scattering from the suspension revealed arcs in the direction of the magnetic field that were attributable to the enhanced scatter when the diffraction vector was parallel to the lamellar normals. This confirmed that the lamellar normals were aligned along the magnetic field. A degree of magnetic orientation of a ± 15° arc was estimated; the information gained from the orientation indicated that there was a nonmeridional component to the scatter that was comparable in intensity to the meridional component. This was interpreted on the basis of proteins associated with the chloroplast membranes. Differences in ionic conditions (presence or absence of magnesium chloride in the medium) demonstrated the effect of membrane pairing in the partition region. A distance between the centers of the membranes across the partition of 77 angstroms was estimated. The results lend support for a mosaic model structure for the chloroplast membrane. (10 refs.)

4926 RADAR AND MIGRATING BIRDS. (Eng.) Krupp, J. H. (USAFSAM, Aerospace Medical Div., Brooks Air Force Base, TX 78235) 11 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A030346].

Studies on the effect of radar on migrating birds are reviewed. Generally, reports of radar influence on bird flight are based on subjective observation without statistical validity in most cases. Cranes have been reported to alter their flight route near an airport after the installation of a new and more powerful radar; however, a detailed analysis of weather influences was not made. A microwave effect on birds has been implicated by experiments in which chickens exposed in the far-field exhibited immediate spontaneous reactions (wing drooping and leg paralysis). Although the field intensity was relatively high (10-46 mW/cm^2), heating was dismissed as a cause despite the fact that temperature measurements were not made. Visual and photographic tracking analysis of birds being tracked by radar pencil beams aimed directly at them have failed to reveal any significant deviation from straight-line flight. In a controlled experiment where radars with wavelengths of 3, 10, 23, 25, and 50 cm were used as perturbing sources and/or trackers in a statistically meaningful way to assess the effect on bird flight, no radar effect was observed. Experiments evaluating the effect on pigeons being fed in a microwave field of 3 mW/cm^2 failed to reveal any disturbance in eating habits, even when the birds were near the radar horn where the field strength was estimated to be 52 mW/cm^2. Therefore, the preponderance of evidence supports the conclusion that radar is not a perturbing influence on birds. (27 refs.)

4927 MICROWAVES AND HUMAN SAFETY. PART II. (Eng.) Minin, B. A. (Joint Publications Res. Service, 1000 North Glebe Rd., Arlington, VA 22201) 195 pp.; 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. JPRS 65506-2].

Fundamental principles pertaining to the protection of humans from super high frequency radiation (microwave) exposure are outlined. Protection measures on both large- and small-scale levels are discussed and include the use of natural screens (existing nonresidential structures, strips of forest, hills); the proper design and placement of microwave antennae; the use of adequate shielding on microwave transmitters; the protection of rooms from external radiation by the application of radioprotective coverings to the walls; and the use of individual protective measures, such as, protective suits, masks, glasses, and helmets. Detailed data are supplied on the characteristics of various radioprotective materials and on methods for theoretically predicting the effectiveness of radioprotective measures. Techniques for measuring the intensity of microwave fields, including those at biologically dangerous levels, are also described. (165 refs.)

4928 BIOPHYSICS - ENERGY ABSORPTION AND DISTRIBUTION. (Eng.) Guy, A. W. *In: AGARD Lecture Series No. 78 on Radiation Hazards*, 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A015200].

Biologic and physical considerations involved in the interpretation of effects of electromagnetic fields on biologic tissues are discussed. Topics covered include dielectric properties and electromagnetic wave propagation through biologic tissues, thermal effects on biologic tissue exposed to electromagnetic fields, relations between plane wave fields and absorbed power density in exposed biologic objects, quasi-static field coupling to spheres and ellipsoids, and field coupling from finite sources. In general, the total amount and distribution of the absorbed electromagnetic power in biologic tissue exposed to electromagnetic fields is a function of the magnitude of the electric and magnetic fields, the relative stored energy in the magnetic and electric fields, the source and tissue configurations, the tissue composition, the radiation frequency, and environmental factors. The average and maximum absorbed power density may vary over many orders of magnitude for the same applied field intensities, and, depending on conditions, power absorption may be predominantly at the surface of the subject or may affect interior tissues. A tabulation of the dielectric properties, the depth of

penetration, and the reflection characteristics of various tissues (muscle, skin, fat, bone, and tissues of high and low water content) exposed to electromagnetic waves as a function of frequency (1 MHz-10 GHz) is provided. (23 refs.)

4929 INVESTIGATION OF THE EFFECT OF LOW-INTENSITY UHF ELECTROMAGNETIC WAVES ON *BACILLUS MESENTERICUS* AND *PSEUDOMONAS FLUORESCENS*. (Rus.) Ostapenkov, A. M. (No affiliation given); Matison, V. A.; Kaptereva, I. V.; Belovolov, A. V.; Lavrova, V. L. *Biol. Nauki* (6): 47-50; 1976.

The effect of ultra-high frequencies on the survival and growth of *Bacillus mesentericus* and *Pseudomonas fluorescens* was studied after irradiation of cell cultures at 200 μW. The cell survival-frequency curves obtained had a resonance character and were different for each species. The survival of *B. mesentericus* was sharply reduced by radiation at 10,450 MHz, while growth stimulation was observed at 10,300 MHz. The growth of *P. fluorescens* was stimulated by irradiation at the frequencies of 1,400-1,500 MHz, 39,450 MHz, and 39,600 MHz. The radiation had considerable bactericidal effect on both species at 39.555 MHz. (9 refs.)

4930 EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON GROWTH AND DIFFERENTIATION OF *PHYSARUM POLYCEPHALUM*. (Eng.) Goodman, E. M.; Greenebaum, B.; Marron, M. T. (Div. Science, Univ. Wisconson-Parkside, Kenosha, WI 53140) 65 pp.; 1976. [Office of Naval Research, Contract No. N-00014-76-C-0180].

The effects of extremely low frequency electromagnetic fields on the growth and differentiation of the myxomycete *Physarum polycephalum* were studied over a 4-yr period. Weak, continuous sine wave (CW), alternating electromagnetic fields (45, 60, or 75 Hz; 2.0 G; 0.7 V/m) affected the cell cycle of the myxomycete by increasing the interval between consecutive nuclear divisions. The mitotic delay was reproducible, and the time required to induce the effect was frequency dependent. About 14 days were required to observe a statistically significant mitotic delay at 45 Hz CW, about 90 days at 60 Hz CW, and about 120 days at 75 Hz CW. Cultures exposed to a modulated 76 Hz signal (0.4 G, 0.14 V/m) also exhibited a mitotic delay; in contrast, plasmodia exposed to CW fields of similar intensity (0.4 G, 0.15 V/m) for 180 days failed to display a mitotic delay. The introduction of cultures already displaying a mitotic delay into either a control environment or into a field about five times weaker than that used for inducing the delay resulted in the disappearance of the delay within about 40 days, indicating that the effect on the mitotic cycle was reversible. Continuous exposure to 45, 60, and 75 Hz CW at 2.0 G and 0.7 V/m resulted in a 7-15% retardation in the rate of shuttle streaming in *P. polycephalum*. At 75 Hz CW, alterations in the streaming period occurred several weeks before significant deviations in the mitotic cycle were noted, and it appears that shuttle streaming may be a more sensitive indicator of extremely low frequency effects than mitosis. Similar decreases in the rate of streaming were observed when plasmodia were exposed to modulated 76 Hz signal (2.0 G, 07 V/m). When the field intensity was reduced five-fold, a decrease in the rate of streaming was still observed; in contrast, similar field intensities at 75 Hz CW failed to affect the rate of shuttle streaming. Plasmodia exposed to 75 Hz CW (2.0 G, 0.7 V/m) displayed an approximate 13% depression in oxygen consumption; exposure to the same field intensity in the modulation mode resulted in an 8% lowering of the respiration rate. When exposed cultures were fused with unexposed cultures, the entire mass was observed to assume average properties, indicating the existence of some transferable substance(s) in the exposed cultures to which the control cultures responded. (17 refs.)

4931 CARDIAC PACEMAKERS AND EMI FROM THERAPEUTIC RADIATION GENERATING MACHINES (MEETING ABSTRACT). (Eng.) Baker, R. J. (Univ. California, San Francisco, CA 94143); Vreeland, W.; Smith, V. *Health Phys.* 31(6): 530; 1976.

When using radiation therapy to treat cancer patients with implanted cardiac pacemakers, there may be concern about the possible electromagnetic interference (EMI) from the radiation generating machine with the normal functioning of the patient's pacemaker. For this reason, a set of measurements were performed on a 4 MV linear accelerator. The first consisted of a survey of the low frequency components and entire microwave generating and transport components with a Narda meter. The second consisted of measurements employing a Tektronix 7L12 frequency spectrum analyzer with one of two calibrated antennae on the treatment couch simulating the patient. A biconical antenna with calibration data from 20 to 200 MHz was available and also log spiral antenna calibrated from 0.2 to 1.0 GHz. For frequencies below 20 MHz, an uncalibrated linear wire antenna was used. The quantitative results of these measurements are given, as well as a brief review of relevant literature. (No refs.)

4932 TUMOR HYPERTHERMY BY MEANS OF RADIOFREQUENCY IN ORDER TO ENHANCE ONCOLYSIS BY CLOSTRIDIUM BUTYRICUM (STRAIN M 55). (Ger.) Dietzel, F. (Abteilung Nuklearmedizin, Zentrum fur Radiologie des Klinikums der Justus-Liebig-Universitat, 63 Giessen, Friedrichstrasse 25, W. Germany); Gericke, D.; Konig, W. *Strahlentherapie* 152(6): 537-541; 1976.

The effect of short-term local hyperthermia induced by high-frequency eddy current fields (461 MHz, 150 W) on the oncolytic activity of *Clostridium butyricum* (strain M 55) was studied in female NMRI mice with tumors of the neck (transplanted solid Ehrlich carcinoma, Harding-Passey melanoma, and methylcholanthrene-induced fibrosarcoma). The tumor temperature was increased to 42-44°C by the

local irradiation, which was followed by intravenous application of *C. butyricum* spores 12 hr later. The animals were sacrificed 5 days after the injection of spores. The rates of oncolysis achieved in animals with Ehrlich carcinoma, Harding-Passey melanoma, and fibrosarcoma were 61.31%, 84.09% and 22.4%, respectively, vs 27.65%, 14.77% and 1.16% in the control treated with spores only. The corresponding tumor weights were 1.27 g, 0.14 g and 1.85 g, respectively, vs 2.36 g, 2.49 g and 2.29 g in the control. The findings indicate that short-term hyperthermia, producing anoxic necrobiotic conditions, significantly enhances the oncolytic activity of *C. butyricum* M 55. (10 refs.)

4933 PROTECTION OF WORKERS OPERATING HIGH-FREQUENCY INDUCTION HEATING EQUIPMENT. (Rus.) Kulikovskaia, E. L. (M. I. Kalinin Polytechnical Inst., Leningrad, USSR). *Gig. Tr. Prof. Zabol.* (11): 47-48; 1976.

Various screen designs for industrial inductive heating units were studied to estimate their irradiation protection efficiency for workers. Cylindrical inductors should be screened by means of two concentric semicylinders, and the screen material should be aluminum alloy sheet with a minimal thickness of 1 mm. The electrical resistance of the alloy should be close to that of aluminum. Sight glasses should be metallized to protect workers from the electrical component of the radiation. (No refs.)

4934 MICROWAVE RADIOMETRY AND ITS POTENTIAL APPLICATIONS IN BIOLOGY AND MEDICINE: EXPERIMENTAL STUDIES. (Eng.) Bigu-Del-Blanco, J. (Anatomy Dept., Queen's Univ., Kingston, Ontario, Canada); Romero-Sierra, C.; Watts, D. G. *Biotelemetry* 2: 298-316; 1975.

Microwave radiometric experiments were performed with humans, rabbits, cats, mice, rats, guinea pigs, and plant tissue. The experiments consisted of measuring the brightness temperature under normal conditions, under the influence of some drugs, and under the influence of microwave radiation. In the latter case, brightness temperature measurements were initiated 3 sec after removal of the microwave field to avoid interference from electronic transients. Radiometric signatures obtained for the above specimens indicated the feasibility of using microwave radiometry to detect radiation emitted by biologic systems at microwave frequencies. In one experiment, when an anesthetized rabbit received 2.5 min of microwave radiation (30 mW/cm^2 as measured in free space), an increase in brightness temperature of about 1.8 Kelvin was observed. This increase diminished rapidly in an exponential fashion, reaching an almost steady value in about 60 sec after the microwave field was switched off. During three sets of experiments involving the irradiation of an unanesthetized rabbit with 30 mW/cm^2 of microwave radiation for 3 min, the steady-state brightness temperatures obtained after removal of the field were practically the same for each experiment. However, the increase in brightness temperature exhibited by the irradiated specimen, at the time of field removal, was largest in the first two experiments and minimal in the third experiment. This result, although difficult to explain in terms of a tissue dielectric heating effect alone, appears to be a condition or an adaptation of the animal to the external stimulus. The radiometers used in the above experiments included a correlation type and a Dicke type, operating in the X-band at about 9 GHz with a sensitivity of about 0.1 Kelvin. (48 refs.)

4935 PUBLIC HEALTH HAZARDS FROM ELECTRICITY-PRODUCING PLANTS. (Eng.) Neyman, J. (Statistical Lab., Univ. California, Berkeley, CA 94720). *Science* 195(4280): 754-758; 1977.

Problems involved with determining safe levels of human exposure to radiation are discussed in connection with potential hazards from electrical power plants. Currently available estimates of radiation effects on humans are based on extrapolations from studies of two kinds; those exemplified by studies of Japanese atomic bomb casualties and laboratory experiments with lower animals. The unreliability of both kinds of extrapolations is connected with the following circumstances: the phenomenon of competing risks in the environment, the dependence of health effects of a given noxious agent on the preexisting local pollution, the dependence of health effects not only on the dose of an agent but also on the rate at which the agent is administered, and difficulties in making extrapolations from one mammal to another. The need for epidemiologic studies of radiation effects is stressed, in particular in such areas as Rocky Flats, Colorado, where increased malformation frequency in domestic animals may be due to the presence of selenium in the food chain or to other sources of contamination, such as a nuclear facility in the area. (20 refs.)

4936 EFFECTS OF NON-IONIZING ELECTROMAGNETIC RADIATION. (Eng.) Mints, S. M. (Joint Publications Res. Service, 1000 North Glebe Road, Arlington, VA 22201) 100 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. JPRS-66512].

A compilation of various articles on the effects of non-ionizing radiation on humans and animals is presented. Topics covered include: the effect of microwave emission on the content of iron, copper, cobalt, and metallic proteins bonded with them in organs and tissues of test animals; cerebral and peripheral circulation in persons handling sources of ultrahigh radio frequencies (UHF) based on the results of rheographic examinations; changes in the membrane potential of nerve cells of isolated ganglia in the mollusk *Planorbis corneus* under the influence of a UHF electromagnetic field; the effects of ionizing radiation in combination with microwaves on the permeability of histo-hematic barriers; the influence of super high frequency (SHF) electromagnetic fields on the capillary bed, parenchyma, and bio-

chemistry of the rat testes; the effects of experimental toxic hepatitis and microwaves on the function of hepatic and renal mitochondria in the rat; the action of SHF electromagnetic fields on human erythrocytes preserved at low temperature; the effects of SHF fields of different intensity on the balance and metabolism of copper, manganese, molybdenum, and nickel in experimental animals; the effect of UHF fields on pathogenic microorganisms; the effect of UHF fields on the course of hypertension in humans; the effect of a low frequency pulsed electromagnetic field on rat testes; hygienic evaluations of the effects of medium wave electromagnetic fields in populated areas; the effect of microwaves on blood serum butyryl cholinesterase activity in rats; the effect of microwaves on the function and structure of hepatic and renal mitochondria of rats; experimental, clinical, and epidemiologic studies of the health hazards and biologic effects associated with microwave exposure; the effects of SHF fields on enzymatic activities and pyridoxine levels in the organs of white rats; metabolic disorders and liver function in rats exposed to low frequency pulsed electromagnetic fields; studies of the digestive system in workers exposed to the effects of UHF electromagnetic fields; hygienic investigations of working conditions during the high frequency heating of metals and semiconductors; the effect of microwaves on the metabolism of trace elements, metalloproteins, and indicators of oxidation-reduction processes in rabbits; and the use of microwave therapy for treating inflammation of the female human genitals. (103 refs.)

4937 LONG-WAVELENGTH ELECTROMAGNETIC POWER ABSORPTION IN ELLIPSOIDAL MODELS OF MAN AND ANIMALS. (Eng.) Massoudi, H. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Durney, C. H.; Johnson, C. C. *IEEE Trans. Microwave Theory Techniques* MTT-25(1): 47-52; 1977.

A previously developed long-wavelength analysis of electromagnetic (EM) plane wave irradiation of ellipsoidal models of humans and experimental animals was used to obtain quantitative theoretic estimates of the average specific absorbed EM power and EM power distributions within the model. The EM specific power absorption varied significantly with the orientation of the ellipsoid axis in the incident field vectors and also with frequency, size, and dielectric properties of the ellipsoid. Theoretic data were obtained for the average specific absorbed power for six different orientations of the ellipsoid with respect to the incident plane wave field vectors; the strongest absorption was found when the electric field vector of the incident plane wave was along the longest dimension of the ellipsoid. Curves showing the distribution of absorbed power inside the model and the average absorbed power versus frequency were presented for humans, dogs, rabbits, rats, mice, and monkeys. Theoretic results for average specific absorbed power in rhesus monkeys were compared with experimental data on live rhesus monkeys and found to be in agreement. The quantitative data presented can be used to estimate tissue power absorption in experimental animals and man. Extrapolation of EM effects in animals can then be applied to those expected in humans, since the biologic effects due to irradiation are expected to be a function of specific absorbed power. (20 refs.)

4938 STUDY OF BIOLOGICAL MEMBRANES ORIENTED IN A HOMOGENEOUS MAGNETIC FIELD. (Eng.) Becker, J. F. (Ph.D. dissertation, Dept. Physics, New York Univ., 1976): 158 pp. [available through Xerox University Microfilms, Ann Arbor, MI 48106, Document No. 76-19, 483].

Living cells in aqueous suspensions under normal physiologic conditions were oriented in a homogeneous magnetic field of 10,000 G or more. Photosynthetic algae (*Chlorella pyrenoidosa, Scenedesmus obliquus*, and *Euglena gracilis*), photosynthetic bacteria (*Rhodopseudomonas palustris* and *R. viridis*), spinach chloroplasts, and bovine visual rod outer segments were oriented. The orientation was caused by the interaction between the magnetic field and the induced diamagnetic moment of ordered cell components having an anisotropic diamagnetic susceptibility. The aromatic amino acid residues of membrane proteins or the chlorophyll molecules were the most probable source of this anisotropy, depending on the type of cell. Cell orientation was monitored by observing the polarization of fluorescence and the linear dichroism of order cell components. It was shown that the whole cell orients in the magnetic field and that there was no detectable re-arrangement of internal cellular components at the magnetic field strength employed. A rhodamine-B staining technique was used to show that the membrane planes were oriented perpendicular to the external magnetic field. Studies of energy transfer in photosynthetic membranes and studies of the photo-induced charge separation occurring in photosynthetically active spinach chloroplast membranes were also performed. Preliminary measurements of the electromotive force in suspensions of oriented chloroplasts demonstrated the anisotropic absorption properties of the membranes. (111 refs.)

4939 EFFECTS OF WEAK ELECTRIC FIELDS ON BEHAVIOR AND EEG OF LABORATORY ANIMALS. (Eng.) Gavalas-Medici, R. (No affiliation given). *Neurosci. Res. Prog. Bull.* 15(1): 27-36; 1977.

Experiments dealing with the effects of extremely low frequency (ELF) electromagnetic fields on reaction time and task performance are reviewed. During experiments where high and low frequencies (2-12 Hz, 4 V/m [root mean square]) were presented in a double-blind test to each of 29 human subjects, the higher frequency of each pair resulted in a longer reaction time. Tests of four monkeys on an inter-response time (IRT) task revealed shifts towards faster IRT's during exposure to 45-Hz magnetic fields in some of the animals during some tests. Experiments in which three monkeys were trained to press a lever for fruit juice reinforcement and then tested in 7-Hz (7 V/m (peak-to-peak) fields revealed a significantly shorter average IRT in the presence

of the field for at least two of the monkeys. Sets of electroencephalogram data selected from the beginning and end of the testing periods and corresponding to correct (i.e., properly timed) and incorrect responses revealed statistically significant differences in data selected from the hippocampus near the end of the run, with the appearance of a spectral peak at the field frequency of 7 Hz. Similar experiments involving the exposure of five monkeys to frequencies ranging from 7-75 Hz and voltage gradients ranging from 1-100 V/m showed that at 10 V/m the 7-Hz field was associated with a reduced average IRT; the mean IRT across all five animals was about 0.12 sec shorter than the control value. Neither 45-Hz nor 75-Hz fields produced a significant change at this voltage level. At 56 V/m, (significant differences (almost three times as large as those seen at 10 V/m (7 Hz)) were observed for both 7-Hz and 75-Hz fields. Data at 100 V/m indicated that field exposure was affecting control tests that occurred 24 hr later. Overall, the results suggest that there may be a frequency-specific threshold for weak ELF fields; sensitivity to 7-Hz fields may reflect the fact that this frequency is within the range of hippocampal theta for monkeys. A dose-dependency relationship also appears to exist since IRT shifts were much larger at 56 V/m than at 10 V/m. (No refs.)

4940 AMPLITUDE-MODULATED, VERY HIGH FREQUENCY (VHF) ELECTRIC FIELDS. (Eng.) Bawin, S. M. (No affiliation given); Adey, W. R. *Neurosci. Res. Prog. Bull.* 15(1): 36-38; 1977.

The effect of amplitude-modulated, very high frequency (VHF) electric fields on conditioned electroencephalogram (EEG) rhythms of cats was investigated. In the first experiment, five cats were initially trained to produce a particular EEG rhythm as a response to a light flash. Prior to VHF exposure, the five cats were retrained. Two cats (with conditioned rhythms in the hippocampus and nucleus centrum medianum, respectively) served as controls and were overtrained and extinguished in the absence of field. The other three cats (two of them with hippocampal rhythms and one with a centrum medianum pattern) were irradiated with a 147-MHz VHF carrier (0.8 mW/cm^2), which was amplitude-modulated at 3 and 4.5 Hz (hippocampal frequencies) and at 14 Hz (centrum medianum frequency) during overtraining and extinction. The control cats maintained regular levels of performance during the training sessions but never exceeded their previous achievement. The extinction of the response in the absence of field was very rapid as in the first conditioning. Performance dropped to 40% during the first session in both animals. The performance of the irradiated animals reached levels equal or superior to the highest scores seen in the first conditioning, and these high performance levels persisted for 25-40 days into the extinction schedule. No change was ever elicited in the EEG of other brain sites not subjected to the conditioning procedure. A second series of experiments involved the selection of two different rhythms in two different brain structures for each of two animals. In one cat, two mutually exclusive patterns were selected: 14 Hz in the nucleus centrum medianum and 10 Hz in the presylvian gyrus. In the other animal, two concurrent patterns were selected: 13 Hz in the caudate nucleus and 4 Hz in the centrum medianum. The spontaneous occurrence of one selected rhythm was used to trigger the VHF fields, which were amplitude modulated at the same frequency for 20 sec. The results clearly indicated that the fields were acting as reinforcers, increasing the rate of occurrence of the initially spontaneous rhythms but only when modulated at frequencies close to the biologically dominant frequency of the selected intrinsic EEG patterns. The results support evidence that the modulation was responsible for the specific EEG enhancements seen in both experiments. (No refs.)

4941 BIOLOGICAL SIGNIFICANCE OF ZERO MAGNETIC FIELD CONDITIONS AND PERTURBATIONS OF MICROWAVE FIELDS BY LIVING ORGANISMS. (Eng.) Beischer, D. E. (No affiliation given). *Neurosci. Res. Prog. Bull.* 15(1): 100-103; 1977.

The interaction of weak non-ionizing electromagnetic fields with nervous tissue is discussed. The coupling of the field to the tissue is extremely weak at extremely low frequencies of radiation. It increases progressively at higher radio frequencies, with the possibility of resonant interactions with molecular components at specific frequencies above about 100 GHz including dielectric interactions for frequencies as high as about 10 GHz. As distinct from the carrier wave itself, there is evidence for the detection of low frequency modulation of the carrier, apparently based on detector properties of tissue phase partitions and associated asymmetries in the distribution of fixed charges on macromolecular sheets at membrane surfaces. Very weak extremely low frequency fields, with tissue gradients of the order of 10^{-5} V/m, have been shown to alter circadian rhythms and subjective timing estimates and to be capable of altering the binding of calcium ions in brain tissue by 15%. In pilot studies of the effects of an alternating magnetic field of 45 Hz and 10^{-4} weber/m^2 strength in man, a possible time-delayed increase in serum triglycerides has been reported. Bee orientation experiments in chambers shielded from the earth's magnetic field have revealed a sharp increase in erroneous orienting responses. Natural magnetic fields may involve transients of as much as 500 gamma, or about 1.0% of the steady level, and bees have been found to be sensitive to as little as 10 gamma. Man appears to suffer no ill physiologic or central nervous system effects from exposure to zero magnetic fields during a period of 2 wk. Calculations of the field pattern for the interaction of a plane wave and a conductive cylinder with its axis parallel to the electric field and a cylinder diameter equal to the wavelength have yielded a reasonable fit to the observed contours for man. In experiments with a conductive mannequin (life-size with a metallic surface), standing wave patterns closely resembling those found for man have been obtained. It has been observed that when the electric field is parallel to the long axis of the body, the structure of the parabolic standing wave field extends a considerable distance to the

sides of the body; whereas, in horizontal polarization the side structure is low in amplitude. This point may be significant when men are exposed standing side by side. (No refs.)

4942 THE EFFECTS OF LOCALIZED MICROWAVE EXPOSURE ON THE DOG THYROID. (Eng.) Magin, R. L. (Ph.D. dissertation, Dept. Radiation Biology and Biophysics, Univ. Rochester, Rochester, NY, 1976); 165 pp. [available through Xerox University Microfilms, Ann Arbor, MI 48106, Document No. 76-26, 914].

The effects of localized continuous wave microwave (2.45 GHz) exposure on the dog thyroid gland were studied. Preliminary experiments demonstrated that the thyroid gland temperature could not be elevated by more than 1°C without thermally damaging the skin and intervening tissues when a dielectrically loaded wave-guide applicator was located on the ventral surface of the neck. Experiments designed to assess the effects of microwave exposure following stimulation of the release of total plasma thyroxine (T4) with thyroid-stimulating hormone (TSH) could not be conducted, since a good control gland response was not established. Therefore, the response of the thyroid gland without the administration of TSH was studied. Cannulated glands were allowed a 1-hr equilibration period followed by a 2-hr exposure period. Sham exposure experiments showed that both of the glands comprising the dog thyroid released T4 at a relatively constant rate for the 3-hr experimental period. During the exposure period, the heated glands were maintained at about 39, 41, or 45°C by the absorption of 58, 131, or 190 W/kg of microwave power. The thyroxine release rate was determined from the difference between the T4 concentration in the thyroid veins and femoral artery, the thyroid vein blood flow, and the hematocrit. The thyroxine release rate was increased during the exposure period to 150, 350, and 1000% of the equilibration period averages for the three temperature groups studied. The blood flow was increased to 140 and 170% of the equilibration period averages in glands heated to 41 and 45°C, respectively. Contralateral control glands maintained a constant thyroxine release rate. These results demonstrate that local heating of the thyroid gland can stimulate both thyroid gland blood flow and the release of thyroxine. (57 refs.)

4943 DIRECT CURRENT STIMULATION OF THE GROWING DEER ANTLER. (Eng.) Lake, F. T. (Ph.D. dissertation, Colorado State Univ., 1976). 207 pp. [available through Xerox University Microfilms, Ann Arbor, MI 48106, Order No. 77-1175].

The effects of direct current (DC) stimulation on the regeneration and bone growth of mature Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) antler were investigated. Direct currents of 0.066, 0.05, 2.0, and 3.0 μamp were used, with the cathode attached to the growing tip of the antler and the anode attached near the antler base. The longterm application of low levels of cathodal DC to growing antlers produced abnormal branching patterns and antlers that grew in atypical directions. The stimulated antler tines showed statistically significant reductions in length and diameter. Moreover, the stimulated antler tines showed a significant reduction in the rate of longitudinal growth during the antler growth cycle. Measurements of the electric potentials on the antler showed that the most negative potential was associated with the most metabolically active portion of the antler, namely, the growing tip. In reference to the antler base, electrical potentials recorded from the antler indicated an electronegative potential at the growing tip during most of the growth cycle. However, as the antler matured, the tip became less negative and approached zero potential when the growth process ceased. This decrease in the electronegative potential of the growing antler tip paralleled the decreased longitudinal growth rate. Bone labeling and subsequent bone dynamic studies of the cortical osteons indicated the following: osteon wall thickness in experimental and control antlers was not significantly different; bone formation rates in the stimulated tines appeared to be decreased; and osteon formation time in the stimulated antlers appeared to be increased. Chemical and gravimetric analyses revealed that bone formed in stimulated tines was similar to bone formed in nonstimulated tines. No consistent histological or histochemical differences were found between experimental and control antlers. (190 refs.)

4944 EFFECTS OF MICROWAVE RADIATION ON APLYSIAN GANGLION CELLS. (Eng.) Seaman, R. L. (No affiliation given). *Neurosci. Res. Prog. Bull.* 15(1): 45-48; 1977.

Comparative studies of microwave and thermal effects on *Aplysia* ganglion cells were performed. Ganglionic warming was produced convectively by flushing warm water through an enclosed space surrounding the chamber housing the ganglion. Microwave frequencies of either 1.5 or 2.45 GHz were used either as a continuous wave (CW) signal or as trains of pulses. Typically, both CW and pulsed microwave irradiations, as well as circulation of warm water, caused a decrease in cell firing rate. Less frequently the microwave field and subsequent heating produced opposite effects. A total of 55 different cells were tested with microwaves; no difference was noted in the effects induced by 1.5 GHz or 2.45 GHz nor between the effects of CW and pulsed radiation for the majority of observations. Convectively, temperature changes of 0.1-2.7°C were found to affect the firing rates of white cells. Effective rates of temperature change ranged from 0.004-0.180°C/sec. Irradiation temperature increases were duplicated by convective heating in 29 white cells, and some cells that showed a consistent firing-rate decrease with increasing temperature exhibited increased firing rate during microwave irradiation. A rapid change in firing rate was often observed at the cessation of irradiation, and these changes were generally similar to those occurring with decreased temperature. However, decreased interspike interval, as seen in some white cells at the onset

of irradiation, was never produced by a simple rise in environmental temperature. Likewise, a decreased interburst interval in burster cells at the termination of irradiation was never produced by an environmental temperature decrease. Both white cells and bursters were tested for their sensitivity as expressed in the lowest effective absorbed power (LEAP). About 50% of the white cells exhibited a LEAP less than 15 mW/cm^3, and 30% were sensitive to absorbed powers of 10 mW/cm^3. Combined data for white cells and bursting cells produced a regression that would predict 0.1% of the cells to be affected by an absorbed power of 1 mW/cm^3. The effects of extracellular currents introduced into the test chambers were also tested to establish the sensitivity of the white cell to these stimuli. For direct current, the largest critical value observed in 12 white cells was 20 μA, which yielded a current density of 110 $\mu A/cm^2$. For alternating currents of 10 Hz, 100 kHz, and 1 MHz, the critical values for one white cell were 118, 3,730, and 8,250 $\mu A/cm^2$ (root mean square), respectively. (No refs.)

4945 EFFECTS OF ALTERNATING MAGNETIC FIELD (12 GAUSS) ON TRANSPLANTED NEUROBLASTOMA. (Eng.) Batkin, S. (John A. Burns Sch. Medicine, Univ. Hawaii, Honolulu, HI 96822); Tabrah, F. L. *Res. Commun. Chem. Pathol. Pharmacol.* 16(2): 351-362; 1977.

A total of 10 A/J female mice bearing transplanted neuroblastoma (C1300) were exposed to a 12-G, 60-Hz magnetic field for 16 days, starting 3 days after tumor transplantation. At 19 days post-transplant, macroscopic and microscopic evaluations of the tumors were performed. The visible growth rate of the tumors was slower in the 15 mice exposed to the magnetic field than it was in another 10 tumor-bearing control mice not exposed to the magnetic field. For the exposed group, there were four evident tumors at day 6 and 6-7 and visible tumors at day 8-9; visible tumors occurred in all 10 exposed animals by post-transplant day 10-11. This contrasted with the appearance of visible growths in all 10 control mice receiving tumor transplants by the 5th-6th post-transplant day. Tumor weights in both groups of mice were not significantly different at the 19th post-transplant day. Microscopically, two distinct histologic differences were observed between exposed tumor-bearing mice and control tumor-bearing mice. Exposed mice had more free red blood cells in the tumor areas and showed a tendency toward focal tumor cell destruction. Two common features were exhibited by the 10 tumor-bearing mice exposed to the magnetic field and by another 10 non-tumor-bearing mice also exposed to the magnetic field; both of these groups were more active than tumor-bearing mice not exposed to the magnetic field, and no odor was perceptible from their cages as compared with an ammonia odor from the cage cleanings of mice not exposed to the magnetic field. The possibility of differential bacterial growth is being considered in connection with these observations. Overall, the results suggest that a small alternating magnetic field may affect transplanted tumor growth. (12 refs.)

4946 THERAPEUTIC USE OF ALTERNATING MAGNETIC FIELD IN THE TREATMENT OF PATIENTS WITH CHRONIC DISEASES OF THE VEINS OF THE LOWER LIMBS. (Rus.) Pasynkov, E. I. (Dept. Surgery, N. I. Pirogov Second Moscow Medical Inst., Moscow, USSR); Konstantinova, G. D.; Vlasova, E. I. *Vopr. Kurortol. Fizioter. Lech. Fiz. Kult.* (5): 16-19; 1976.

A total of 271 patients with chronic venous insufficiency, varicose veins, and trophic ulcer of the shin were treated with alternating magnetic field (15-20 min/day, courses of 20-20 sessions). Good therapeutic results were achieved in 236 cases, satisfactory results in 34, and no effect was observed in one case. When the interval between acute phlebothrombosis and treatment was short, the therapeutic result was better. In some cases, good results were achieved only after a second therapy course given 6 mo after the first one. Magnetic field therapy is indicated for the treatment of cellulitis, in association with other therapeutic methods, and in the prophylaxis of postoperative complications in patients with varicose veins and postthrombotic conditions. (3 refs.)

4947 NON-THERMAL HAZARDS OF EXPOSURE TO RADIO FREQUENCY FIELDS. MICROWAVE STUDIES. (Eng.) Mickey, G. H.; Heller, J. H.; Snyder, E. (The New England Inst., P.O. Box 308, Ridgefield, CT 06877). 51 pp.; 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A019359].

Cytogenetic and genetic tests of nonthermal hazards associated with *in vitro* and *in vivo* exposures (10-500 mW/cm^2 average field power densities) to radiofrequencies in the 15-40 MHz range and microwaves in the X-band (9,345-9,405 MHz) and K-band (23,800-24,270 MHz) range were performed. Radiofrequencies in the 15-40 MHz range were effective in inhibiting mitosis and in producing chromosome abnormalities in human lymphocytes and in Chinese hamster lung cells in culture. Significant increases in chromosome abnormalities occurred following irradiation at 21, 25, and 40 MHz. *In vivo* treatment of Chinese hamster bone marrow and testicular cells at 20, 25, 30, and 35 MHz for 1-9 days induced significant increases in aneuploid and polyploid cells but very few chromosome breaks. In bone marrow cells, the percent of abnormal cells reached as high as 1.65% as compared with a maximum of 0.6% for control cells. A stronger effect was observed in germ cells where 25% of the cells irradiated at 35 MHz for 57 hr were abnormal as compared with 1.7% for control cells. Corneal epithelium and hair follicle cells were negative to such exposures. Brain cells of *Drosophila melanogaster* larvae also showed no evidence of nondisjunction at these radiofrequencies. K-band microwaves produced chromosome abnormalities in tissue cultures of Chinese hamster lung cells, with the rate of abnormalities increasing 4-12 hr after treatment. In contrast, no significant increases in chromosome abnormalities occurred after irradiation with X-band microwaves. *In vivo* microwave tests showed that K-band microwaves were effective in producing chromosome aberrations in Chinese hamster bone marrow and

testicular cells, with the effect increasing with the period of microwave exposure. Chromosome breakage in bone marrow cells showed statistically significant increases after exposure periods of 12, 18, 19, 28, and 35 hr. Abnormal cells in the testis of irradiated animals showed significant increases after 28 hr of exposure or more. X-band microwaves were ineffective against bone marrow, male germ cells, lung cells, and corneal epithelium cells. Genetic tests with *D. melanogaster* following irradiation of marker females at 20, 25, 30, and 35 MHz showed no significant increase in nondisjunction in successive broods of offspring. (24 refs.)

4948 COMPARATIVE ASSESSMENT OF ULTRASOUND AND MICROWAVE THERAPY OF CHRONIC TONSILLITIS IN EPILEPTIC PATIENTS. (Rus.) Khodan, I. V. (Volyn Oblast Psychiatric Hosp., USSR). *Zh. Ushn. Nos. Gorl. Bolezn.* (4): 96-97; 1976.

Results of ultrasonic and microwave treatment of epileptic patients with chronic tonsillitis are presented. Thirty patients with compensated and 20 patients with subcompensated chronic tonsillitis underwent ultrasonic therapy (0.4 W/cm^2, 5 min/day, 10 days). In patients with compensated tonsillitis, good results were achieved in 86.6% and satisfactory results, in 10%. In patients with subcompensated tonsillitis good results were obtained in 20% and satisfactory results, in 25%. Twenty-eight patients with compensated, and 20 patients with subcompensated tonsillitis underwent microwave irradiation (2,375 ± 50 MHz, 0.4-0.5 W/cm^2, 5 min/day, 12 days). Good results were obtained in 78.6%, satisfactory results in 14.4% of the cases of compensated tonsillitis, versus 50% and 20% in subcompensated tonsillitis. The efficiency of antiepileptic therapy was improved, i.e., the frequency of epileptic seizures was decreased, in patients in whom the ultrasonic and microwave treatment for tonsillitis was successful. (7 refs.)

4949 SOME POSSIBLE EFFECTS OF STATIC MAGNETIC FIELDS ON CANCER. (Eng.) Kim, Y. S. (Dept. Physics, Ohio State Univ., Columbus, OH 43210). *IIT J. Life Sci.* 6: 11-28; 1976.

Some possible effects of static magnetic fields on cancer cells are discussed. Topics covered include: the electric and magnetic properties of tumor cells and tissues; biomagnetic effects on membranes, genes and replication, metabolic rates, and growth; and the biomechanical actions of magnetism. Evidence exists that at least some cancer cells are more susceptible to magnetic fields than normal cells, that cancer cells are less organized and less cohesive than normal cells, that the surface of cancer cells are more negatively charged than normal cell surfaces, that they have larger dielectric constants, and that they fail to form membrane junctions for intercellular communication. Cancer cells appear to be more paramagnetic than normal cells when they are allowed to proliferate, but due to the presence of anoxic cells in solid tumors, the magnetic susceptibility of tumor tissues (solid) can be more diamagnetic than normal tissues. Magnetic fields can affect cellular functions by distorting membranes and the orientation of various cellular components. These actions may be translated into such biologic effects as growth retardation, cell membrane depolarization, localization and rejection of tumors, temporary and semipermanent genetic and replication anomalies, cell degeneration, and, perhaps, reversion of some cancer cells to normalcy. Biomagnetic effects on tumor growth rates at field strengths ranging from 0-77,000 Oe are tabulated for various types of tumors. Reduced growth rates are reported for Ehrlich adenocarcinoma exposed to 1,500-1,700 Oe, and tumor regression is reported for crown gall tumor exposed to 100-2,200 Oe over a 3-mo period. Tumor rejection in some animals is reported for mice tumors (H2712, C3HBA, and T2146) exposed to 3,000-4,500 Oe. Tumor cell degeneration has been observed with Ehrlich S-37 ascites tumor exposed to 7,300 Oe for a few hr. (101 refs.)

4950 BIOSYNTHESIS OF ACETYLCHOLINE IN DIFFERENT BRAIN REGIONS *IN VIVO* FOLLOWING ALTERNATIVE METHODS OF SACRIFICE BY MICROWAVE IRRADIATION. (Eng.) Nordberg, A. (Dept. Pharmacology, Faculty Pharmacy, Biomedical Center, Univ. Uppsala, Uppsala, Sweden); Sundwell, A. *Acta Physiol. Scand.* 98(3): 307-317; 1976.

The amounts of endogenous acetylcholine (ACh) and choline (Ch) and the rate of biotransformation of tritium-labelled choline (^{3}H-CH) were studied in the brain regions of female NMRI mice (18-24 g) following three different methods of sacrifice. The animals were sacrificed by whole body irradiation (1.3 kW, 7 sec), by head irradiation (5 kW, 0.25 sec), or by dislocation of the spine 1, 5, 10, or 20 min after intravenous injection of 15 nmol ^{3}H-Ch. The brain temperature was measured in different locations 10 to 60 sec after irradiation. The slope of the temperature time curves indicated a brain temperature of about 85-90°C at the termination of exposure to both types of irradiation. Acetylcholinesterase (AChE) and choline acetyltransferase (CAT) were almost completely inactivated when measured 1 to 2 min after sacrifice. To study the rate of turnover of ACh, the brains were dissected into six regions, extracted, and analyzed. No significant difference (except in cortex) in the amount of endogenous ACh was found when whole body irradiation was used in comparison with dislocation of the spine. However, the amount of ^{3}H-acetylcholine (^{3}H-ACh) was much higher in the striatum, hippocampus and cortex. Endogenous ACh (in nmol/g) was markedly increased in the brain regions of head-irradiated animals (shorter inactivation time) compared with spine-dislocated animals: medulla oblongata, 29.1 ± 1.10 versus 19.8 ± 1.07; midbrain, 29.4 ± 1.65 versus 21.1 ± 1.24; striatum, 75.3 ± 1.84 versus 37.1 ± 2.06; cortex, 24.2 ± 1.52 versus 13.2 ± 0.74. However, there was no further increase in the radioactive ACh. The difference regarding the postmortem sensitivity of endogenous and radioactive ACh does not seem to have been due to methodologic artifacts but rather sug-

gests that they are handled differently by the brain tissue. Plots of the specific radioactivity of Ch and ACh versus time indicated fairly distinct precursor-product relationship in the different regions, when the animals were sacrificed by irradiation of the head. (24 refs.)

4951 ELECTROMAGNETIC RADIATION: EFFECTS ON THE EYE. (Eng.) Mitchell, J. C. *In: AGARD Lecture Series No. 78 on Radiation Hazards*, 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A015200].

Animal and human studies concerning the ocular effects of electromagnetic radiation (EMR) exposure were surveyed to assess and synthesize the principal findings. An overview of the studies revealed that the acute thermal insult from high intensity EMR fields is cataractogenic if intraocular temperatures reach 45-55°C. The EMR exposure threshold is about 100-150 mW/cm^2 applied for about 60-100 min. Additionally, there does not appear to be a cumulative effect from EMR exposures unless each single exposure is sufficient to produce some irreparable degree of injury to the eye. A review of retrospective studies on actual or suspected exposure of human populations to EMR fields shows that human data alone do not provide conclusive evidence that EMR produces cataracts in man. Some surveys indicate statistically significant increases in lenticular defects in microwave-exposed workers, but none shows any clinically significant defects in terms of decreased visual acuity, i.e., apparent loss of functional vision. Case reports indicate that diathermy treatment in the area of the eye using multiple exposures at power densities from 80-240 mW/cm^2 does not result in cataractogenesis. The exposure levels with which clinically significant cataracts have been tenuously associated indicate the cataractogenic threshold is over 100 mW/cm^2 for man. Human populations, including groups that work with or near EMR emitters, are rarely subjected to fields having average power densities greater than about 1 mW/cm^2, and in most cases the fields are lower. While the emphasis in past research has been on acute EMR cataractogenesis, the author suggests that future studies should consider more subtle indications of energy transfer, such as, alterations in lens protein, and/or ultrastructural changes, and any possible long-term adverse effects. (26 refs.)

4952 BIOLOGIC AND PATHOPHYSIOLOGIC EFFECTS OF EXPOSURE TO MICROWAVE OR ULTRASONIC ENERGY--AN OVERVIEW. (Eng.) Michaelson, S. M. *In: AGARD Lecture Series No. 78 on Radiation Hazards*, 1975. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A015200].

The increased use of processes and devices that utilize or emit nonionizing radiation, such as, microwaves and ultrasound is discussed and the biologic effects of such radiation are briefly reviewed. A significant and growing portion of the U.S. population is exposed in varying degrees to microwaves from various sources including communications devices, microwave ovens, and medical diathermy treatments. It is estimated that by 1980 there will be approximately 5 million microwave ovens in use. The biologic effects of microwaves can be divided into three categories: high average intensities (>10 mW/cm^2) at which distinct thermal effects occur, which in some instances may be hazardous; the range below 1 mW/cm^2 in which gross thermal effects are improbable; and the range of intermediate or subtle effects from about 1-10 mW/cm^2 in which weak but noticeable thermal effects occur as well as direct effects and perhaps effects of a microscopic or macroscopic nature. The border limits of these regions are approximate and may differ for various species of animals and may also depend on frequency and modulation. In view of the expanding use of microwave energy and the complexity of the interactions of nonionizing radiation in biologic systems, it is concluded that an interdisciplinary approach is necessary to assess and elucidate the possible biomedical effects. (13 refs.)

4953 INFRARED SPECTRA OF ERYTHROCYTE SHADOWS IN THE REGION OF AMIDE I AND AMIDE II BANDS UNDER MICROWAVE IRRADIATION. (Rus.) Ismailov, E. S. (Dagestan Polytechnical Inst., Mkhachkala, USSR). *Biofizika* 21(5): 940-942; 1976.

The effect of ultra-high frequency irradiation (1,009 MHz, 30 min at 25°C) on the ultrastructure of human erythrocyte membranes was studied by infrared spectrometry. Irradiation with an intensity of 45 mW/cm^3 resulted in small conformational reconstructions of membrane molecules without inducing a notable transition of alpha-helix into beta structure. Both pulsed and permanent irradiation with 45 mW/cm^3 caused a marked decrease in the intensity of the shoulder at 1,740 cm^{-1}. The deuterium exchange in the peptide molecules, and the corresponding shift of the amide II band from 1,540 cm^{-1} to 1,450 cm^{-1} proceeded faster under irradiation with 45 mW/cm^3 than they did in the control. These changes were dose-dependent and were not manifested at radiation intensities of 5-8 mW/cm^3. (12 refs.)

4954 EFFECT OF LOW-FREQUENCY ELECTRIC STIMULATION OF THE CAUDATE NUCLEUS ON THE CORTICAL ELECTRIC ACTIVITY AND THE WAKEFULNESS-SLEEP CYCLE. (Rus.) Oniani, T. N. (Inst. Physiology, Acad. Sciences Georgian SSR, Tbilisi, USSR); Keshelava-Gogichadze, M. V. *Fiziol. Zh.* 62(1): 29-37; 1976.

The effect of low-frequency electric stimulation (0.8-12/sec, 4-7 V) of the caudate nucleus on the electric activity of the neopallium and archipallium and on the wakefulness-sleep cycle was studied in nonimmobilized cats with implanted electrodes. The δ, θ, α, β_1 and β_2 rhythms of the sensorimotor area of the neopallium and of the dorsal hippocampus were analyzed. After single stimulation, evoked potential occurred more readily in the neopallium than in the

dorsal hippocampus. In the hippocampus, the evoked potentials became facilitated and stable at a frequency of 4-6/sec. The evoked potentials are most pronounced, though variable, at 6-8/sec frequency in the sensorimotor cortex, and spindling occurs at 8-12/sec. As a behavioral correlation of the synchronized activity in the neopallial and archipallial structures during the low-frequency stimulation of the caudate nucleus, drowsiness may develop, which along with the electroencephalographic signs disappears with the cessation of stimulation. Low-frequency stimulation during the paradoxical phase of sleep also provokes synchronization of the electrocardiogram, but the structure of the paradoxical phase recurs after stimulation. The synchronizing stimulation of the caudate nucleus causes considerable changes in the wakefulness-sleep cycle after the stimulation (reduction in the overall duration of short-wave sleep, and increase in the duration of the paradoxical phase). (35 refs.)

4955 EFFECT OF SMALL DOSES OF UHF ELECTROMAGNETIC WAVES ON SOME INDICES OF RENAL FUNCTION AND WATER-SALT METABOLISM. (Rus.) Grin, A. N. (A. N. Marzeev Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR). *Vrach. Delo* (10): 130-132; 1976.

The effect of ultra-high frequency electromagnetic fields (5, 10, and 50 $\mu W/cm^2$, 3 hr/day, 10 days) on the renal function and water-salt metabolism was studied in 231 adult male and female rats. Significant but rather moderate increase was observed in the diuresis and in the urinary excretion of chlorides after exposure to 5, 10, 50 5+10, and to 5+10+50 $\mu W/cm^2$. The most pronounced changes in the renal function were produced by a single, 3-hr exposure to 500 $\mu W/cm^2$. The functional changes caused by this high dose, as well as the time required for the normalization of the renal function, were considerably less marked in animals pretreated with 5, 10, and 50 $\mu W/cm^2$ doses prior to exposure to a single $\mu W/cm^2$ dose. (No refs.)

4956 THERMAL AND ELECTRONIC CONTRIBUTIONS TO SWITCHING IN MELANINS. (Eng.) Filatovs, J. (Sch. Engineering, North Carolina A & T State Univ., Greensboro, NC 27411); McGinness, J.; Corry, P. *Biopolymers* 15(11): 2309-2312; 1976.

The recent discovery that melanin responds to applied electric and acoustic fields has led to a new variety of possible biologic roles *in vivo* as well as the design of a potential new modality for treating melanoma. Criteria useful in separating thermal from electrical contributions to switching are presented. Synthetic melanins and melanosomes extracted from human malignant melanoma were prepared and a cylindrical sample of melanin was compressed between carbon electrodes in a teflon holder whose temperature could be controlled between 24° and 200°C. A regulated power supply was used to apply direct current voltage across the sample and load resistor; the resistor was chosen at a low value to ensure memory switching. The threshold electric field and threshold temperature required to activate memory switching for a 0.1-sec pulse were determined for synthetic melanin and melanosomes. The latter showed essentially the same results as purified melanins for the initial critical temperature, but they degraded below 110°C (where synthetic melanin switches off), and the off state could not be reached by heating. Increasing the hydration of the bulk sample lowered the threshold temperature and electric field required for activation but did not change the temperature at which samples switched back off. Neither the hydration, temperature, current, applied field, nor power alone is sufficient to ensure switching; the temperature, hydration, and either the applied field, current, or power must be specified. Melanins offer a unique experimental system for development of a working concept of biologic semiconductivity, since they are stable, can absorb other molecules, and express this interaction by a conductivity change of as much as ten orders of magnitude. (10 refs.)

4957 MICROWAVE-POWER ABSORPTION BY RECTANGULAR-SHAPED CONDUCTIVE DIELECTRIC SAMPLE IN STRIPLINE. (Eng.) Joines, W. T. (Dept. Electrical Engineering, Duke Univ., Durham, NC 27706); Dakermandji, G.; Seaman, R. L.; Wachtel, H. *IEEE Trans. Microwave Theory Techniques* 24(8): 536-538; 1976.

The microwave power absorbed by a rectangular sample of seawater in a plexiglas container (.775 x 1.04 x 1.7 cm) within the uniform field of a stripline is calculated and measured over the 1-2-GHz range. Equations, which account for the sample's disturbance of the otherwise uniform plane-wave field of the stripline, are given, and restrictions on sample size for best accuracy are stated in terms of stripline dimensions. The power absorption measurements on the sample of seawater are compared with calculations using the developed equations. (12 refs.)

4958 THE EFFECT OF 1.6 GHz RADIATION ON NEUROTRANSMITTERS IN DISCRETE AREAS OF THE RAT BRAIN. (Eng.) Merritt, J. H.; Hartzell, R. H.; Frazer, J. W. (USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 11 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A023677].

The effects of thermogenic microwave power densities on the neurotransmitter content of discrete areas of the rat brain were investigated and compared with the hyperthermic effects caused by exposure to a warm environment. When male Sprague Dawley rats were exposed to 1.6 GHz radiation at a measured power density of 80 mW/cm^2 for 10 min, their body temperature rose 4°C. Hyperthermal control rats were then exposed to a warm air environment to raise core body temperature 4°C. The norepinephrine content of the hypothalamus of the irradiated animals was significantly reduced compared with control animals (50% of control content). Hippocampal serotonin was de-