tremely low frequency electromagnetic fields on circadian and intradiel aspects of behavior, metabolism, activity, and thermoregulation in rats and mice are described. The basic exposure facility consists of circular parallel-plate electrodes separated by a distance of 30.5 cm. Fields are held uniform by a set of three guard hoops or rings spaced between the electrodes. Animals are exposed in glass or plastic cages in either a horizontal or vertical orientation to the field. Miniprobe measurements of field strengths within the cages revealed that the fields are highly uniform, homogeneous, and reproducible from cage to cage. The facilities have been tested at 60 Hz, and preliminary measurements indicate that reasonably accurate indirect measurements can be made of the moment-to-moment fluctuations of the total current in the animal as it moves about within the cage. There is no simple relationship between posture of the animal and total current. Dimensionally, the total current in the animal is an increasing function of the potential difference across the body of the animal and also an increasing function of the area that the animal projects on the ground plane. These two factors are somewhat in opposition, and as a result the current becomes a complicated function of the animal's shape. Current density increases as the animal assumes a more upright posture and as the cross-sectional area projected on the ground plane decreases. Thus, it may be possible to utilize lateral and vertical shadowgrams to obtain an estimate of the moment-to-moment variations of the average body current density. Noticeable input from the corona, ozone, or transformer hum was not observed at 60 Hz.

6754 A PROTOTYPE SYSTEM FOR EXPOSING SMALL LABORATORY ANIMALS TO 60-Hz VERTICAL ELECTRIC FIELDS: ELECTRICAL MEASUREMENTS. *(Eng.)* Kaune, W. T. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 225-240; 1979 (6 refs).

The electrical properties of a prototype parallel-plate exposure system for subjecting mice or rats to 60-Hz vertical electrical fields are described. In this system, the animals stand on and are in electrical contact with the lower plate. The system comprises two horizontal, planar (1.0 by 1.8 m) parallel metal electrodes spaced 0.58 m apart and placed in a 3.5- by 3.7-m grounded metal-screen enclosure. The upper electrode is energized and the lower grounded. The lower electrode, and the effects on electric fie uniformity of grounded conducting walls and plas cages were measured. The electric field is 97% of t ideal parallel-plate value at the center of the low electrode and is uniform to within 7.5% over a 0.5- 1.0-m area of the lower electrode surface; over th area the estimated horizontal field components 10 c above the lower electrode surface are less than 3 of the vertical component. The presence of a groun ed wall close to the electrodes adversely affect field uniformity, but energizing both electrodes wi equal magnitude but oppositely phased voltag relative to the room walls minimized wall-electro interaction and improved field uniformity. The effe on uniformity of the electric field of grounded co ducting walls and plastic cages was studied in thr cage configurations: 1) a 4.8-mm-thick plexigla sheet, 30 cm wide x 51 cm high, placed 10 cm abo the lower electrode increased the floor-level fie strength by 1%; 2) a 4.8-mm-thick a plexiglass wall. cm wide x 10 cm high, reduced the field strength its base by 2.5%; and 3) a complete 10 cm wide x cm long x 10 cm high plexiglass cage with ro resulted in a 5% variation in field strength over th surface of the cage floor.

6755 1,000-kV PROJECT: RESEARCH ON TH BIOLOGICAL EFFECTS OF 50-Hz ELE TRIC FIELDS IN ITALY. *(Eng.)* Cerretelli, P. (Dep Physiology [III], Univ. Milan, Milan, Italy); Veic teinas, A.; Margonato, V.; Cantone, A.; Viola, D Malaguti, C.; Previ, A. *In: Biological Effects of E tremely Low Frequency Electromagnetic Fields. Pr ceedings of the Eighteenth Annual Hanford Li Sciences Symposium held October 16-18, 1978 Richland, Washington.* [available through Nation Technical Information Service, Springfield, VA 2216 Document No. CONF-781016]: 593 pp.; pp. 241-25 1979 (19 refs).

Basic cardiovascular variables, blood morpholo and chemistry, growth and fertility, teratology, ar changes in resistance to induced infections were i vestigated in mice, rats, rabbits, and dogs expose to 50-Hz electric fields of up to 100 kV/m for 30 sec hr/day over periods of up to 2 mo as part of an inte national program on ultrahigh voltage (UHF) tran mission (1,000 kV Project). The electric fields were i duced between two 1.5- by 2-m steel plates. The bo tom plate, on the floor of a room, was grounded, an the energized electrode was hung above the groun ed plate at a height that could be adjusted by mean of pulleys. Thus, the animals that were house on the grounded electrode could be exposed t various field intensities, depending on the distanc between the plates and the applied voltage. No e fects of exposure to the 50-Hz fields were observe

was significantly lower than that of controls. The fertility of rats was not affected by exposures to 100 kV/m (8 hr/day for 48 days). The resistance in albino mice to induced infections was not influenced by exposures of up to 25 kV/m (8 hr/day for 42 days). No teratogenic effects were detected in rats exposed to 100 kV/m (8 hr/day for 48 consecutive days).

6756 POWER FREQUENCY ELECTRIC FIELDS AND BIOLOGICAL STRESS: A CAUSE-AND-EFFECT RELATIONSHIP. *(Eng.)* Marino, A. A. (VA Hosp., Syracuse, NY 13210); Cullen, J. M.; Reichmanis, M.; Becker, R. O. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium in October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 258-276; 1979 (36 refs).

The effects of 60-Hz electric fields on the extent of fracture healing in 27-day-old male Sprague-Dawley rats were studied to test the hypothesis that such fields can act as biologic stressors. The fractures were performed at the midshaft of the fibula, and the extent of healing was assayed 14 days thereafter on the basis of blind scoring of serial histologic preparations. The rats were housed individually in totally plastic enclosures. Both food and water were supplied on essentially the same equipotential plane as that occupied by the animals. Half of the rats were exposed to a 60-Hz electric field of 5,000 V/m, and the other half served as controls. At 14 days after fracture, the degree of healing manifested by the exposed animals was substantially less than that of unexposed controls. The exposed animals had new bone with much thinner trabeculae than the controls, an increased amount of cartilage throughout the callus, and a scarcity of new bone in the fracture, indicating a relatively immature stage of fracture repair. It was estimated that the 14-day field-exposed fractures resembled a normal fracture site at 10 days after fracture. The entire experiment was repeated, and the results were identical. However, when rats were exposed at 1,000 V/m in two replicate experiments, no differences were seen in the degree of fracture healing between exposed and control rats. It is concluded that the above results indicate that a 60-Hz field of 5,000 V/m is a biologic stressor.

6757 EFFECTS OF CHRONIC EXPOSURE TO A 60-Hz ELECTRIC FIELD ON SYNAPTIC TRANSMISSION AND PERIPHERAL NERVE FUNCTION IN THE RAT. *(Eng.)* Jaffe, R. A. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352), Phillips, R. D., Kaune, W. T. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016] 593 pp.; pp. 277-296, 1979 (11 refs).

The effects of a 30-day exposure of male Sprague-Dawley rats (77-91 days old) to a 60-Hz, 100-kV/m electric field on synaptic transmission and peripheral nerve function were studied. Superior cervical sympathetic ganglia, vagus nerves, and sciatic nerves were removed from urethane-anesthetized rats after sham or electric field exposure in a parallel-plate exposure system. The nerves or ganglia were placed in a temperature-controlled chamber and continuously superfused with a modified mammalian Ringer's solution equilibrated with 95% oxygen and 5% carbon dioxide. Synaptic transmission and peripheral nerve function were characterized by the following parameters and tests: amplitude, area, and configuration of the postsynaptic or whole-nerve compound action potential; conduction velocity and synaptic delay; accommodation, refractory period, strength versus duration curves, conditioning test response; frequency response, post-tetanic response; and high-frequency-induced fatigue. Rats exposed to the 60-Hz, 100-kV/m field showed increased C-fiber conduction velocity, decreased rate of fatigue, and shifts in strength versus duration and conditioning test response curves in comparison with unexposed controls. These results suggest that such electric field exposures may increase neuron excitability.

6758 CLINICAL PATHOLOGIC EVALUATIONS IN RATS AND MICE CHRONICALLY EXPOSED TO 60-Hz ELECTRIC FIELDS. *(Eng.)* Ragan, H. A. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Pipes, M. J.; Kaune, W. T.; Phillips, R. D. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016] 593 pp.; pp. 297-325; 1979 (16 refs).

Hematologic and serum chemistry parameters were examined in rats and mice exposed to 60-Hz unperturbed fields of 100 kV/m for 15, 30, 60, or 120 days. The conditions were designed to eliminate secondary field influences. The first study on female Swiss-Webster mice (74 days old) showed no consistent hematologic or serum chemistry changes attributable to electric field exposure. In some cases, statistically significant differences were found between exposed and sham-exposed mice, but these changes were never consistent either between replications or between different exposure periods.

However, there was a statistically significant increase ($p<0.01$) in the replicate composites of platelet concentrations of rats exposed for 60 days. The composite leukocyte concentrations were also significantly greater ($p<0.05$) in exposed rats than in sham-exposed rats after 60 days of exposure; this apparent leukocytosis was due to an absolute increase in lymphocytes. However, this difference was due entirely to the marked difference in total leukocytes from the second replicate since values of both groups were almost identical in the first replicate. In addition, leukocyte concentrations in sham-exposed rats were significantly lower than those from either the exposed or cage-control groups of rats. Overall, it is concluded that, with the possible exception of elevated platelet concentrations at the 60-day exposure period, there were no consistent effects observed in clinical pathologic parameters in either mice or rats exposed to 100-kV/m electric fields for as long as 60 days.

6759 IMMUNOLOGICAL STUDIES WITH 60-Hz ELECTRIC FIELDS. *(Eng.)* Morris, J. E. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Ragan, H. A. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 326-334; 1979 (16 refs).

Humoral and cellular immune parameters were measured in male and female Swiss-Webster mice (about 75 days of age) who were exposed for 21 hr/day to a 60-Hz, 100-kV/m unperturbed electric field for either 30 or 60 days. There were no significant differences between electric field-exposed and sham-exposed mice in terms of serum immunoglobulins, complement levels, distribution of thymus-derived or bone marrow-derived lymphocytes, or primary antibody response to keyhole limpet hemocyanin. In one study of 60-day exposed mice, total leukocyte and lymphocyte concentrations in the blood were significantly lower ($p<0.02$ and $p>0.01$, respectively) in the electric field-exposed mice than in sham-exposed mice. However, in a replicate study, total leukocyte and lymphocyte concentrations were significantly higher ($p<0.01$ and $p<0.05$) in electric field-exposed mice than in sham-exposed mice. In general, no significant changes in humoral and cellular limits of the immune system were observed in mice exposed to the 60-Hz field.

6760 DEVELOPMENTAL TOXICOLOGY

Low Frequency Electromagnetic Fields. Proceedi
of the Eighteenth Annual Hanford Life Sciences S
posium held October 16-18, 1978 in Richla
Washington. [available through National Techni
Information Service, Springfield, VA 22161, Docum
No. CONF-781016]: 593 pp.; pp. 335-347; 1979 (9 ref

The effect of exposure to uniform 60-Hz, 100-kV electric fields (21 hr/day) on reproduction and fetal and postnatal growth and development was vestigated in Sprague-Dawley rats. In an initial periment, exposure to the electric field for 6 da prior to mating did not influence the fertility number of animals that mated of either males females. Litter size, prenatal death, and the sex ra were also not significantly affected by electric fi exposure. Exposure continuing through 20 days gestation also did not influence the morphologic tegrity of the fetuses or their size. Continued posure of the sires of these litters as well as females that did not mate during the initial breedi period did not alter their subsequent breeding p formance or the ability of females to implant a maintain a litter to 14 days of gestation. In two ad tional experiments involving exposure to the elect field during gestation and for the first 8 days postnatal life (experiment 2) or during the last 5 da of gestation and the first 25 days of postnatal life (periment 3), no significant detrimental effects on t growth or survival of the offspring or on their physi development were noted. Only a few measures postnatal neuromuscular development show statistically significant differences between sha exposed and electric field-exposed rats. The o notable difference (occurring in experiment 2) wa greater percent of exposed offspring showing mot behaviors (movement, grooming, and standing) an smaller percent showing the righting reflex at 14 da of age ($p<0.05$). However, on retesting at 21 days age, the results for sham-exposed and electric fie exposed groups were indistinguishable. In expe ment 3, the only measure that was significantly fected in electric field-exposed rats was negati geotropism ($p=0.03$).

6761 ENHANCED GROWTH IN PUBESCE MALE PRIMATES CHRONICALLY E POSED TO EXTREMELY LOW FREQUENCY FIELD *(Eng.)* Grissett, J. D. (Naval Aerospace Medical Re Lab., Pensacola, FL 32508). *In Biological Effects Extremely Low Frequency Electromagnetic Fiel Proceedings of the Eighteenth Annual Hanford L Sciences Symposium held October 16-18, 1978 Richland, Washington.* [available through Natior Technical Information Service, Springfield, VA 221 Document No. CONF-781016]: 593 pp., pp. 348-3 1979 (4 refs).

of 0.2 mtesla and an electric field strength of 20 V/m to determine the biologic effects of fields with the same waveform but greater magnitude than those generated by the Navy's proposed extremely low frequency submarine communications system. The electric field distribution in the exposure chambers was measured with a high-impedance electric field probe. The most significant finding was that exposed males gained weight at a faster rate than did control males. The difference in weight was not accompanied by a difference in bone-length measurements. The divergence in weight gain occurred only during the first year, and the difference in weight gained for the entire 147-wk period is only significant at p=0.09. During the first year, blood urea nitrogen and serum glucose levels were lower in exposed males (p=0.05 and p=0.01, respectively); however, values for both exposed and control males were within normal limits. The gamma-glutamyl transpeptidase level was lower in exposed males (p=0.06), and, though consistently lower in exposed females, the difference was not significant (p=0.37). In males the difference tended to increase slightly with time while the opposite was true in females. Levels of serum glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, and creatine phosphokinase were significantly lower in exposed males during the first week of exposure (p=0.05). Significant differences were not evident thereafter, although glutamic pyruvic transaminase levels continued to be lower in exposed males (p=0.14). Both exposed and nonexposed control monkeys appear to be healthy. It is suggested that the basis for the observed effect of electromagnetic fields on the growth of male monkeys may be related to the difference in maturity of males and females at the start of the experiment.

6762 A SYSTEM FOR THE EXPOSURE OF MINIATURE SWINE TO 60-Hz VERTICAL ELECTRIC FIELDS: CURRENT STATUS. *(Eng.)* Kaune, W. T. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Allen, C. H.; Beamer, J. L.; Gillis, M. F.; Miller, M. C.; Phillips, R. D. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 363-378, 1979 (7 refs).

The construction of a facility for exposing 40 miniature swine to 60-Hz vertical electric fields is described. Originally, an overhead 4.6-m high electrode with four parallel 7.6-cm diameter conductors was built to generate ground-level, 60-Hz, vertical electric fields of 30 kV/m. Fiberglass pens were built inside a nonconducting building located under the electrode. Initial tests with animals in the pens showed that the electric field was severely distorted by the building. It was observed that as the electric field was interacting with and destroying certain parts of the building. The seam regions between adjacent panels and, subsequently, the panel interiors had become contaminated with water, sufficient leakage currents existed to produce a significant distortion of the electric field and to damage the building. Thus, a new grid electrode, consisting of 21 conductors, was built inside the exposure building, with the height of the electrode being 2.29 m in the building's center and 1.70 m at the outer edges. The inside surfaces of the building were convered with metal screen that was electrically grounded, thus preventing exposure of the building to the electric field. The ground level electric field for this new arrangement is uniform to 5%. Enhancement of the electric field at the surface of a swine's body as a result of the lowered electrode height is less than 5%. The electric field total harmonic distortion is 0.5%. No ozone concentrations above ambient background levels in the building are generated by the energized electrode.

6763 MAGNETIC FIELD EFFECTS ON HUMANS: EPIDEMIOLOGICAL STUDY DESIGN. *(Eng.)* Budinger, T. F. (Donner Lab., Univ. California, Berkeley, CA 94720); Wong, P. D.; Yen, C. K. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 379-399; 1979 (3 refs).

The design of a retrospective epidemiologic study of the health effects of stationary and low-frequency alternating magnetic fields on humans is described. The study population will comprise 1,000 cyclotron and bubble chamber workers who have been occupationally exposed to magnetic fields of at least 5 G in magnitude for 8,000 G-hr during their working careers. The study includes acquisition of medical data from exposed subjects as well as from 1,000 matched controls from eight facilities in North America. Studies of the latent effects from acute and very high exposures will involve subjects who have worked in fields greater than 400 G at facilities such as calutrons during World War II. In addition, individuals involved in calibrating large magnets and individuals exposed to very high fields around bubble chambers will comprise this high-field exposure population. The study will include identification of exposed personnel and controls, the use of exposure information questionnaires, medical record encoding, estimation of magnetic field exposures by field measurements, computer modeling, and data analysis. Based on a sample size of 1,000 exposed subjects, it is estimated that a 50% increase in the prevalence of cardiovascular disease or cancer will

6764 FERROMAGNETISM IN FRESHWATER BACTERIA. *(Eng.)* Blakemore, R. P. (Dept. Microbiology, Univ. New Hampshire, Durham, NH); Frankel, R. B.; Wolfe, R. S. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 400-407; 1979 (5 refs).

Magnetotactic bacteria of the unclassified *Spirillum* type were isolated from swamp water and were cultured in the magnetic and nonmagnetic state. Cells of the magnetic *Spirillum*, but not of the nonmagnetic form, contained chains of crystals similar to those found previously in other magnetic bacteria of marshes and bogs. Energy dispersive x-ray analysis indicated that the magnetic cells had a significantly higher iron content than nonmagnetic cells. Atomic absorption spectrophotometry of acid-digested whole cells indicated that 1.5% of the dry weight of magnetic bacteria was iron, this value was 13 times that for nonmagnetic cells. Values for nonmagnetic cells were only slightly higher than published for other heterotrophic bacteria. These results suggested that iron was localized in the crystals of magnetic bacteria. When the Mossbauer spectrum for magnetic cells was compared with published spectra of magnetic and nonmagnetic iron-containing substances, the spectrum for magnetic cells resembled most closely the spectrum of magnetite. Pure magnetite was analyzed under similar conditions, and minor differences in the two spectra were observed. These differences may relate to differences in the types of samples (i.e., magnetite in biologic material versus pure stoichiometric magnetite) or may indicate the presence of additional iron-containing substances in magnetic cells.

6765 RESPONSE OF AGAROSE SOLUTIONS TO MAGNETIC FIELDS. *(Eng.)* Kalkwarf, D. R. (Physical Sciences Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Langford, J. C. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 408-416; 1979 (14 refs).

The effects of homogeneous magnetic fields of 0 and 1 tesla (T) on the gelation of electrophoresis-grade agarose and on the properties of the resulting gel were examined. Gelation temperatures of nucleic acid than gels formed at 0 T. Gels formed a T melted at 1.7 ± 1.0 C higher than those form at 0 T. These results indicate that agarose selectively oriented in liquid solution by la magnetic fields and suggest that the same type of teraction may lead to magnetic effects in tissues r in the structurally related mucopolysaccharides.

6766 IN VITRO EVALUATIONS OF STA MAGNETIC FIELDS. *(Eng.)* Frazier, M (Biology Dept., Battelle Pacific Northwest La Richland, WA 99352); Andrews, T. K.; Thompson, B. *In: Biological Effects of Extremely Low Freque Electromagnetic Fields. Proceedings of the Ei teenth Annual Hanford Life Sciences Sympos held October 16-18, 1978 in Richland, Washingt* [available through National Technical Informat Service, Springfield, VA 22161, Document No. COI 781016]: 593 pp., pp. 417-435; 1979 (28 refs)

Cultures of various cell lines were exposed to sta magnetic fields of 0.1-1.0 tesla (T) to determin there was a reproducible effect on cell morphol or physiology. In one group of studies, the cell lir L929, WI38, monkey kidney cells (VERO), and Syr hamster embryo cells were exposed in the fro *state* to 0.5 or 1.0 T for 4, 8, or 24 hr, they were th thawed and grown in culture by standard tiss culture techniques. Magnetic fields of up to 1.0 T 24 hr produced no consistent effects on cell viabil growth rate, cell size, morphology, or transforr tion. In another set of experiments, VERO cells w continuously exposed to 0.1 or 0.3 T for up to passages (approximately 80 cell doublings) culture. The only effect observed was a change colony-forming efficiency of cultures exposed to T. This appeared to be the result of increased c clumping rather than magnetic-field-induced inh tion of cell division. However, this cell clumping m have been related to the magnetic field exposur

6767 EFFECT OF CONSTANT AND ALTI NATING MAGNETIC FIELDS ON TUM CELLS IN VITRO AND IN VIVO. *(Eng.)* Chandra, (Service Therapeutic Radiology, VA, Edward J. Hir Jr. Hosp., Hines, IL); Stefani, S. *In: Biological Effe of Extremely Low Frequency Electromagnetic Fiel Proceedings of the Eighteenth Annual Hanford L Sciences Symposium held October 16-18, 1978 Richland, Washington.* [available through National formation Service, Springfield, VA 22161, Docum No. CONF-781016] 593 pp., pp. 436-446, 1979 refs).

The effect of constant magnetic fields (CMF) up to

bronchogenic carcinoma were exposed for 1 or 2 hr to various strengths of the CMF. Some cultures received a single exposure, while others were exposed daily for 3 days. Tumor growth was not affected in either cell line at CMF strengths up to 1.0 T. In another series of experiments, transplantable mouse mammary tumors subcutaneously implanted into syngeneic hosts were exposed to various CMF strengths (0.1-1.0 T) or to a 0.16-T AMF for 45-60 min/day for 3 or 4 days after tumor size had reached approximately 8-10 mm in diameter. Neither the CMF nor the AMF had any effect on tumor growth in vitro, in vivo, or when inhomogeneity of the magnetic field was introduced.

6768 AN ENVIRONMENTALLY CONTROLLED SYSTEM FOR EXPOSURE OF MICE TO LARGE DIRECT-CURRENT MAGNETIC FIELDS. *(Eng.)* Decker, J. R. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Kuffel, E. G.; Mahlum, D. D.; Sikov, M. R.; Harris, C. P. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 447-461, 1979 (3 refs).

An environmentally controlled system for exposing mice to vertically oriented direct current magnetic fields is described. The system is designed to expose mice in sufficient numbers for adequate statistical evaluation to magnetic fields similar to or greater than those to which man is expected to be exposed in the operation of a 5,000-MW tokamak-type fusion power reactor. The exposure system was designed to minimize artifactual or masking effects. Two closed chambers are constructed so that sham-exposed and exposed mice (5 groups of 10 mice each) can be maintained under the same ambient environmental conditions with controlled temperatures, airflows, and lighting, and be provided with food and water. The chambers are mounted into two identical water-cooled, beam-bending magnets capable of producing a maximum vertical field of 1.5 tesla with an alternating current ripple of less than 0.0002% and a drift component of about 0.02% the nominal value. One magnet is energized to produce the desired field, and the other serves for sham exposure. The magnetic field can be automatically ramped on and off to simulate the cycling of a tokamak reactor. With the use of a step-function on-or-off signal, the slightly underdamped field has a minimum rise time of 2.4 sec and a minimum fall time of 15.3 sec. Better control of room temperature and chamber humidity is suggested to improve the system design.

CURRENT MAGNETIC FIELDS. *(Eng.)* Sikov, M. R. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Mahlum, D. D.; Montgomery, L. D.; Decker, J. R. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 462-473, 1979 (9 refs).

Gravid Swiss-Webster mice of known gestational age were exposed either to a homogeneous 1-tesla (T) or to a gradient (2.5 T/m) direct current magnetic field with a maximum strength of 1 T to determine the effects of intrauterine exposure on subsequent prenatal or postnatal development and growth. Experimental animals were housed in environmentally controlled chambers that were mounted within the bore of a beam-bending magnet; sham-exposed control mice were housed under identical conditions in a nonenergized magnet. For studies performed with the homogeneous field, the exposure chambers were centered on the poles of each magnet. Two replicate experiments were performed by using exposure on 0.5-7, 6-15, 10-18, or 0.5-17 days of gestation (dg) for prenatal evaluation and on 6-18 dg for postnatal evaluation. A second series of studies was performed using gradient field exposures (with one side of the chamber between the magnetic poles) on 0.5-7 or 0.5-18 dg for prenatal and 0.5-17 dg for postnatal evaluation. Overall, it appeared that no developmental effects were produced under the above exposure conditions. However, the number of mated mice that were found to be pregnant was lower than customarily found, and this resulted in inadequate litters per replicate to test for inter-replicate differences. Even when the data from the two replicates were pooled to give a larger group size, this was usually inadequate for unequivocal statistical analyses, especially in view of the marked variability between litters.

6770 DOMINANT LETHAL STUDIES IN MICE EXPOSED TO DIRECT-CURRENT MAGNETIC FIELDS. *(Eng.)* Mahlum, D. D. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Sikov, M. R.; Decker, J. R. *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 474-484, 1979 (7 refs).

To evaluate the possibility that magnetic fields may induce mutations, groups of 10 male Swiss-Webster

gradient field (2.5 T/m) for 28 days (group 2); or to a time-ramped, gradient field (2.5 T/m) for 42 hr (group 3). Following exposure, the group 1 and 2 males were bred with females of the same strain for 4 wk. Group 3 males were bred for 7 consecutive wk. Females were replaced weekly and were killed 10 days after separation from the males. The incidence of dominant lethal mutations, calculated from differences in the number of early resorptions or mean litter size, was not affected by any of the above exposure regimens. There were small differences between exposed and control groups in the total number of offspring produced, i.e., males exposed to homogeneous fields sired fewer total offspring than did nonexposed, whereas males exposed to either steady or pulsed gradient fields sired more offspring. In all cases, the differences between exposed and control groups were due to differences in the number of pregnant females, and it is unclear whether these differences are due to magnetic field exposure or represent normal variability. In another study where better breeding performance was obtained with Hilltop Swiss-Webster mice exposed to a time-ramped, gradient field (2.5 T/m) for 42 hr, the frequency of early resorptions was consistently higher in the exposed than in the sham-exposed group. However, the difference was not statistically significant by a chi-square test for any single week of breeding. When the difference between frequencies was tested over the entire breeding period (8 wk), the result was significantly different ($p<0.05$).

6771 ELECTRICAL PARAMETERS OF THE HIGH-VOLTAGE DIRECT-CURRENT TRANSMISSION-LINE ENVIRONMENT. *(Eng.)* Bracken, T. D. (Bonneville Power Admin., Vancouver, WA). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 485-500; 1979 (17 refs).

Ground-level electrical parameters of high-voltage, direct-current (HVDC) transmission lines handling up to ±600 kV are discussed, and HVDC is contrasted with extra-high-voltage, alternating current (AC) transmission lines. Three parameters are required to describe the complex electrical environment near an HVDC transmission line: electric field, space-charge density, and ion current density. Wind is a significant factor in determining the magnitude of the HVDC electrical parameters at ground level. The wind- and corona-induced dynamic quality of the parameters requires long-term averages for an adequate description. Field measurements undertaken a the Dalles HVDC test line of the Bonneville Power Ad-

20 kV/m, 40 nA/m^2, and 12 nC/m^2, respectively. These measurements demonstrated the feasibility of quantifying the HVDC electrical environment of any line. Proximity effects within the HVDC transmission line environment generally occur less frequently and with less severity than analogous AC effects.

6772 OZONE FIELD STUDIES ADJACENT TO A HIGH-VOLTAGE DIRECT-CURRENT TEST LINE. *(Eng.)* Droppo, J. G. (Atmospheric Sciences Dept., Battelle Pacific Northwest Lab., Richland, WA 99352). *In: Biological Effects of Extremely Low Frequency Electromagnetic Fields. Proceedings of the Eighteenth Annual Hanford Life Sciences Symposium held October 16-18, 1978 in Richland, Washington.* [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp., pp. 501-529; 1979 (17 refs).

Ozone concentrations attributed to corona lossess were measured as a primary indicator of oxidant levels at a Bonneville Power Administration high-voltage direct-current (HVDC) test facility. The measurements indicated that environmental ozone levels from HVDC transmission lines, even under worst-case conditions, are reasonably well predicted by extrapolating ozone production rates from wind-tunnel tests. This confirmation of the ozone production rates is based on agreement between observed and predicted ozone plume parameters during precipitation conditions. The magnitudes of changes in ozone concentrations attributable to energized conductors were small for all weather conditions. For fair weather conditions the levels were not detectable in the natural variability of ambient ozone. The worst-case plume produced a 10-parts/billion increase for low-wind and precipitation conditions, with the monitor being 26 m from the conductor centerline and the line being operated at ±500 kV with 70 mA of corona current. The surface level increase of ozone was less but of the same order of magnitude. This high value and extended vertical distribution are attributed to the long fetch created by winds nearly parallel to the conductors. A roving-profile measurement technique proved to be an effective method for defining the low concentrations of ozone emission from HVDC transmission lines. The origins of ozone plumes were identified in a reliable and consistent fashion as a result of the sensitivity of this method.

6773 MUTAGENIC EFFECTS OF HIGH-STRENGTH ELECTRIC FIELDS. *(Eng.)* Hungate, F. P. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Fujihara, M. P.; Strankman, S. R. *In: Biological Effects of Extremely*

Washington. [available through National Technical Information Service, Springfield, VA 22161, Document No. CONF-781016]: 593 pp.; pp. 530-537; 1979 (3 refs).

Three different bacterial test systems and *Drosophila* pupae were exposed to direct current electric fields at strengths of up to 800 kV/m to investigate the possible mutagenic effects of such fields. An exposure system was developed for exposing small organisms to large electric fields. Overnight exposure of *Salmonella* strain TA-100 to these fields resulted in a significant ($p=0.01$) increase in the frequency of mutants compared with unexposed control cells. This strain mutates primarily by base exchange. In contrast, *Salmonella* strain TA-98, which mutates primarily by frameshift, failed to show any significant differences in frequencies of revertants after exposures at similar field strengths. A significant increase in the frequency of mutant-type colonies ($p<0.01$) was also observed for *Photobacterium fisheri* (tested for resistance to tetracycline) under similar exposure conditions. Data on the induction of sex-linked recessive lethal mutations in 1-day-old *Drosophila* pupae exposed for 3 days in a 185-kV/m field were inconclusive.

MEETING ABSTRACTS

6774 MICROWAVE-INDUCED HYPERTHERMIA: AN EXPERIMENTAL ADJUNCT TO BRAIN TUMOR THERAPY (MEETING ABSTRACT). *(Eng.)* Samaras, G. M. (Sch. Medicine, Univ. Maryland, Baltimore, MD 21201); Salcman, M.; Cheung, A. Y.; Taylor, L.; Robinson, J. E.; Scott, R. M.; Slawson, R. G. *In. Proceedings of the International Symposium on Multidisciplinary Aspects of Brain Tumor Therapy held June 8-10, 1979 in Brescia, Italy*. p. 27; 1979 (no refs).

Two approaches for the use of microwave-induced hyperthermia as an adjunct to brain tumor therapy are described. The first approach employs an implantable miniature coaxial cable (outer diameter, 1.83 mm) configured as a sleeve antenna. Powered by a 2,450-MHz diathermy unit, it generates a roughly ellipsoidal heating pattern. Thermal fields at 24 sites were mapped in normal feline brains. The resultant thermal fields, 2 cm below the cortical surface, were controllable to fractions of a centimeter, were reversible to baseline values within 2 min of power cutoff, required only 6-10 W for production, and had no effects on core temperature and various other physiologic responses. The second approach employs a dual microprocessor controlled multiplexing control system that permits superposition of multiple beams of microwave radiation. Miniature microwave antennae external to the scalp are dicated that as few as four beams can produce a thermal gradient potentially lethal to a central tumor while leaving intervening tissue at a near normal temperature.

6775 MICROWAVE THAWING OF CANINE KIDNEYS (MEETING ABSTRACT). *(Eng.)* Holst, H. I. (Univ. Pennsylvania, Philadelphia, PA 19104); Lehr, H. B.; Ketterer, F. D. *Cryobiology* 15(6): 723-724; 1978 (no refs).

A unilateral kidney was removed from each of 16 anesthetized dogs (15-20 Kg body wt) perfused, frozen, thawed by 2,450-MHz microwaves, and reimplanted as an autograft in the neck of the animal. Four kidneys were perfused, frozen, and thawed as described by Guttman and 12 were perfused with a modification of perfusates utilizing Haemeccel and helium, frozen at 1-2 C/min in a silicone bath, and thawed with bursts of 2,450 MHz. All four kidneys prepared by Guttman's technique necrosed. Of the remaining 12, 5 partially survived reimplantation. All surviving kidneys were similar in that arteries, veins, pelves, and ureters survived, while cortex and medulla were almost completely replaced with scar tissue. Two of these kidneys were stored for 1 wk at +95 C before thawing and reimplantation.

6776 EFFECT OF MICROWAVE RADIATION ON ACUTE MYOCARDIAL ISCHEMIA IN CATS (MEETING ABSTRACT). *(Eng.)* Galvin, M. J. (Natl. Inst. Environmental Health Sciences, Research Triangle Park, NC 27709); McRee, D. I. *Fed Proc* 39(3, Part 2): 989; 1980 (no refs).

The effect of local microwave radiation with 2.45 GHz on the course of myocardial ischemia (MI) was investigated in cats. MI or sham ischemia was induced in cats by occlusion of the left anterior descending coronary artery, and the hearts were exposed to either microwaves (30 mW/g, absorbed energy) or sham irradiation immediately after occlusion. The cats were monitored for 5 hr following artery occlusion. The specific absorption rate of microwaves was determined directly from the time-temperature profile of irradiated myocardium using a Vitek temperature probe. Mean arterial blood pressure (MABP), cardiac output (CO), heart rate (HR), plasma and myocardial creatine phosphokinase (CPK), and S-T segment were not altered by microwaves in control cats. The animals with MI plus microwave exposure and the cats with MI only had comparable values of MABP (124 versus 125 mmHg), CO (52 versus 59 ml/min/kg), HR (124 versus 123 beats/min), plasma CPK (8.5 versus 9.0 International units/mg protein), and S-T segment (0.60 versus 0.63 mV) at 5

6777 THE EFFECT OF 2,450 MHz MICROWAVE RADIATION ON MAST CELLS (MEETING ABSTRACT). *(Eng.)* Ortner, M. J. (Natl. Inst. Environmental Health Sciences, Research Triangle Park, NC 27709); Galvin, M. J. *Fed Proc* 39(3, Part 2): 989; 1980 (no refs).

See Current Literature 6801 for description of this article.

6778 PHYSIOLOGICAL RESPONSE TO ACUTE MICROWAVE EXPOSURE DEPENDS ON THE CIRCADIAN RHYTHM (MEETING ABSTRACT). *(Eng.)* Lotz, W. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). *Fed Proc* 39(3, Part 2): 989; 1979 (no refs).

To determine if the increase in circulating cortisol levels resulting from acute exposure of rhesus monkeys to 1.29 GHz microwave radiation (threshold intensity of 38 mW/cm^2, 3.2 W/kg absorbed) is affected by the circadian rhythm, identical exposures were carried out at two different phases of the circadian cycle. Rectal temperature and plasma cortisol levels were determined hourly in three adult male rhesus monkeys before, during, and after an 8-hr exposure to pulsed microwave radiation, 1.29 GHz, over a total time period of 24 hr (lights on 0600-2200). Animals were exposed from 1200-2000 (day) or from 2200-0600 (night) to far-field conditions in an anechoic chamber at average incident power densities of 0 (sham) or 38 mW/cm^2. Rectal temperature increased an average of 1.5 and 2.0 C for the day and night exposures, respectively, although the absolute temperature reached was less during the night exposures (38.8 versus 39.3 C). Increased cortisol levels were observed in two of the three monkeys during the day exposures, but no difference was found between exposed and sham-exposed cortisol levels during night exposures. These results indicate that the physiologic response to acute microwave exposure is influenced by the circadian rhythm, but the mechanism of this interaction is unclear.

6779 GENETIC CONTROL OF MICROWAVE-INDUCED EFFECTS ON THE IMMUNE SYSTEM (MEETING ABSTRACT). *(Eng.)* Schlagel, C. J. (Naval Medical Res. Inst., Bethesda, MD 20014); Woody, J. N. *Fed Proc* 39(3, Part 1): 645; 1980 (no refs).

Inbred mice of the H-2^a haplotype (CBA/J, CBA/N, AKR, C3H/HeJ, and C3H/HeN) were subjected to a single 30-min exposure to 2,450 MHz microwaves. Six days later, significant increases in the frequency of complement receptor positive (CR$^+$) spleen cells as nonresponders reacted with increases in CR$^+$ cells after irradiation. Congenic B6-H-2^a mice having the responder H-2^a haplotype and nonresponder background genes failed to respond to microwave irradiation, whereas AKR-H-2 mice with the background genes of the AKR strain but with the H-2 haplotype acted as responders. The results indicated that there is a genetic predisposition for microwave-induced effects on the immune system. The gene or genes controlling the microwave-induced increase in CR$^+$ cells was found outside the H-2 complex with responsiveness being dominant over nonresponsiveness. The observation that in inbred mice responsiveness was associated with the H-2^a haplotype suggests that responsiveness may be controlled by non-H-2 genes closely associated with the H-2 complex.

6780 THE EFFECT OF MICROWAVES (9.7 GHz) ON MEMBRANE BOUND ACETYLCHOLINESTERASE IN THE VAGAL HEART SYSTEM (MEETING ABSTRACT). *(Eng.)* Young, W. (Sch. Optometry, Univ. California, Berkeley, CA 94720). *Fed Proc* 39(3, Part 1): 410; 1980 (2 refs).

The effect of microwave irradiation at 9.7 GHz on the vagal heart system was studied. Acetylcholine (ACh) was introduced either by electrical stimulation of the vagus nerve or by injection into the sinus. Microwave irradiation (30 min) at the mW/cm^2-level inhibited the membrane-bound acetylcholinesterase (AChE) activity by 60%. The activity gradually returned to normal. Contractility of the cardiac muscle was not affected. The cardiac rate, however, fell to about 7[illegible]% of the control. Addition of calcium in the perfusing fluid produced a similar inhibitory effect. The effect of microwave on membrane-bound AChE is interpreted as a release of bound calcium from the glycocalyx of the postjunctional membrane.

6781 LACTATE DEHYDROGENASE ACTIVITY OF HUMAN ORAL LEUKOCYTES MIGRATED BY MICROWAVE STIMULATION (MEETING ABSTRACT). *(Eng.)* Radchenko, V. (Res. Inst., American Dental Assoc. Health Foundation, Chicago, IL 60611). *J Dent Res* 59(A): 505; 1980 (no refs).

The stimulating effect of low energy microwaves on human oral leukocyte migration rate (OLMR) was studied. Saliva samples were collected by rinsing with 0.9% saline solution (about 10 ml) from 25 adult men before and after exposure to microwave radiation (1.0-2.0 W, continuous or pulse modulated, duration 10 min). Lactate dehydrogenase (LDH) enzyme activity of the migrated leukocytes was measured to quantify their viability. LDH activities of precipitate

stimulates human OLMR without degradation of leukocytes as indicated by their unaltered LDH activity.

6782 A STUDY OF MAGNETOPHOSPHENE THRESHOLD PARAMETERS (MEETING ABSTRACT). *(Eng.)* Lobel, D. (Natl. Magnet Lab., Massachusetts Inst. Technology, Cambridge, MA); Hale, J. R. *Invest Ophthalmol Vis Sci* 19(Suppl.): 8; 1980 (no refs).

A pilot study using normals and clinical subjects to investigate various parameters of magnetophosphenes was carried out. Alternating magnetic fields up to 1,000 G were generated using a coil and a variable frequency generator. Regulation of coil current and generator frequency allowed the investigation of frequency variation and root mean square field intensity on subjective thresholds. Individuals were seated facing a uniformly-illuminated hemisphere in a darkened room, with the magnetic coil adjacent to the eye to be measured. Varying the intensity and color of the light illuminating the hemisphere not only aided in measuring changing threshold levels, but enabled the investigation of the effects of various states of adaptation on the threshold. Use of the hemisphere aided in documenting the extent of the perceived phosphenes in the subject's visual field.

6783 INFLUENCE OF ELECTRIC FIELDS ON RPE GROWTH RATES (MEETING ABSTRACT) *(Eng.)* Byer, H. H. (Scheie Eye Inst., Philadelphia, PA 19132); Sassani, J. W. *Invest Ophthalmol Vis Sci* 19(Suppl.): 41; 1980 (no refs).

The effect of electric fields (E) on the cellular function (as measured by the proliferation rate) of bovine retinal pigment epithelial cells (RPE) was studied. Adult bovine RPE cells were grown in tissue culture while exposed to E fields at various magnitudes (1,300, 1,000, 650, and 300 V/cm) and pulse intervals (1/60, 1/30, 1/15, and 1/5 Hz), as well as with reversed field direction. Growth curves were generated by counting stained and fixed cells that were retrieved on alternate days over a 2-wk period. Results showed that the in vitro growth rates of RPE are significantly increased over controls when higher field strengths are applied in the apical-to-basilar direction, whereas growth rates are lower than controls when the field direction is reversed. While it is known that fibroblast production of deoxyribonucleic acid and collagen can be enhanced by E fields, these results appear to be the first demonstration of electric field influence on RPE.

MICROWAVE IRRADIATION (MEETING ABSTRACT). *(Eng.)* Stewart-DeHaan, P. J. (Univ. Western Ontario, London, Ontario, Canada); Trevithick, J. R.; Creighton, M. O.; Ross, W. M.; Larsen, L. E.; Jacobi, J. H. *Invest Ophthalmol Vis Sci* 19(Suppl.): 151; 1980 (no refs).

The effect of heat and microwave irradiation on rat lenses was investigated in vitro. Intact lenses in tissue culture medium were exposed to elevated temperatures for periods of up to 1 hr, followed by incubation at 35.5 C for 2 days. The maximum depth of degeneration, observed by scanning electron microscopy (SEM), was proportional to temperature up to 50 C. Lenses heated for 5 min were almost as damaged as those heated for 20 min at 41 C, suggesting that the initial heat shock is the critical factor in heat-induced cataract formation. The lenses, housed in a temperature-jacketed apparatus to be able to investigate separately the effects of elevated temperature and microwave radiation, were irradiated with 915 MHz microwave radiation using both high energy pulse (PU) and continuous wave (CW) of the same average power. The pulsed radiation was optimized for the production of thermal acoustic expansion. SEM was performed on lenses fixed immediately after irradiation. Controls at 39 C showed very small changes from normal lens morphologic appearance in both epithelial and fiber cells, whereas progressive damage (greater with PU than CW) occurred with increasing time of exposure. The maximum damage, observed at this temperature, occurred at the maximum PU time of exposure tested (20 min); this involved the production of holes in the equatorial lens fiber cells to a depth of approximately 80-100 μm below the lens capsule.

6785 A NON-INVASIVE FORM OF ELECTRICAL STIMULATION OF UNUNITED FRACTURES OF THE TIBIA (MEETING ABSTRACT). *(Eng.)* de Haas, W. G. (No affiliation given). *J Bone Joint Surg [Br]* 62B(1): 131; 1980 (no refs).

Fourteen patients were treated with an iron-cored electromagnet for ununited fractures of the tibia. The apparatus consisted of a U-shaped laminated iron electromagnet and an electronic power unit that supplied a square wave signal at a repetition rate of 1 Hz. The magnetic flux density reached 900 G at the pole pieces. The magnetic field was orientated transversely across the fracture site for approximately 20 hr/day for 4-8 wk after which cast immobilization was continued for 4-6 mo. Fourteen of the 15 fractures united soundly. Refractures, which have subsequently healed, occurred in three patients. No harmful effects were observed.

TION (MEETING ABSTRACT). *(Eng.)* Sutcliffe, M. L. (No affiliation given); Sharrard, W. J.; MacEachern, A. G. *J Bone Joint Surg [Br]* 62B(1): 123; 1980 (no refs).

Twenty-three patients suffering from either infantile pseudarthrosis of the tibia (5 patients) or nonunion of a fracture (18 patients) were treated by pulsing electromagnetic fields. The affected bones included 10 ununited fractures of the tibia, 3 of the femur, 3 of the radius, 1 of the ulna, 1 failed arthrodesis of the ankle, and 5 infantile pseudarthroses of the tibia and fibula. The time since fracture ranged from 1 to 29 yr. Two Helmholtz-aiding "O" coils were placed on the outer surface of a plaster cast and fed by a highly specific pulsed current (Bassett's technique). A magnetic field of about 2 G induced a flow of current in the bone of 1.0 to 1.5 mV/cm². Treatment was applied for 15 hr/day until clinical and radiologic evidence of union was present. As union proceeded, axial impactive compression exercises and progressive weight-bearing in plaster were used to stimulate the progress of union. Union was achieved in 15/18 ununited fractures and 4/5 pseudarthroses of tibia, with a mean time of union of 5.5 mo and 7.75 mo, respectively. It is suggested that failure may have been due to inadequate immobilization or the presence of a synovial pseudarthrosis. The presence of metal internal fixation did not bar success, and sepsis or sinuses usually healed during treatment.

6787 THE CAUSALITY OF ELASTIC, ELECTRICAL AND MAGNETIC FORCES IN THE HEALTHY AND DEFECTIVE BONE (MEETING ABSTRACT). *(Eng.)* Kraus, W. (Institut fur Medizinische Physik, Augustenstrasse 41, 8000 Munchen 2, W. Germany). *In: Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-1; 1979 (no refs).

A hypotheses concerning the interaction of mechanical and magnetic forces in the living structure, analogous to the mechanical-electrical causality of piezoelectrical polarization of collagen fibers, is presented. It is proposed that separation of charges in the cytoplasm and the build up of electrical potential on either side of the mitochondrial membrane are produced by magnetic forces. The conditions of the Hall effect are met in the healthy organism. This arises in the presence of the earth's magnetic field via acceleration of ions during the elastic waves of systolic blood pulsation in the vessels. The decrease in the amplitude of elastic oscillation (e.g., because of arteriosclerosis) would thus lead to a decrease in results of some experimental applications of electrodynamic field therapy are also reported. 1) Experiments with probes of human spongy bon resected during hip joint operations were conducte using electrodynamic field therapy. The probes wer then further stimulated in Hank's solution, saturate with calcium phosphate, and within 24 hr showed highly significant increase in calcium uptake (appro imately 70% higher than nontreated probes). X-ra analysis showed a significant increase in density c the stimulated probe. 2) Experiments with screw an plate implantations in the lower jaws of beagle demonstrated that the electrodynamic procedur resulted in bone that was superior to the contr group on the basis of mechanical strength and o histologic analysis (ratio 1:3, p=0.0001). 3) Preliminar results on 132 patients receiving magnetic field trea ment for advanced loosening of prothese demonstrated that a revisionary operation was n longer deemed necessary in 92 patients. Th average duration of treatment was for 20 wk, 40 min 3 times/day. The period of observation extende over 5 yr.

6788 RECENT EXPERIMENTAL AND CLINICA RESULTS OF THE ELECTRODYNAMI FIELD THERAPY (KRAUS-LECHNER) (MEETIN ABSTRACT). *(Eng.)* Lechner, F. (Dept. Surger Garmisch-Partenkirchen Hosp., Garmisch Partenkirchen, W. Germany); Ascherl, R. *In: Pr ceedings of the Second Meeting of the Europea Society of Biomechanics and First Symposium of th Groupe d'Etudes de Biomecanique Oste-Articulai de Strasbourg held September 13-15, 1979 Strasbourg, France.* (General Assembly of the Cour cil of Europe): C-2; 1979 (no refs).

Electrodynamic field therapy (EFT), a semi-invasiv procedure for electrostimulation of bone repair usin low-frequency alternating current, has been used i clinical practice for 9 yr. EFT results in an externa magnetic field of 2.4×10^{-1} A/mm and a current dens ty of approximately 10 μamps/mm² near the elec trode's surface. Results from recent experiment with EFT are briefly described. 1) When calcium up take was measured in vitro after EFT, a significant in crease (3.84 compared to 2.2 μvals/cm³ for control was demonstrated in two spongy bone block prepared from the resection end of the femoral nec after total replacement of the hip joint. 2) Bone cor solidation was achieved in 92% of 273 patients suffe ing from pseudoarthroses; hospitalization usually re quired only about 8 wk. 3) EFT used to treat som cases of primary or secondary bone tumors, whe radiation, cytostatics, and amputation had bee refused, demonstrated a transformation c osteoclastic reactions to osteoblastic reactions

Straumann, Waldenburg, Switzerland). *In: Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-3; 1979. (3 refs).

Three physicochemical effects are discussed in relation to the proposed electric and magnetic mechanisms for bone growth stimulation. 1) According to Neumann's principle, excitation by magnetic and electric fields or current cannot produce the high differentiation of the solid bone matrix; at best, only a diffuse precipitation of the solid matter is possible. 2) The response of a material (i.e., tissue) to electromagnetic stimulation is completely determined by material equations. The energies of polarization may then be obtained and compared with chemical and mechanical free energies. This energy, however, is too small to account for the suggested stimulation procedures. 3) The possible stimulation by current electrodes may be explained by Faraday electrode reactions. A transport equation must also be solved to obtain local ion concentrations around the electrode. Thus, the effect of a direct current stimulation could be explained simply by "local alcalosis" at the cathode, which results in local storage of calcium and phosphate, and "local acidosis" at the anode, which mobilizes the calcium from storage. Thus, if the buffer capacity of the extracellular fluid is overwhelmed, a current threshold should be observed. High currents should, on the other hand, induce toxicity so that a "stimulation window" becomes apparent. It is concluded that with one exception, the laws of physics do not support bone growth stimulation by electromagnetic fields.

6790 THE RESPONSE OF BIOLOGICAL SYSTEMS TO ELECTRIC CURRENTS INDUCED BY PULSED MAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Jackson, S. F. (Strangeways Res. Lab., Cambridge, England); Farndale, R. W.; Jones, D. *In: Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-4; 1979. (8 refs).

Studies to determine the way biologic mechanisms respond to induced electric currents have been conducted at the Strangeways Laboratory in Cambridge, England to determine 1) if the normal rates of synthesis of major extracellular macromolecules are altered during the laying down of osteogenic and chrondrogenic tissues, 2) if the cellular mechanisms under the control of cyclic-3',5'-adenosine monophosphate are also affected, 3) if the long bone rudiments exposed to treatment with magnetic fields, consisting of 8 days of alternating 6-hr on-off periods, were used as models. The results indicated that considerable welts of periosteal bone are laid down during the second half of culture, that the dry weight of the bony shafts is increased by over 50%, that the net rates of synthesis of hydroxyproline and hexosamine (used, respectively, as a measure of the amount of collagen and ground substance produced) are not grossly accelerated by treatment with the coils, and that the rate of uptake of bound ^{45}Ca osteogenic tissue, expressed as counts/min/μg deoxyribonucleic acid, may be critically inter-related with the phased (6 hr) on-off periods of treatment. To determine if specific ion transport across the cellular membranes is modulated, the ion flux of various cell systems exposed to pulsed magnetic fields (PMF) was measured, and specific inhibitors were used to determine if the observed ionic movements across the cell membrane were mediated by the metabolic activity of the cell or by a direct effect on the ion. The potassium flux in the human red blood cells was studied with a ^{86}rubidium tracer. The results indicated that the flux rates of both ouabain-sensitive and ouabain-insensitive components are altered as compared to those of untreated controls.

6791 ELECTROMAGNETIC MODULATION OF FRACTURE REPAIR IN THE RAT (MEETING ABSTRACT). *(Eng.)* Christel, P. (Bioelectrochemistry Lab., Orthopedic Res., Dept. Orthopedic Surgery, Columbia Univ., 630 West 168th St., New York, NY 10032); Cerf, G.; Pilla, A. A. *In Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-7; 1979. (no refs)

The hypothesis that a kinetic perturbation of the real-time electrical response of a cell and/or tissue system may have a modulating effect on specific cellular functions was assessed. Utilization of the electrochemical information transfer approach coupled with ancillary real-time transient analysis of living cell membranes resulted in the configuration of a family of low-level pulsating current waveforms predicted to have a biologic effect. The waveform configurations are inductively coupled and are designed to examine several perturbation/relaxation regimens that have quantitatively different real-time coupling to the cell or tissue system. In addition, the effect of tim and amplitude asymmetry in these necessarily bipolar signals was assessed. The specific waveforms surveyed consisted of single pulses of 325-μsec duration having repetition rates of 70-500 Hz and of pulse bursts of 200-μsec duration having burst durations of 5-50 msec and burst repeti-

μA/cm² was carried out. A transverse mid-shaft radial osteotomy was performed bilaterally on Sprague-Dawley rats (body wt 250-300 g); after recovery, each animal was exposed for 12 hr/day to each waveform tested and then sacrificed 14 days postoperatively. Each properly aligned radius (average 11 samples for each of the 15 waveforms) was subjected to a destructive tensile test. The results show that the induced waveform configuration as well as the perturbation/relaxation modality had a statistically significant effect on ultimate tensile strength, stiffness, brittleness, and energy to failure. The effect of time/amplitude asymmetry for each waveform type showed that a more advanced healing stage is achieved when the opposite polarity portion of the waveform is sufficiently short to enable a kinetically unipolar real-time tissue coupling to be achieved. For example, a 325-μsec single pulse having a 20-μsec opposite polarity duration resulted in a 20% increase in ultimate tensile strength, whereas the same pulse with a 4-msec low amplitude opposite polarity duration, resulted in a statistically significant difference in this quantity. Similar effects were obtained as a function of the signal repetition rate. The "best" signal tested resulted in a 30% increase in ultimate tensile strength versus controls. This preliminary study shows that electromagnetically-induced electrochemical information transfer may be a valuable tool for the study of fundamental cellular processes. The effect of the mode of the kinetic coupling (perturbation/relaxation regime) on the ultimate tissue result may provide evidence concerning the effect of the cell's microenvironment, its cycle stage, state of differentiation, etc., on the required waveform parameters for optimal kinetic modulation.

6792 ELECTROCHEMICAL INFORMATION: TRANSFER VIA PULSING ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Pilla, A. A. (Biochemistry Lab., Orthopedic Res., Dept. Orthopedic Surgery, Columbia Univ., 630 West 168th St., New York, NY 10032). *In: Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-8; 1979 (no refs).

A theoretical model that provides real-time electrochemical response pathways for a cellular system that has been exposed to low level current is proposed. The interactions and/or transport of charged species at a cell's surfaces and junctions can exhibit kinetic potential dependence that is relatively reversible. Basically three general types of electrochemical processes are considered. The first involves the dielectric nature of the cell membrane coupled with nonspecific electrostatic interactions at

results of electrochemical kinetic analysis indicat that excitation of membrane transport, i.e., ion membrane flux, appears to be the predominant rea time response modality. Thus, the choice waveform parameters involves consideration of th expected exponential dependence of amplitude (cu rent density) versus repetition rate. In addition, th ability of a given cell to respond via a regulatory (ve sus, e.g., defense) pathway will probably depend c the net rate of change of intracellular ionic conce tration versus the kinetics of the regulatory proces involved. A family of current waveforms has bee developed to couple with expected ranges of ce surface coupled regulatory kinetics. This approac was tested on several in vitro and in vivo system The rate of amphibian red blood cell (RBC) "dedi ferentiation" was shown to be a window function the repetition rate of bipolar single pulse waveform in which the duration of both polarities was sufficier to kinetically couple with, e.g., membrane transpor The rate of Ca^{++} uptake by embryonic chick lim rudiments at short times (1 hr) was found to b significantly larger for long than for short perturbi tion times, with all other parameters equal. another experiment, the enhancement of deox ribonucleic acid synthesis in isolated bone cel was dependent on the time/amplitude asymmetry induced bipolar waveforms, demonstrating effec similar to those observed with the amphibian RB system. The results of these experiments and othe more recent studies demonstrate that the particul cell response to which induced pulsating curre waveforms can couple depends on the cell and i microenvironment.

6793 NON-INVASIVE OUT PATIENT TREA MENT OF SURGICALLY-RESISTAN NON-UNIONS BY INDUCED PULSING CURREN CLINICAL RESULTS (MEETING ABSTRACT). *(Eng* Mulier, J. C. (Dept. Orthopedic Surgery, Uni Leuven, Leuven, Belgium); Spaas, F. *In Proceedin of the Second Meeting of The European Society Biomechanics and First Symposium of the Grou d'Etudes de Biomecanique de Oste-Articulaire Strasbourg held September 13-15, 1979 in Strasbour France.* (General Assembly of the Council Europe): C-9; 1979 (no refs).

The results of a clinical study that involved the ap plication of electromagnetic coils externally ove fracture sites to treat nonunions are reporte Twenty-one patients with long-standing nonunions with infections), who had previous unsuccessf surgical intervention (average, 3.1 interventions/pe son) at least 50 mo before treatment (range, 5 mo-4 yr), were treated. The fractures were of the tibia in 1 humerus in 3, and ulna in 1. The prior disability tim ranged from 1.25 to 8.33 yr. The coils and puls generator were adapated to the patient on the bas

0.001 C occurs. Nonweight-bearing is essential during the initial months of treatment. At the time of this report, treatment resulted in nine patients with total fractures to a definable end-point, six with functional union (bridging on x-ray; no mobility, pain, or tenderness; free or supported weight-bearing), two withdrawals from the study, and one without any progress. Problems associated with the routine included the need for absolute accuracy in locating the coils (by means of x-rays), application of the correct electrical signals, and occasional lack of patient cooperation. The results demonstrate that the treatment was effective in some cases of difficult nonunions. The authors conclude that the technique is generally well accepted and economically of interest since it avoids costly surgery and hospitalization in the future.

6794 FRACTURE HEALING AND ELECTRICAL STIMULATION (MEETING ABSTRACT). *(Eng.)* Perren, S. M. (Lab. Experimental Surgery, Swiss Res. Inst., CH-7270 Davos-Platz, Switzerland); Chapman, M. W. *In: Proceedings of the Second Meeting of the European Society of Biomechanics and First Symposium of the Groupe d'Etudes de Biomecanique de Oste-Articulaire de Strasbourg held September 13-15, 1979 in Strasbourg, France.* (General Assembly of the Council of Europe): C-10; 1979 (no refs).

The mechanism of action of electrical bone stimulation and the theoretical basis for the various techniques are discussed. Direct current produces bone formation mostly at the cathode. It has not yet been determined if this is a specific biologic reaction. The bone formation that is observed may be a reaction to electrical irritation, with electrical information serving as the link between mechanical load and functional adaptation in the bone. Alternating potential arising out of changing bone stresses has not yet been demonstrated to produce meaningful changes in the bone structure; therefore, the authors conclude that piezoelectricity cannot account for the mechanism of electrical stimulation. Three different types of electrical stimulation based on different theoretical explanations are currently in use: 1) direct current applied at 10-20 μamp via metal electrodes implanted in bone (Brighton), 2) electromagnetic stimulation applied as a pulsating magnetic field transverse to the longitudinal axis of bone (Bassett), and 3) the combined method of Kraus and Lechner that produces a magnetic field parallel to the longitudinal axis of bone, and, via an implanted inductor, generates alternating potentials of approximately 100 mV. The minimum requirements for proof of the efficacy of these methods are experimental verification in a double-blind study conducted in an independent laboratory, quantitatively significant results using an adequate experimental model, and a problem since they are frequently complicated by infection. It is suggested that any method that can provide equal or better results than cancellous bone grafting or can be used to augment the healing from bone grafting is of interest. The authors conclude that the stimulation of bone healing is an area of potential fruitful laboratory research, in view of its important clinical applications. Most likely the ideal solution to the stimulation of bone healing will be a combination of several differing methods that permit achievement of an optimal functional result.

6795 RADIOFREQUENCY LESIONS IN THE TREATMENT OF PAINFUL SYNDROMES: CONSIDERATION IN 155 CASES (MEETING ABSTRACT). *(Eng.)* Frank, F. (Second Neurosurgical Div., Ospedale Maggiore Sezione Bellaria, Bologna, Italy); Galassi, E.; Frank, G.; Gaist, G.; Tognetti, F. *Acta Neurochir (Wien)* 51(1/2): 144; 1979 (no refs).

Percutaneous radio frequency techniques were used over a 15-mo period to treat painful syndromes. One hundred and eighteen trigeminal thermorhizotomies and 37 cervical cordotomies were performed with this procedure. Special references to the indications, advantages, and limits of this kind of management are presented.

6796 EFFECT OF ELECTRIC FIELDS ON BONE ATROPHY OF DISUSE IN THE RAT (MEETING ABSTRACT). *(Eng.)* Perumal, T. A. (Dept. Physiology, Christian Medical Coll., Vellore, India); Bullard, T. K.; Jayachandran, C. *Indian J Physiol Pharmacol* 22(2): 227-228; 1978 (no refs).

The effect of capacitively coupled electric fields on the development of disuse atrophy in bone was studied in the rat. One hind limb of a rat was immobilized in a plaster cast containing two insulated brass plate electrodes that were located on the lateral and medial surfaces of the limb. Electric pulses of 1-msec duration (100 V and 200 V, 500 Hz) were applied to the electrodes producing an electric field around the limb between them for a period of 6 hr/day. The contralateral limb was free and not restricted in any way. A dose of tetracycline (100 mg/g) was given intraperitoneally on the 1st and 14th day of the experiment. Control animals were subjected to the same procedures without application of the electric fields. At the end of 21 days of treatment all animals were sacrificed and the following parameters were measured in tibia of both limbs: dry wt, percent ash, new bone deposition rate, and x-ray density. Differences obtained between electrically treated and normal bones in experimental animals were compared with differences observed between "sham-treated" and normal bones in control

fields used were effective in decreasing the degree of bone atrophy of disuse caused by immobilization.

6797 BONE HEALING UNDER ALTERNATING ELECTROMAGNETIC FIELDS? (MEETING ABSTRACT). *(Eng/Ger.)* Sturmer, K. M. (Abteilung fur Unfallchirurgie, Universitatsklinikum, D-4300 Essen, W. Germany); Kehr, H.; Schmit-Neuerburg, K. P.; Seidel, K. *Langenbecks Arch Chir* (47): 709-710; 1978 (no refs).

Atrophic and infected nonunions of both ulnae in 21 female beagle dogs were treated with alternating electromagnetic fields and alternating current transducers at the bone, according to the Kraus' technique, in a right-left trial. X-rays, microangiography, microradiography, polychrome sequence labeling, stained histology, and polarization were evaluated. One group showed more periosteal reaction on the treated side but not better healing. The second group with additional cancellous bone graft developed more new bone in the defect on the electrically treated side compared with the control side.

6798 NEUROBEHAVIORAL CONSEQUENCES OF MICROWAVE IRRADIATION IN JAPANESE QUAIL (*COTURNIX COTURNIX* JAPONICA) EXPOSED DURING EMBRYOGENESIS (MEETING ABSTRACT). *(Eng.)* Cabe, P. A. (Lab. Behavioral and Neurological Toxicology, Natl. Inst. Environmental Res. Sciences, Research Triangle Park, NC 27709); Burne, T. A.; McRee, D. I. *Environ Health Perspect* 33: 322; 1979 (no refs).

Eight male Japanese quail exposed to 2,450 MHz microwave irradiation at an incident power density of 5 mW/cm² over the first 12 days of incubation were tested in a series of behavioral screening procedures. Eight male birds served as controls. Body weights, which did not differ between exposed and control groups at any time, were measured weekly from 7-18 wk. Four triweekly evaluations of spontaneous motor activity also showed no microwave effect. Exposed birds, however, did show significantly fewer avoidance responses in a shock-motivated escape-avoidance test, both during acquisition training and in a 3-wk retention test. Control birds had significantly more intertrial interval response, and significantly fewer escapes than exposed animals on retention testing. Failures to respond (escapes lost) were not different at either acquisition or retention. A series of operant conditioning procedures using a food rewarded key-peck response demonstrated that exposed birds had a somewhat higher operant level sistently lower rate under a random interval sche of reinforcement. These results indicate the feasi ty of the several screening techniques used. potential usefulness of the Japanese quail mo and the possible behavioral teratogenic effect microwave irradiation.

6799 EFFECTS OF MICROWAVE RADIAT ON THE VITALITY OF ISOLATED FR SCIATIC NERVES (MEETING ABSTRACT). *(E* McRee, D. I. (Lab. Environmental Biophysics, N Inst. Environmental Health Sciences, Resea Triangle Park, NC 27709); Wachtel, H. *Environ He Perspect* 33: 342; 1979 (no refs).

Isolated frog sciatic nerves were exposed i waveguide system to 2.45 GHz continuous wave (microwave radiation at specific absorption ra (SARs) ranging from 0 mW/g to 100 mW/g. The ef of microwaves on the vitality of the nerves measured in terms of the ability of the nerves to s tain a high firing rate over prolonged periods with suffering appreciable changes in the characteris of the compound action potential (CAP). The ner were stimulated by using twin pulses separated b 5-msec interval at a repetition rate of 50 pulses/s For SARs >10 mW/g, the exposed nerves were f seen to undergo a prolongation of their refract period, followed later by severe decreases in maximal CAP. These effects appeared to microwave-specific; they were not observed eit when the temperature was held constant or when temperature was increased in the absence microwaves. The effects also were found to be reversible since the nerves did not revitalize or crease their activity on termination of exposure. significant effects on vitality of the nerves w observed for a SAR of 5 mW/g.

6800 EXPOSURE OF PREGNANT MICE TO 2 GHz MICROWAVE RADIATION (MEETI ABSTRACT). *(Eng.)* McRee, D. I. (Lab. Environmer Biophysics, Natl. Inst. Environmental Hea Sciences, Research Triangle Park, NC 277 Nawrot, P. *Environ Health Perspect* 33: 342; 1979 refs).

The effects of 2.45 GHz microwave radiation on pr nant mice (CD-1 strain, 49- to 55-days old, 27-29 g) a their developing fetuses were studied. Separ groups of mice were exposed to 5, 21, and mW/cm² incident power density. The correspond specific absorption rates were approximately 5 22.3, and 31.8 mW/g. The mice were exposed fo

to 15 for power densities of 21 and 30 mW/cm². Control groups were established to evaluate the effects of other factors, such as elevated temperature and handling. Environmental temperatures were set to simulate the thermal stress produced by microwave exposure. Maternal and fetal response to the different conditions was determined by measuring pregnancy rate, maternal weight gain, number of litters, implantation sites per litter, resorptions, live fetuses per litter, average fetal weight, stunted fetuses, dead fetuses, and malformed fetuses. The results of the experiment show that a significant decrease in pregnancy rate from 86 to 72% was measured due to handling during the early stages of pregnancy (days 1-6). An additional decrease to 65% occurred at exposure to 21 mW/cm² (days 1-6), and to 50% at 30 mW/cm² (days 1-6). A significant decrease in maternal weight gain was measured in all handled groups of animals. No difference was measured between the irradiated handled and temperature handled groups. A significant difference in average fetal weight was measured due to a combination of handling and heating. No significant difference occurred between irradiated handled and temperature handled groups. A significant increase in congenital malformations occurred only at the 30 mW/cm² (6-15 days) exposure. An increase from 1.7% in the temperature handled control group to 3.1% in the irradiated handled group was measured. Two-thirds of the malformations were cleft palte.

6801 EFFECT OF 2,450 MHz MICROWAVE RADIATION ON RAT PERITONEAL CELLS (MEETING ABSTRACT). *(Eng.)* Ortner, M. J. (Lab. Environmental Biophysics, Natl. Inst. Environmental Health Sciences, Research Triangle Park, NC 27709); Galvin, M.; Turek, N.; Hall, C. *Environ Health Perspect* 33: 343; 1979 (no refs).

A microwave exposure system was developed for studying functioning secretory cells under the influence of nonionizing radiation. Cells were exposed to 2,450 MHz microwave radiation at both 8.5 and 42.5 mW/ml of cell suspension for periods of up to 3 hr. The cells were maintained at 37 C throughout the exposure period. The specific absorption rate of Locke's solution containing mast cells was determined directly from the time-temperature profile of specimens at the beginning of exposure. Microwave exposure caused no change in the morphologic characteristics or cell viability as determined by trypan blue exclusion. When irradiated mast cells were stimulated with compound 48/80, the dose/response curves showed that, even at submaximal concentrations, prior irradiation of mast cells did not affect 48/80-induced secretion. When mast cells that had been continuously irradiated for 3 hr were treated with 48/80 during irradiation, the secretory response to 48/80 was not inhibited. These exfor 10 min became totally refractory to 48/80, whereas cells from the same sample exposed to 3 hr of radiation at 37 C responded normally, indicating that no heat-induced damage to the mast cell membranes during microwave exposure was observed. It is suggested that rat peritoneal mast cells can be useful as a biologic test system to determine the effects of microwave exposure on isolated cells.

6802 ELECTROMAGNETIC RODENT CONTROL FOR POULTRY FACILITIES (MEETING ABSTRACT). *(Eng.)* Muller, H. D. (Cooperative Extension Service, Univ. Georgia, Athens, GA 30602). *Poult Sci* 57(4): 1107; 1978 (no refs).

The role of electromagnetic devices for rodent control in poultry facilities is reviewed. Field evaluations of several commercial electromagnetic rodent control devices have demonstrated rodent population reduction when units were properly located and installed. Rodent control programs utilizing magnetic repellers have been assisted by harborage reduction. Initially, devices evoked increased activity such as burrowing followed by atypical behavior including distorted diet patterns, burrow avoidance, lethargy, reduced reproduction, anorexia, and hypoactivity resulting in death. The mode of action is hypothesized to involve an induced neurologic dysfunction manifested by reduced reaction time and asthenia. Recovery was noted when the magnetic field was interrupted or withdrawn. Responses were confined to rats and mice. Rodent control devices that reputedly evoke rodent control by electromagnetic charging of the ground and/or structures offer a new approach to rodent damage and hazard control.

6803 EXPOSURE OF CHICKEN EGGS TO AN ELECTROMAGNETIC FIELD PRIOR TO INCUBATION (MEETING ABSTRACT). *(Eng.)* Hester, P. Y. (Dept. Animal Sciences, Purdue Univ., West Lafayette, IN 47907); Fabijanska, I. *Poult Sci* 57(4): 1145; 1978 (1 ref).

White Leghorn eggs were exposed to electromagnetic (EMG) fields prior to incubation. The eggs were individually rolled through a magnetic coil with an exposure time of 3 sec/egg. Hatchability percent and body weights of chicks from control and treated eggs were determined at 20.5 and 21.5 days of incubation. The treated eggs of trial 1 were exposed to a 90 G EMG field produced by a direct current. The four treated groups of trial 2 consisted of the following: direct current 125 G, direct current 160 G, alternating current 125 G, and alternating current 160 G. It was concluded that the levels of EMG energy utilized

description, which claimed that comparable levels of EMG energy caused a 5-8% increase in hatchability percent when compared with untreated controls.

6804 EFFECTS OF MICROWAVES ON FEATHER RELEASE IN CHICKENS (MEETING ABSTRACT). *(Eng.)* Kula, S. A. (Dept. Animal Sciences, Colorado State Univ., Fort Collins, CO 80523); Miller, B. F.; Enos, H. L.; Goble, J. W. *Poult Sci* 57(4): 1150; 1978 (no refs).

One hundred and ninety-three birds were processed by microwaves. All of the feather tracts were tested for feather release and tissue damage on each bird. A statistical discriminant analysis was done and it was concluded that proper feather release can be achieved, depending on the bird's weight, the power used, and the time stressed, and also depending on which area of the bird the feather release is observed (either extremities or torso feather tracts). An estimation of energy consumption indicated hot water scalding would require about 200 BTU per bird, compared to 132 BTU using microwave-induced feather release, a potential energy savings of 34%.

6805 REPRODUCTION IN JAPANESE QUAIL SUBJECTED TO MICROWAVE RADIATION AS EMBRYOS (MEETING ABSTRACT). *(Eng.)* Thaxton, J. P. (Dept. Poultry Science, North Carolina State Univ., Raleigh, NC 27650); Parkhurst, C. R.; McRee, D. I. *Poult Sci* 57(4): 1167; 1978 (no refs).

Japanese quail embryos were subjected to microwave radiation exposure during the first 12 days of embryogenesis. Nonexposed quail eggs served as controls. Reproductive performance was monitored from 6 through 22 wk of age. Nonexposed controls of both sexes, as well as exposed females, performed normally. The exposed males demonstrated reduced sperm numbers, reduced sperm motility, and a decreased percent of fertile eggs produced by control or exposed females when paired with exposed males. Mating behavior was normal in both exposed and nonexposed males.

6806 REARING OF CHICKEN FROM HATCHING TO THE END OF THE 1ST LAYING-PERIOD IN AN ELECTRIC FIELD (30 kV/m, 50 Hz) (MEETING ABSTRACT). *(Eng.)* Bootz, A. (Dept. Veterinary Physiology, Free Univ., Berlin

Chickens that were bred under a 5.0 kV/m ele field were continuously exposed to an alterna electric field (50 Hz) of 30 kV/m for 43 wk. The crease of weight until the 20th wk was identical that of controls. From the 21st-43rd wk, there wa difference in egg numbers (exposed animals, eggs/hen; controls, 117 eggs/hen). The m weights of eggs, however, revealed increasing ferences between animals within and outside field. From the 26th-43rd wk, the mean egg weigl the control group increased by 11.9 g while that o field group increased by only 5.6 g. Exposed c exhibited behavioral alterations, e.g., being m more aggressive than unexposed chickens. Fem also showed behavioral changes, such as nes and sitting on eggs, that were not observed in zero-field. The eggs of the exposed and cor groups were gathered and subsequently incuba Hatching rates of about 80% resulted in both the and control groups. All descendants of the animals developed normally. When the laying-h and the cocks were dissected and the organ wei determined and blood samples serologically lyzed, no anomalies were noted in the expo animals.

6807 EFFECTS OF APPLIED MAGNE FIELDS ON HOMING PIGEON ORIEN TION (MEETING ABSTRACT). *(Eng.)* Visalberghi (Instituto di Biologia Generale, Universita di P Pisa, Italy); Alleva, A. *Monit Zool Ital* 12(1): 73 1978 (1 ref)

Three pigeon groups equipped with either Hemh coils of the Nup or Sup type or with Hemholtz c without circulating current (controls) were relea under overcast conditions from three sites (32 ENE, 23.5 km E, and 44.5 km ESE). Thirty-three N 34 Sup, and 17 control birds were tossed and 18, and 10, respectively, vanishing points were rec ed. Pooling the bearings resulted in findings sim to those observed in a previous study: for the f birds there was a significant clustering of vanish points around the direction opposite to that of the ($p<0.005$), whereas for the Sup and control bi there was a significant clustering around the ho direction ($p<0.05$, $p<0.05$). No significant differen were noticed in both homing and vanishing time the different treatments. Pooled data of five relea performed under sunny conditions from three ferent sites (48.3 km ESE, 46.2 km SSE, and 105 ESE) from the loft (44 Nup, 44 Sup, and 44 contr released and 27, 38, and 41 vanishing poi respectively, were recorded) showed a signific clustering of vanishing points of the three gro around the home direction (Nup $p<0.0001$, S $p<0.0001$, and controls $p<0.0001$). Although the m

Both Nup and Sup groups homed significantly slower than control birds ($p<0.009$ and $p<0.005$, respectively). No differences in the vanishing times among the three treatments were observed. Our results confirm the existence of a magnetic compass in the homing pigeon. The authors suggest that the delay in homing of Nup and Sup birds under sunny conditions be investigated.

6808 DIELECTRIC PERTURBATION OF HYDROGEN-BONDED SYSTEMS BY HIGH ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* Hellemans, L. (Dept. Chemistry, Univ. Leuven, 200 D Celestijnenlaan, B-3030 Heverlee, Belgium); De Maeyer, M.; Ooms, R. *Arch Int Physiol Biochim* 87(5): 1209; 1979 (3 refs).

The effect of high electric fields on chemical equilibria involving hydrogen bonding in nonpolar medium was investigated. A condition for perturbation by the field was the different polarity of the reaction partners. The nonlinear dielectric response of the perturbed systems was measured in the frequency domain of 1-100 MHz. Systems including the association of ε-caprolactam in cyclohexane, the association of *n*-butanol in paraffin, and the complexation with proton transfer of 2,4,6-trichlorophenol and triethylamine in cyclohexane were analyzed. The reactions were all extremely fast (nearly diffusion-controlled) and a variety of nonlinear effects of different origin was encountered. Amplitudes provided thermodynamic information (K, μ), which matched the kinetic results obtained from the relaxation times. The helix-coil equilibrium in polypeptides is established by competition between internal hydrogen bonding and bonding to solvent molecules. Measurements on some synthetic polypeptides are discussed. Interference from nonlinear effects not related to the field-promoted conformational change was illustrated. The systems stand as model for field-dependent membrane processes as conditions of polarity and field strength (100 kV/cm) were comparable in both situations.

6809 MICROWAVE MEASUREMENTS OF CRYOPROTECTANT PROPERTIES (MEETING ABSTRACT). *(Eng.)* Ketterer, F. D. (Harrison Dept. Surgical Res., Univ. Pennsylvania, Philadelphia, PA 19104), Macklis, J. D., Noorchasm, M. R.; Holst, H. I., Lehr, H. B. *Cryobiology* 15(6) 722, 1978 (no refs).

The nature of microwave measurement of cryoprotectant properties is briefly reviewed, and some experimental results are briefly discussed. To obtain a better understanding of the heating process, act analytical model of the re-entrant cavity, the dielectric constant and conductivity may be determined. The cavity is then cooled and measurements are repeated, so that the electrical properties may be determined over the range of -100 to +25 C. To date the properties of pure dimethylsulfoxide, glycerol, and ethylene glycol have been measured, as well as ethylene glycol in varying concentrations. The results indicate that the electrical properties depend strongly on temperature, concentration, and choice of cryoprotectant.

6810 MICROTHERMOMETER FOR ORGAN THAWING (MEETING ABSTRACT). *(Eng.)* Ketterer, F. D. (Harrison Dept. Surgical Res., Univ. Pennsylvania, Philadelphia, PA 19104), Holst, H. I., Lehr, H. B. *Cryobiology* 15(6): 722-723, 1978 (no refs).

A microthermometer that is based on the minute displacement of a low-temperature liquid as temperature changes was developed. A pulsed-light-emitting diode transmits light through optical fibers to the sensor that reflects a portion back through a second bundle of fibers to a photodiode detector. The signal is processed and displayed as a digital read-out. Preliminary data on a prototype indicate a temperature range -60 to +25 C with acceptable linearity. A probe diameter of approximately 2 mm should allow the probe to be implanted in the organ prior to freeze-thawing to monitor interior organ temperatures during microwave heating.

6811 MICROWAVE EFFECTS ON VIABILITY AND HEREDITY OF MAMMALIAN CELL LINES (MEETING ABSTRACT). *(Eng.)* Gillois, M. (Laboratoire de Genetique Cellulaire, Centre de Recherches de Tolouse, B.P. No 12, 31320 Castanet-Tolosan, France), Auge, C., Chevalet, C. *In Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France* p 4, 1980 (no refs).

A method is described that permits the observation of the nonthermal effects of nonionizing electromagnetic waves (2,450 MHz) on mammalian cells. Cells were exposed to the waves in their culture medium, with their usual support. Somatic cell genetic techniques were used. Nonionizing electromagnetic waves were demonstrated to have a specific nonthermal lethal effect, to have no mutagenic effect, and to increase the mutagenic power of ethyl methane sulfonate for two established cell lines, CHO and PK 15.

In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France. p. 4; 1980 (no refs).

Previously reported findings of frequency-dependent microwave effects on the growth rate of yeast cells are confirmed. Using an improved set-up, fine-tuning studies in a 50-MHz wide band near 41.8 GHz were conducted. The growth rates measured without irradiation were scattered by not more than +3% from a mean value, while the relative growth rates of the irradiated samples deviated from 19% to -12%, depending on the frequency (on a MHz-sacle). Correlation with the applied microwave power was discussed.

6813 INFLUENCE OF CENTIMETER WAVES ALONE OR COMBINED WITH UV RADIATIONS ON EUCARYOTIC CELLS (MEETING ABSTRACT). *(Eng.)* Dardalhon, M. (Institut Curie, 26, rue d'Ulm, 75005 Paris, France); Averbeck, D.; Berteaud, A. J. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 5; 1980 (no refs).

The action of centimeter waves (17 GHz at 50 mW/cm^2 and 9.4 GHz at 5 mW/cm^2) on the strain D$_7$ of the yeast *Saccharomyces cerevisiae* was investigated. No significant effect on survival, the induction of cytoplasmic "petite" mutations, or the induction of mitotic recombination was observed. There was also no effect on sporulation, i.e., meiosis. The results demonstrated that microwaves do not induce genetic effects in nuclear and mitochondrial deoxyribonucleic acid (DNA) and confirmed results of previous studies using millimeter waves (70-75 GHz). To investigate whether microwaves interfere with the repair of lesions induced in cellular DNA by UV radiation, the effects of combined treatments were studied. Exposure to microwaves at 17 GHz (at 50 mW/cm^2) and UV irradiation for 1 hr produced biologic effects of small amplitude but with the same tendency compared with the effects produced by UV radiation alone: decrease of survival and increases in mitotic recombination and cytoplasmic "petite" mutations. These effects disappeared as the power was lowered by a factor of 20 and were absent when using microwaves at 9.4 GHz at 5 mW/cm^2. These effects cannot be explained by the simple heating of the cells. However, it cannot be excluded that they are due to specific thermal effects of the the microwaves. The results are compared to those obtained in interaction experiments with x-rays.

ABSTRACT). *(Eng.)* More, C. (Groupe de Recher GR35, CNRS, 2 rue H. Dunart, 94320 Thiais, Fran Dardalhon, M.; Berteaud, A. J.; Averbeck, D. *Abstracts of the Proceedings of the Internatic Symposium on the Biologic Effects of E tromagnetic Waves held June 30-July 4, 1980 in J en Josas, France.* p. 5; 1980 (no refs).

A method of fluorescence polarization that was u to determine the microviscosity (i.e., the "state" the cytoplasm after microwave irradiation is desc ed. The fluorescence was observed after enzy hydrolysis of the nonfluorescent marker fluoresc diacetate in the cytoplasm. The degree of polar tion was obtained directly for each sample us automatic recording and a computer device results obtained on strain 211 of the ye *Saccharomyces cerevisiae* after exposure to 2 GHz irradiation show that this method can be u for the rapid detection of hyperthermic effects microwaves on the cytoplasm.

6815 TEMPERATURE DEPENDENCE OF π ABSORPTION IN BIOLOGICAL CEL (MEETING ABSTRACT). *(Eng.)* Kremer, F. (M Planck-Institut fur Festkorperforschung, 7000 St gart 80, W. Germany); Genzel, L.; Drissler, F. *Abstracts of the Proceedings of the Internatic Symposium on the Biologic Effects of E tromagnetic Waves held June 30-July 4, 1980 in J en Josas, France.* p. 6; 1980 (no refs).

A newly developed millimeter absorption sp trometer is described. An approximately isotro and homogeneous radiation field is generated in oversized cylindrical resonator with highly reflect walls, textured inner surfaces, and a rotating mo stirrer. The Q-value of such an oversized multimo resonator is only slightly dependent on the frequ cy. Radiation passes repeatedly, and from all dir tions, through an optically thin sample placed ins the cavity. Energy loss is caused only by absorpti but not by scattering from the sample. By measur the Q-value, with and without the sample, the ener loss of the sample can be determined. With this s up, the temperature dependence of the absorpti (at 53 GHz) in biologic cells (algae, yeast, *Escheric coli*) was measured in the temperature range fr -196 C to 200 C. It is concluded that this type temperature dependent absorption is a gene biologic phenomenon. It is suggested that this m be caused by bound water in the cells, since bou water, at least when absorbed on inorga substrates, has a freezing point far below that water.

Genes, Italy); Chiabrera, A.; Grattarola, M.; Ponta, D. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 6; 1980 (no refs).

The problem of cell reactivation in vitro by means of changes of the chemical environment and of suitable electromagnetic exposure is reviewed. The reactivation of two cell classes (differentiated, cycling confluent) is considered. The first step of the reactivation process is the opening of chromatin conformation; this step is dependent on the chemical and electromagnetic microenvironments. The related chromatin conformational changes were measured by automated cytometric methods. The dependence of cell responses on the frequency content of the electromagnetic signal was demonstrated.

6817 COMPARISON OF HYPERTHERMIC CELLULAR SURVIVAL IN THE PRESENCE OR ABSENCE OF 2,450 MHz MICROWAVE RADIATION (MEETING ABSTRACT). *(Eng.)* Harrison, G. H. (Dept. Radiation Therapy, Sch. Medicine, Univ. Maryland, Baltimore, MD 21201); Robinson, J. E.; McCulloch, D.; Cheung, A. Y. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 7; 1980 (1 ref).

In vitro cellular survival as a result of heating with or without microwaves was studied. Mammalian cells (CHO) and bacterial cells (*Serratia marcesens*) were exposed at hyperthermic temperatures in glass micropipettes within a water-filled temperature-controlled waveguide exposure chamber. An electric field map indicated that the power density ranged from 158 to 527 mW/cm^2 for irradiated cells. The colony-forming ability of treated cells was measured as a function of heating time at 43, 44, and 45 C for CHO cells and at 48, 49, and 50 C for *S. marcesens*. Thermal sensitivity, as judged by survival curve slope, approximately doubled for each 1-degree temperature increase. For *S. marcesens*, there was no statistically significant difference between the survival of irradiated and nonirradiated cells. For CHO cells, microwave irradiation produced a statistically significant increase in survival curve slopes--a result equivalent to that expected from an additional 0.37 C increase in temperature of irradiated cells. Thermometry within micropipettes is in progress to study this effect.

6818 CUMULATIVE EFFECT OF MICROWAVES (MEETING ABSTRACT). *(Eng.)* Tahan, Y. *Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 7; 1980 (no refs).

Planaria were repeatedly irradiated (with the time interval between the irradiation equal to 1 hr and 24 hr) in an X-band waveguide to determine whether microwaves have a cumulative effect. Reduction of microwave energy absorption by individual planaria was observed after each session. A sublethal dose of repetitive radiation did not injure the planaria if the time interval between irradiations was ≥24 hr; for intervals of <24 hr, repetitive irradiation may produce injury or even death.

6819 BIOLOGICAL EFFECTS OF MICROWAVE EXPOSURE AT DIFFERENT NONTHERMAL LEVELS (MEETING ABSTRACT). *(Eng.)* Shandala, M. G. (A. N. Marzeev Res. Inst. General and Communal Hygiene, Kiev, USSR). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 10; 1980 (no refs).

Changes in brain bioelectric activity and behavioral reactions of animals, as well as cytochemical and immunologic effects, were studied under long-term microwave exposure to 2,375 MHz at power densities (PD) of 500, 50, 10, 5, and 1 μW/cm^2. Unfavorable changes were found in all studied indices at PD of 500 and 50 μW/cm^2. Inhibition of the central nervous system (manifested through increased specific weight of the electroencephalogram slow waves, decreased investigative activity and capacity for work, and inhibited feeding reactions and other behavioral reactions) and the inhibition of immunocompetent cells functional activity, accompanied by the tension of energy metabolism in neutrophils, were observed. A PD of 10 μW/cm produced certain biologic activity, which recovered after termination of the exposure, suggesting that compensatory and adaptative reactions in organisms occur at this radiation level. These data may be used as an experimental basis for hygienic standards of microwave exposure.

6820 CHRONIC LOW-LEVEL EFFECTS IN RABBITS EXPOSED TO 2,450 MHz MICROWAVE RADIATION (MEETING ABSTRACT). *(Eng.)* Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Sch. Medicine, Univ. Washington, Seattle, WA 98195); Guy, A. W.; Borneman, L.; Kunz, L. L. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 10; 1980

two separate periods of 90 days each. The incident power density of the first and second period was 0.5 and 5 mW/cm², respectively. During each study, 16 animals were adapted to a miniature anechoic chamber exposure system for 2 wk, and then 8 animals were dorsally exposed, individually in the anechoic chamber, for 7 hr/day, 5 days/wk for 13 wk; the remaining 8 animals were sham-exposed. Thermographic data showed a maximum specific absorption rate of 5.45 W/kg in the head and 14 W/kg in the back of the rabbit for the 5 mW/cm² incident power density. After each 7-hr session, the animals were returned to their cages. Body wt and food consumption in the exposure chamber were measured daily. Blood samples were taken before exposure and monthly thereafter for hematologic, chemical, morphologic, protein electrophoresis, and lymphoblast transformation studies. Eyes were examined for cataract formation. Pathologic examinations on 31 specimens of organs and tissues were also performed. Statistically, there were no consistent significant differences in measured parameters observed between the exposed and the sham-exposed animals. However, there was a 20% reduction of mean food consumption in the exposure cages ($p<0.05$). Despite the lower food intake in the exposure cage, the body wt of the exposed group was similar to that of the sham-exposed group. The glucose level was slightly but consistently higher in the exposed group.

6821 THE EFFECT OF HIGH-FREQUENCY ELECTROMAGNETIC FIELD ON THE FROG NEUROMUSCULAR PREPARATION (MEETING ABSTRACT). *(Eng.)* Tigranyan, R. E. (Inst. Biological Physics, Acad. Sciences USSR, Pushchino, USSR); Khafisov, R. Z.; Tyazhelov, V. V. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 11; 1980 (no refs).

The time dependence of the excitement transmission in a frog neuromuscular preparation under regular stimulation was investigated. At a sufficiently low stimulation frequency (1 Hz), the transmission was blocked some minutes after the onset of excitation. Irradiating the preparation with microwaves (800 MHz, power density 12 mW/cm²) simultaneously with the stimulation removed the block of excitation transmission for a long time period.

6822 DECREASE IN HEART FREQUENCY AFTER EXPOSURE TO A MICROWAVE FIELD IN THE WHITE RAT (MEETING ABSTRACT). *(Eng.)* Servantie, B. (EASSM-CERB, Hopital d'Instrumentation des Armees Sainte-Anne, 83800 *Electromagnetic Waves held June 30-July 4, 1980 Jouy en Josas, France.* p. 11, 1980 (no refs).

White rats were exposed to 2.45-GHz, 3-GHz, and 9. GHz frequency microwave fields for exposure dur tions between 5 and 15 days. The incident averag power density in far field was 5 mW/cm². Electroc ticographic and electrocardiographic records we made. Irradiated animals had a heart frequency low than those of control animals. The decrease w more important for animals exposed to the 3-GH field.

6823 EFFECTS OF MICROWAVE EXPOSUR ON ANESTHESIA IN THE MOUS (MEETING ABSTRACT). *(Eng.)* Blackwell, R. P. (Na Radiological Protection Board, Didcot, Oxon, Harwe OX11 ORQ, England). *In: Abstracts of the Pr ceedings of the International Symposium on t Biologic Effects of Electromagnetic Waves held Ju 30-July 4, 1980 in Jouy en Josas, France.* p. 12. 198 (no refs).

The effects of 2.45-GHz far-field microwave exposu on sodium hexobarbitone and Althesin anesthesia the mouse were studied. A dose-dependent redu tion in duration of hexobarbitone anesthesia w seen at thermogenic power densities of 250 and 5 Wm^{-2}, compared with sham exposure. No significa effect on Althesin anesthesia was seen at eith power density. Since stress, reflected by increase blood corticosterone levels, has been shown reduce hexobarbitone-induced sleeping tim measurements of plasma corticosterone were mad in mice anesthetized with hexobarbitone. Both 25 and 500-Wm^{-2} exposures produced significant lower levels than sham exposed controls. Thus, stress-mediated effect is not implicated.

6824 INFLUENCE OF THE MICROWAVE E POSURE TIME ON TRIGLYCERIDEMIA THE MOUSE (MEETING ABSTRACT). *(Eng.)* Duma J. C. (CERT/DERMO, 2, avenue E. Belin, B.P. 402 31055 Tolouse cedex, France); Nougarolis, D Plurien, G.; Stoll, M. *In: Abstracts of the Proceedin of the International Symposium on the Biologic E fects of Electromagnetic Waves held June 30-July 1980 in Jouy en Josas, France.* p. 12. 1980 (no refs)

The kinetics of the rise in serum triglycerides in mi exposed to microwave radiation were studied. Th mice were irradiated with continuous wa microwaves at 2,450 MHz at power densities of 8 or 12 ± 2 mW/cm². The results showed that the effe of continuous exposure occurred rapidly. The ma imal effect, however, was only reached after a 9-d period and remained stable thereafter. When th

rapidly reversible. The effect of a repeated rather than continuous exposure was far less intense. Thus, the variation of triglyceride level in the mouse induced by continuous exposure to microwave radiation is a rapid, long-lasting but reversible phenomenon; its amplitude is diminished for repeated exposures.

6825 EFFECT OF 2.45 GHz MICROWAVE RADIATION ON EMBRYONIC QUAIL HEARTS (MEETING ABSTRACT). *(Eng.)* Galvin, M. J. (Lab. Environmental Biophysics, Natl. Inst. Environmental Health Sciences, P. O. Box 12233, Research Triangle Park, NC 27709); McRee, D. I.; Lieberman, M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 13, 1980. (no refs).

The effect of microwave radiation on cardiogenesis of Japanese quail embryos exposed during the first 8 days of development to 2.45-GHz continuous wave microwaves at an incident power density of 5 mW/cm^2 or 20 mW/cm^2 was studied. The specific absorption rates were 4.03 and 16.2 mW/g, respectively. The ambient temperature for each each exposure was set to maintain the embryonated eggs at 37.5 C. The results showed that neither exposure level was capable of inducing changes in either the morphology of the embryonic heart or the ultrastructure of the myocardial cells. A comparison of the enzyme activities of lactate dehydrogenase (LDH), glutamic oxaloacetic transaminase (GOT), and creatinine phosphokinase (CPK) failed to reveal any statistical difference between the nonexposed controls and the exposed groups. The values obtained for each enzyme expressed relative to 100 μg protein were as follows: LDH, 650 Wroblewski units; GOT, 120 Karmen units; and CPK, 275 IU. These data indicate that 2.45-GHz microwave irradiation at 5 or 20 mW/cm^2 had no effect on the measured parameters of the Japanese quail myocardium during the first 8 days of development.

6826 STUDIES OF MOUSE TESTIS CYTOLOGY FOLLOWING 30 DAYS EXPOSURE TO 2,450 MHz CW (MEETING ABSTRACT). *(Eng.)* Harding, R. K. (Radiation Biology Section, Defense Res. Establishment, Ottawa, Ontario K1A 0Z4 Canada); Cairnie, A. B. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 13, 1980. (no refs).

Two groups of 18 male mice were housed singly and controls. No changes were seen in the sperm count or percent abnormal sperm assay, at intervals up to 8 wk after exposure. No changes in vital-dye exclusion by a suspension of testicular cells were seen following the 30-day exposure. Cooling curve extrapolations performed on mice killed immediately after a 16-hr exposure to 50 mW/cm^2 indicated no significant increase in intratesticular temperature. Miniature E-field probe measurements predict a specific absorption rate (SAR) of 13.6 (±40%) W/kg in the testis of a mouse exposed to 50 mW/cm^2. The SAR in testis did not vary significantly with the orientation of the mouse.

6827 EFFECTS OF MICROWAVE NEONATAL EXPOSURE ON THE DEVELOPMENT OF CORTICOTROP AND GONADOTROP FUNCTIONS IN THE RAT (MEETING ABSTRACT). *(Eng.)* Manier, J. (Laboratoire de Physiologie des Regulations, Campus de Beaulieu, 35042 Rennes cedex, France); Le Ruz, P. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 14, 1980. (no refs).

Male rats were exposed 15 days after birth to pulsed microwave radiation at 3.5 GHz, of mean power density 10 mW/cm^2. Body wt and testicle and adrenal wt increased more than that of controls over the first 2 mo of life. The growth rate then decreased and at 3 mo the weight of the glands was lower than for controls. Histologic studies suggested some perturbation in spermatogenesis. At all developmental stages (1, 1.5, 2, and 3 mo), neonatal irradiation diminished the content of adrenocorticotrophic hormone in the pituitary, modified the gonadotrophin (follicle stimulating hormone and luteinizing hormone) content in the pituitary, and slightly but consistently increased the plasma concentration of these two hormones. The concentration of corticosterone in the adrenals was 3 to 5 times greater at 3 mo. The hypothesis that microwave irradiation induces a perturbation in the hypothalamus in the neonatal period is discussed.

6828 NONLINEAR OSCILLATIONS IN BIOLOGICAL MODEL SYSTEMS INTERACTIONS WITH EXTERNAL FIELDS (MEETING ABSTRACT). *(Eng.)* Kaiser, F. (Inst. Theoretical Physics, Univ. Stuttgart, Pfaffenwaldring 57, 7000 Stuttgart 80, W. Germany). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 16, 1980. (no refs).

cycle type (LC). 1) Observable biologic oscillations must be stable LCs, including sets of coupled LCs. 2) Stable LCs are a suitable basis to model coherent oscillations in active biologic systems. 3) Stable LCs may be important to describe effects of external fields on biologic systems. The LC concept reveals a possible explanation of the experimentally found specific sensitivities of biologic systems to a weak external stimulus: i.e., only a small amount of external energy is necessary to create a response since the inherently stored LC energy will build up the signal. This concept is applied to some model systems: 1) the generalized Van der Pol oscillator to describe threshold and excitability, 2) the coherent oscillation model to describe extreme sensitivity of brain function, and 3) the high polarization model to discuss energy exchanges between oscillating biomolecules.

6829 TWO TYPES OF MICROWAVE AUDITORY SENSATION AND THEIR POSSIBLE MECHANISMS (MEETING ABSTRACT). *(Eng.)* Khizhnyak, E. P. (Inst. Biological Physics, Acad. Sciences USSR, Pushchino, Moscow, USSR); Shorokhov, V. V.; Tyazhelov, V. V. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 16; 1980 (no refs).

Experimental data pointing to the existence of two types of auditory sensory effects are considered. The thermoelastic theory by A. Guy and J. Lin accounts for only one of these effects. A model that can form the basis of the mechanism of the second type of radio sound is suggested.

6830 PECULIARITIES OF MICROWAVE EFFECT ON GRAMICIDIN MODIFIED BILAYERS (MEETING ABSTRACT). *(Eng.)* Tyazhelov, V. V. (Inst. Biological Physics, Acad. Sciences USSR, Pushchino, Moscow, USSR); Alekseev, S. I.; Faizova, L. K.; Chertischev, V. V. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 17; 1980 (no refs).

Peculiarities of microwave effects on conductivity of gramicidin modified bilayers are described. Data on the value of conductivity changes and peculiarities of their kinetics are given. The value of conductivity changes are determined by the total ionic strength rather than by the ion-carrier concentration. The observed relations correspond to the "microheating" mechanism of the effect.

QUENCY RADIATION: EFFECT OF A 50 MHz CA RIER FREQUENCY ON THE POWER DENSI DEPENDENCE (MEETING ABSTRACT). *(Eng* Blackman, C. F. (Health Effects Res. Lab., EP Research Triangle Park, NC 27111); Benane, S. G Joines, W. T.; Hollis, M. A.; House, D. E. *Abstracts of the Proceedings of the Internatior Symposium on the Biologic Effects of Ele tromagnetic Waves held June 30-July 4, 1980 in Jo en Josas, France.* p. 17; 1980 (no refs).

The effect of radio frequency radiation on th calcium-ion binding of brain tissue exposed to pow densities of a 50-MHz carrier, amplitude modu ate by a 16-Hz sine wave, was reported. Brain sampl were treated in vitro in a Crawford cell; four bra tissues plus six dummy loads were exposed togeth to broaden any power window and to enhance the o portunity for detection of changes in the calcium-i binding kinetics. The results of a power dens series demonstrated two effective ranges: one i cluded 1.44 and 1.67 mW/cm² and the other include 3.64 mW/cm², bracketed by no-effect results at 0.7 2.17, and 4.32 mW/cm². Possible reasons for th marked difference between these results and thos obtained using higher carrier frequencies a discussed.

6832 THE EFFECTS OF CW MILLIMETER WAV IRRADIATION ON MITOCHONDRIAL O IDATIVE PHOSPHORYLATION AND Ca TRANSPORT (MEETING ABSTRACT). *(Eng.)* Motzki S. M. (Polytechnic Inst. New York, 333 Jay S Brooklyn, NY 11201); Melnick, R.; Rubenstein, C Rosenthal, S.; Birenbaum, L. *In: Abstracts of the Pr ceedings of the International Symposium on th Biologic Effects of Electromagnetic Waves held Jul 30-July 4, 1980 in Jouy en Josas, France.* p. 18; 198 (no refs).

The effects of continuous wave (CW) millimeter radiation on oxidative phosphorylation and Ca transport in freshly prepared rat liver mitochondr were examined at 8.58 mm (35 GHz) and at 41 discre wavelengths between 5.00 and 6.00 mm (60-50 GH Millimeter wave exposure systems using waveguic components that monitor power density, reflection and frequency stability were employed. Mitocho drial suspensions were exposed for 15 min at 8 mm and subsequently evaluated for their efficienc in coupling succinate oxidation to phosphorylation adenosine diphosphate. Changes in respiratory co trol ratios observed at 250, 500, and 1,000 mW/cm 30 C indicated membrane damage. At 25 respiratory control ratios were maintained at high exposure levels and at 4 C, some coupling of th mitochondria was maintained even at 1,000 mW/cm A new assay was developed to evaluate C millimeter effects on actively phosphorylatin

ATP synthesis was observed when mitochondria were irradiated at 25 C for 2 min at 8.58 mm from .01 to 1,000 mW/cm² or at 5.0-6.0 mm at 5 mW/cm². Uptake and efflux of calcium were also examined in carrier-mediated succinate driven transport studies. Mitochondrial suspensions irradiated at 25 C at 8.58 mm and 5.00-6.00 mm at power densities of 1-1,000 and 5 mW/cm², respectively, were evaluated for their ability to couple a proton gradient to Ca^{++} uptake and efflux. At 8.58 mm, changes in ^{45}Ca uptake after 15 min and efflux after 5 min of irradiation were not observed below 100 mW/cm². Above 100 mW/cm², decreased uptake and increased efflux were correlated with membrane damage due to thermal changes. No differences in uptake or release were noted in the 5.00- to 6.00-mm range.

6833 CALCIUM DEPENDENT SECRETORY PROTEIN RELEASE AND CALCIUM EFFLUX, AFTER VHF ELECTROMAGNETIC RADIATION OF RAT PANCREATIC SLICES (MEETING ABSTRACT). *(Eng.)* Albert, E. N. (Dept. Anatomy, Medical Center, George Washington Univ., Washington, DC 20037); Blackman, C. F.; Slaby, F. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 18; 1980 (no refs).

The effects of 147-MHz radiation, amplitude modulated at 16 Hz, on rat pancreatic tissue slices were investigated. The field incident energy was 2 mW/cm² and the specific absorption rate was estimated at <0.1 mW/g. After 60 to 150 min of irradiation of pancreatic tissue slices (incubated in HEPES buffered medium under 100% O_2 atmosphere), the release of pulse-labeled secretory proteins and $^{45}Ca^{++}$ efflux was measured. The data, collected in a Crawford cell exposure facility, demonstrated that 147 MHz electromagnetic radiation, sinusoidally modulated at 16 Hz, caused an 11% increase in $^{45}Ca^{++}$ efflux from pancreatic tissue when compared to sham exposed samples. However, the radiation did not affect the calcium dependent release of pulse-labeled protein from either control or carbamylcholine stimulated tissue slices. The lack of calcium dependent protein release raises some questions about the physiologic significance of the increased calcium efflux.

6834 THE EFFECT OF MICROWAVE IRRADIATION ON RAT SERUM PEROXIDASE ACTIVITY (MEETING ABSTRACT). *(Eng.)* Mezykowski, T. (Military Inst. Aviation Medicine, Krasinskiego 54, 01-755 Warszawa, Poland). *In: Abstracts of the Pro-*

The influence of 2.2-2.32-GHz microwaves (power density 2-3 mW/cm²) on the activity of rat serum peroxidase was investigated. There was a marked decrease in the rate of product formation in the exposed group as compared to the control group. Some effects on the enzyme-substrate affinity (measured as K_m and V_{max} values) in irradiated samples were also observed. The results may indicate conformational modification of the enzyme molecule.

6835 BIOCHEMICAL STUDIES OF THE COMBINED EFFECT OF ANTICHOLINESTERASE AND MICROWAVE RADIATION ON THE BLOOD BRAIN BARRIER IN THE RAT (MEETING ABSTRACT). *(Eng.)* Ashani, Y. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Catravas, G. N. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France* p. 19; 1980 (no refs).

Low level microwave irradiation was found to enhance the biologic activity of anticholinesterase drugs such as phospholine iodide and paraoxon in the rat. The observed changes were measured in terms of hypothermia that developed after administration of the drug followed by exposure of the animals to the microwave field. Hypothermia also developed when the anticholinesterase antidote 2-pyridine aldoxime methiodide was administered under the same conditions as the anticholinesterase. Paraoxon induced significant changes in the blood-brain barrier whereas phospholine iodide did not seem to affect this biologic target. The biochemical evidence on the blood-brain barrier changes as indicated by acetylcholinesterase level measurements could not be quantitatively correlated with the low level microwave enhancement of the hypothermia induced by the above drugs.

6836 THE EFFECTS OF LOW-LEVEL RF RADIATION ON THE BLOOD BRAIN BARRIER IN MICE AND RATS: AN ELEVATION OF NATURALLY-OCCURRING AMINO ACIDS IN MOUSE BRAIN (MEETING ABSTRACT). *(Eng.)* Spackman, D. H. (Pacific Northwest Res. Foundation, Seattle, WA 98104); Riley, V.; Guy, A. W.; Chou, C. K. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France* p. 20; 1980 (no refs).

The effects of radio frequency radiation (RFR) on altering concentrations of naturally occurring amino

specific absorption rate for mice, 2.1 W/kg). Deproteinized extracts of plasma and of brain homogenates were then analyzed on an amino acid analyzer. Similar samples from nonirradiated, fasted controls were also examined. Of the seven natural amino acids analyzed, six were significantly statistically elevated in the brains of irradiated animals. Phenylalanine was increased two-fold. Two amino acids that were elevated in the brain were absent in plasma, and the plasma levels of the others did not change. Thus, in addition to active transport across the blood-brain barrier, there may be other mechanisms that can increase brain concentrations of specific compounds in conjunction with RFR. An alternate possibility is that increased levels of amino acid precursors, derived either from plasma or from brain metabolism, are then transaminated, decarboxylated, etc., in the brain. Since increased levels of brain amino acids have also been observed in sham-irradiated mice, stress-evoked elevations of plasma corticosterone resulting from RFR and experimental treatment may play a role.

6837 MODIFICATION OF ACUTE STAPHYLOCOCCAL INFECTIONS BY LONG-TERM EXPOSITION TO LOW-LEVEL MICROWAVE FIELDS OR WHOLE BODY MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Szmigielski, S. (Dept. Biological Effects of Nonionizing Radiation, Center for Radiobiology and Radioprotection, 00-909 Warsaw, Poland); Roszkowski, W.; Jeljaszewicz, J. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 22; 1980 (no refs).

Mice and rabbits were irradiated with 2,450 MHz microwaves (MW) at a mean power density of 5 or 15 mW/cm² (anechoic chamber, far-field conditions), 2 hr/day for 6 or 12 wk. Other mice were exposed to whole-body body MW hyperthermia (increase of rectal temperature to 42.5 ± 0.5 C) at mean power density of 40-60 mW/cm², 2 hr/day for 4, 7, 10, or 14 days. One day after termination of exposure to MW or hyperthermia, the animals were infected intravenously with viable *Staphylococcus aureus*. Functional tests of granulopoiesis (blood granulocytosis, release of bone marrow reserve pool, serum lysozyme activity and nitro-BT reduction by blood granulocytes), phagocytosis of ^{32}P-labeled bacteria by peritoneal macrophages, delayed hypersensitivity to oxazolone, and reactivity of spleen lymphocytes to phytohemagglutinin and lipopolysaccharide were investigated before infection (effect of exposure to MW) and every second day after infection. The mortality rate (mice only) was evaluated daily. Long-term exposure to 2,450 MHz MW at 15 mW/cm² led to impairments and increased mortality from the infection. T specific cellular immunity did not change unc these conditions. At 5 mW/cm², increas phagocytosis was found, however, no significa changes either in kinetics of granulopoiesis specific cellular immunity were observed. Who body MW hyperthermia lasting 7-14 days resulted lowering of natural bacterial resistance (slow clearance of microorganisms from peripheral bloc weakened phagocytosis by macrophages) a higher mortality from staphylococcal infections. Th was accompanied by suppression of specific cellu immunity.

6838 EFFECTS OF PULSED 3 GH MICROWAVES ON THE I MUNOLOGICAL CHANGES OF MICE, IN VIV (MEETING ABSTRACT). *(Eng.)* Draussin, M. (Servi Central de Medecine Nucleaire, Centre Hospitali Regional, Universitaire de Nimes, 5 rue Hoche, B. 26, 3006 Nimes cedex, France); Chevalier, J. M Gouget, P.; Serre, L.; Servantie, B.; Miro, L. *Abstracts of the Proceedings of the Internatior Symposium on the Biologic Effects of Ele tromagnetic Waves held June 30-July 4, 1980 in Jo en Josas, France.* p. 22; 1980 (no refs).

Sixty Swiss male mice were exposed in an anecho chamber for 15 days to pulsed 3-GHz microwa fields (duty cycle, 525 Hz; pulse width, 1 μsec; mea power density, 1-2 mW/cm²). Sixty Swiss male mi served as controls. The humoral change observe after an intravenous injection of sheep red bloc cells (10⁸ red cells) was analyzed in 20 controls by seroagglutination test. Delayed hypersensitivity sheep red blood antigen was analyzed in 40 expose and 40 control mice by the food pad technique. N significant difference between the behavior of co trols and exposed animals was found. Histologic e amination of liver, bone marrow, lymph node spleen, and thymus revealed no thermal injury. A glutinin titers were significantly increased ($p<0.0$ from the 6th day after the beginning to the 15th da after the end of irradiation. Delayed hypersensitivi was significantly increased for exposed animals relation to the controls only between the 10th the 15 day of irradiation ($p<0.01$). Histologic studies co firmed results obtained in earlier experiments: i e an increased mitotic lymphocyte index in the thym and better individualization of Malpighi corpuscle into the spleen.

6839 STUDIES OF IMMUNE RESPONSE IN TH MOUSE AFTER MICROWAVE RADIATIO OF 2,450 MHz (MEETING ABSTRACT). *(Eng* Descheux, P. (Laboratoire de Physiologie Cellulai

Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France. p. 23; 1980 (no refs).

Swiss male mice (2 mo old) were exposed to 2.45-GHz microwave radiation at various power densities (10, 5, and 1 mW/cm^2) in a multimode cavity for 4 hr/day for 5 days. Stimulation of humoral immunity was observed at power densities between 1 and 5 mW/cm^2. The protecting effect of the vaccine *Salmonella typhimurium*, Rc mutant, was not modified.

6840 THE EFFECT OF A UNIFORM CONSTANT MAGNETIC FIELD ON SPLENIC INDEX OF HEALTHY MOUSE AND IRRADIATED MOUSE (MEETING ABSTRACT). *(Eng.)* Bellossi, A. (Laboratoire de Biophysique, Av. du Pr. L. Bernard, 35043 Rennes cedex, France); de Certaines, J.; Tchuempe Tchuente, G.; Ruelloux, M.; Poubanne, B. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 23; 1980 (no refs).

The splenic index (SI) was measured in Swiss mice subjected to a uniform constant magnetic field (MF) of intensity 0.05-0.8 Tesla for 2 hr/1x/day or for 2 hr/1x every 2, 3, or 4 day. The mice were either healthy or previously irradiated with 25 million electron-V (MeV, at a lethal dose). MF exposure did not modify healthy mice SI. Irradiation with 25 MeV caused a dramatic decrease of SI. Postirradiation MF exposure resulted in a temporary increase in the SI; this effect was found when the MF exposure occurred 1x during the 4 days after the irradiation. A second MF exposure was efficient only after more than 24 hr of the first exposure. Spleen aqueous retention, local protective effects, or a cell draining from bone marrow, does not explain the observed SI increase following MF exposure of irradiated mice.

6841 MICROWAVE RADIATION (2,450 MHz) ALTERS THE ENDOTOXIN-INDUCED HYPOTHERMIC RESPONSE OF RATS (MEETING ABSTRACT). *(Eng.)* Smialowicz, R. J. (Health Effects Res. Lab., EPA, Research Triangle Park, NC 27711); Compton, K. L.; House, D. E.; Riddle, M. M.; Rogers, R. R.; Brugnolotti, P. L. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 24; 1980 (no refs).

Rats injected with endotoxin were exposed, under controlled environmental conditions (22 C and 50% relative humidity), to 2,450 MHz continuous wave microwaves (incident power densities of 10, 5, or 1 mW/cm^2; specific absorption rate of 1, 0.5, and 0.1 mediately after the 90-min treatment period. The change in body temperature was calculated for each rat. Statistically significant differences were observed in the mean temperature change of endotoxin-injected rats irradiated at levels as low as 1.0 mW/cm^2 compared to endotoxin-injected sham-irradiated rats. Following the administration of endotoxin rats were rendered ectothermal in their response to thermal energy. The observed alteration in the hypothermic response of rats to endotoxin was apparently due to the thermal properties of microwave radiation since endotoxin-injected rats held at environmental temperatures of ≥26 C had rectal temperatures significantly higher than rats held at 22 C. Consequently, very subtle thermal energy input by microwaves was detectable with this model. These results indicate that claims for "nonthermal" microwave-induced bioeffects in laboratory rodents exposed at low intensities (≤10 mW/cm^2) should be evaluated more prudently.

6842 EFFECTS OF LOW DIRECT CURRENT ON MONOMOLECULAR LAYERS OF METAL STEARATES COATING ELECTRODES IN BACTERIAL CULTURES AND ON SURGICAL IMPLANTS (MEETING ABSTRACT). *(Eng.)* Colmano, G. (Virginia Polytechnic Inst., Blacksburg, VA 24061); Edwards, S. S.; Barranco, S. D. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 24; 1980 (no refs).

A study of possible intra- and extracellular interactions of electromagnetic energy on molecular ions and their behavior at cellular membrane interfaces, induced by changes in experimental design, was attempted. The effects of pure metals (Ag, Al, Au, Cu, Pt) or stainless steel or glass electrodes, coated with monolayers of different metal stearates (of Ag, Al, Au, Ba, Cr, Cu, Li, Ni, P, S, Sn, Sr, alone or in different combinations) and with or without contamination by bacterial cultures (*Staphylococcus aureus, Proteus vulgaris, Pseudomonas aeruginosa*), were tested in vitro (in broth and agar) and in vivo (in the femurs of rabbits and dogs). The responses to electrodes, not activated or activated by low-positive or negative direct current, were charted for their inhibition or enhancement of cellular growth. A nanomolar concentration of silver from current activated silver electrodes had bacteriocidal effects in vitro and in vivo. As a practical result, 1 hr of 12 μamp of positive direct current/cm^2 on 100 monolayers of silver stearate on stainless steel were found to inhibit possible osteomyelitis infections by approximately 3,000 *Staphylococcus aureus* in dog femurs.

6843 BIOLOGICAL EFFECTS OF EXTREMELY

(Dept. Electrical Engineering, Univ. Salford, Salford, M5 4WT, England). Flinn, E. A.; Smith, C. W. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 25; 1980 (2 refs).

Bacteria (*Escherichia coli, Staphylococcus albus*, and *Chromobacterium lividum*) were grown under controlled conditions in magnetic fields ranging from 0 to several kG. Preliminary results indicated that the effects of direct current magnetic fields on *E. coli* are much less than those reported by other workers. However, it appeared that the growth rate of *E. coli* was depressed by fields between 1 and 2 kG, but increased by fields less than 1 kG or greater than 2 kG. For fields above 2.5 kG, the temperature tolerance of *E. coli* was significantly increased.

6844 EFFECTS OF A WEAK CONSTANT MAGNETIC FIELD UPON HUMAN FOREHEAD *(Eng.)* Masterman, W. D. (Univ. Texas at Dallas, 1800 First Natl. Bank Building, Dallas, TX 75202). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 25; 1980 (1 ref).

Thirty-four humans were exposed on a blind basis to a weak (5,000 gamma) constant magnetic field. Each subject served as his own control. Group forehead skin temperature asymmetries were highly significant ($p<.01$) in both the exposure and after-effect trials of the field-on session. Asymmetries were determined by paired sample *t* tests on the simultaneous differences between the left and right forehead temperatures. Differences in forehead temperature levels were interpreted as lateralized changes in intracranial blood flow. A significant increase in group left forehead temperature and decrease in variance occurred in the after-effect trial of the field-on session. These data were analyzed postexperimentally by dividing the subjects into three categories depending on whether an individual showed a significant left forehead temperature increase, a decrease, or no significant change. This procedure divided the group into three almost equal categories that showed distinctly different temperature (blood flow) and verbal anxiety field effects. These results suggested that (1) forehead skin temperature may constitute a simple and effective marker variable for detecting weak field effects and (2) it may be critical in designing experiments to classify humans by autonomic reactivity patterns before testing for possible field effects on autonomic variables.

LEVEL EXPOSITION TO 2,450 MHz MICROWAVI (MEETING ABSTRACT). *(Eng.)* Szudzinski, A. (De Dermatology, Military Postgraduate Medical Cent Warsaw, Poland); Pietraszek, A.; Roszkowski, W Szmigielski, S. *In: Abstracts of the Proceedings the International Symposium on the Biologic Effe of Electromagnetic Waves held June 30-July 4, 198 Jouy en Josas, France*. p. 26; 1980 (no refs).

BALB/c mice were treated with 3,4-benzopyre (BP, painting of skin with 0.01 ml of 1% BP in aceto every second day) to induce skin cancer, and th exposed to 2,450 MHz microwaves (MW, anecho chamber, far-field conditions, field power density or 15 mW/cm², 2 hr/day) at different periods before during BP treatment. The following groups (animals per group) were studied: a) MW irradiati during 3 or 6 mo simultaneously with BP exposure groups; b) MW irradiation during 1, 2, or 3 mo befo BP exposure, 6 groups; and c) controls, normal a sham irradiated mice exposed to BP, 4 group Monitoring of cell mediated immune reactio (delayed hypersensitivity to oxazolone, number of lymphocytes, reactivity of spleen lymphocytes phytohemagglutinin and lipopolysaccharide), as w as ability of peritoneal macrophages phagocytosis were tested, 2, 4, 6, and 8 mo after E exposure. Irradiation of mice with 2,450 MHz MW at mW/cm² significantly hastened development of sk cancer and shortened survival of mice treated wi BP (mean cancer development time, 291 ± 34 days controls and 204 ± 22 in MW-exposed mice). Develo ment of skin cancer was accompanied by lowering delayed hypersensitivity reaction to oxazolone ar depressed phagocytosis. No significant difference in cancer development were observed between mi irradiated with MW at 15 mW/cm² and those irradiate at 5 mW/cm² simultaneously with BP treatmer however, exposure to MW prior to treatment with E (either 5 or 15 mW/cm²) did not significantly influenc development of skin cancer.

6846 THE EFFECT OF 5.62 GHz MICROWAVE ON REPEATED ACQUISITION C RESPONSE SEQUENCES IN SQUIRREL MONKEY (MEETING ABSTRACT). *(Eng.)* de Lorge, J. (Nav Aerospace Medical Res. Lab., Pensacola, FL 3250 Knepton, J. *In: Abstracts of the Proceedings of t International Symposium on the Biologic Effects Electromagnetic Waves held June 30-July 4, 1980 Jouy en Josas, France*. p. 28; 1980 (no refs).

The effects of 5.62-GHz microwaves pulsed at pow densities of 17 to 46 mW/cm² on four male squirr monkeys, *Saimiri sciureus*, ability to learn s quences of three responses were studied. Th response sequence was rearranged daily resulting a repeated acquisition of the response sequence b a monkey. The monkeys performed the task wh

mW/cm². Learning, per se, which occurred early in a session, was not primarily affected; the major effect was on performance, which deteriorated in the latter portions of a 60-min session after a sequence had been learned. Colonic temperature increased with increases in power density. No permanent effects of the microwaves on behavior were found. The specific absorption rates of energy absorbed in both saline and flesh-simulating models was also obtained. The normalized specific absorption rate in the saline model was 0.18 W/kg/mW/cm². It is concluded that although no intrinsic effect of microwaves on learning occurred, a definite effect on performance occurred at the 38 mW/cm² level and this effect was associated with a rise in colonic temperature at 1 C or more.

6847 EVALUATION OF THE EFFECTS OF A 2.45 GHz CW RADIATION ON THE MOTOR ACTIVITY AND THE BLOOD COUNT OF THE MOUSE C57BL6 (MEETING ABSTRACT). *(Eng.)* Klein, M. J. (Division de Neurophysiologie Applique, Centre d'Etudes et de Recherches de Medecine Aerospatiale, 26 Bld. Victor, 75996 Paris Armees, France); Milhaud, C. L.; Nathie, J. G.; Charrieau, J. L. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 28; 1980 (no refs).

The effects of a short microwave radiation (14 hr/day) repeated for 4 and 5 days on the motor activity and the blood count of male C57BL6 mice were investigated. The individual and simultaneous motor activity of a pair of subjects (irradiated + control) was registered for 1 hr in four groups of mice: following the radiation (2.45 GHz, continuous wave, 5 ± 2 mW/cm²) and after 1, 4, and 6 hr. Blood was sampled after the motor activity session. A variance-analysis of the findings relative to 160 subjects (four groups of 20 subjects, controls + irradiated) showed that the motor activity was significantly reduced in the irradiated subjects ($p<0.01$) for the first 30 min and that the dynamics of the motor activity were disturbed 0, 1, and 4 hr following irradiation. No effect related to the irradiated time was noted or on blood count perturbations. The effects observed on the innate behavior of the mouse confirm some synchronizing effects of microwaves previously reported. The generally described effects are confirmed by the lack of change in the hemogram following low-level irradiation.

6848 MICROWAVE MODIFICATION OF THERMOREGULATORY BEHAVIOR: EFFECTS *of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 29; 1980 (no refs).

To determine the effect on thermoregulatory behavior, squirrel monkeys were exposed to 2,450-MHz continuous wave (CW) microwaves (E polarization) at a power density of 4 and 10 mW/cm² (specific absorption rate 0.6 and 1.5 W/kg, respectively) for periods ranging from 5 to 25 min. Monkeys were restrained in the far-field of a horn antenna inside a 1.8 x 1.8 x 2.5 m anechoic chamber that was heated and cooled by forced convection. The animals learned to control the temperature of the circulating chamber air by selecting between two preset air temperatures, 15 and 55 C. No microwaves were present during 4-hr control experiments. The 4-mW/cm² microwave exposure did not modify thermoregulatory behavior. The 10-mW/cm² exposure stimulated the monkeys to select an ambient temperature 2.5-3.0 C cooler than control levels ($p<.01$). Except for the first microwave presentation of each experimental session, exposure duration had no significant effect on the air temperature selected or the resulting body temperatures.

6849 FAILURE TO DISRUPT MAZE LEARNING IN RATS BY POST-TRIAL EXPOSURE TO MICROWAVES (MEETING ABSTRACT). *(Eng.)* Lovely, R. H. (Dept. Rehabilitation Medicine, RJ-30, Medical Sch., Univ. Washington, Seattle, WA 98195); Gesford, J.; Guy, A. W. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 29; 1980 (no refs).

The effect of microwaves, 915 MHz, circularly polarized and square-wave modulated at 11 Hz, with an average incident power density of 1.25 mW/cm² and a peak power of 2.5 mW/cm² (specific absorption rate approximately 0.5 W/kg), on maze learning behavior in rats was investigated. Albino rats were trained to acquire a position discrimination for food reward in a T-maze until they had run to the correct position six out of eight trials for 2 days. After reaching this criterion the position of the rewarded goal box was reversed and the rats had to acquire the reversal to the same criterion as the original position discrimination. This procedure was repeated until all rats had learned at least three reversals. Throughout the study rats were exposed to microwave radiation for 15 min following each day's training or else they were sham-exposed (factor 1). The exposure or sham-exposure was given either immediately or delayed (factor 2) until 4 hr had elapsed after training. Analysis of the data in this 2 x 2 factorial experiment failed to reveal any learning/memory disrupting effects of the post-trial microwave exposure.

CHLORODIAZEPOXIDE EFFECTS ON FIXED-INTERVAL BEHAVIOR IN THE RAT (MEETING ABSTRACT). *(Eng.)* Lovely, R. H. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Lundstrom, D. L.; Phillips, R. D. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 30; 1980 (no refs).

Rats were maintained at 80% of their ad-lib body wt and trained to press a bar for food reward on a fixed-interval (1-min) schedule of reinforcement. Subsequently, the rats were adapted to a restraint holder in an anechoic chamber for 30 min/day prior to working for food. After adaptation to the restraint holder a dose-response curve was generated for each rat illustrating the effect of chlorodiazepoxide on fixed-interval behavior. These data were compared to those obtained by combining microwave exposure (2.88 GHz, 300 pulses/sec, 3.0-μsec pulse width, average incident power density 1 mW/cm^2) and administration of chlorodiazepoxide. The results of this synergistic pairing on the rats' fixed-interval performance will be compared to results obtained from similar studies carried out in other laboratories.

6851 **BEHAVIORAL CHANGES DURING LONG-TERM MICROWAVE IRRADIATION (MEETING ABSTRACT).** *(Eng.)* Lebovitz, R. M. (Dept. Physiology, Univ. Texas Health Science Center, Dallas, TX). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 30; 1980 (no refs).

A specialized laboratory was established to study the effects of long-term microwave exposure on complex behavior in the rat. This laboratory consisted of a computer-controlled behavioral array within which rats could be individually exposed to stable and closely regulated levels of microwave radiation (MWR) while simultaneously performing operant behavioral tasks of varying complexity, using a paradigm designed to measure bar-press performance for food reward as well as uncued motor activity (exploratory bar-press). rats were exposed to pulse modulated MWR (1.3 GHz, 1-μsec pulse width at 600 pulses/sec) for periods of up to 10 wk. At an average dose rate of 1.5 mW/g, there were no discernable differences in the food reward mediated bar-press behavior of the irradiated versus the nonirradiated rats. Exploratory bar-press behavior was more variable in the irradiated group but was not significantly different overall from the controls. At 3.6 mW/g, there was no apparent effect of the irradiation on food mediated bar-press behavior. Exploratory bar-press behavior, however, was transiently reduced in the irradiated rats. At 6.8 mW/g, there was a slight reduction in reward mediated bar-press behavior. The differences between control and i radiated groups tended to diminish with continue exposure. The author concludes that actively rewar ed operant behavior can be highly resistant t change by levels of MWR exposure that ar metabolically significant while parallel, operant unrewarded behavior can show major interruption

6852 **HEALTH CONDITION OF WORKERS EX POSED TO LONG-TERM RADIO FRE QUENCY RADIATION (0.3-30 MHz) (MEETIN ABSTRACT).** *(Eng.)* Pazderova-Vejlupkova, J. (Dep Occupational Diseases, University Hosp., Vysehrac ska 49, 128 21 Prague 2, Czechoslovakia); Lukas, E Nemcova, M.; Dvorak, J.; Pickova, J.; Bryndova, V *In: Abstracts of the Proceedings of the Internation Symposium on the Biologic Effects of Ele tromagnetic Waves held June 30-July 4, 1980 in Jou en Josas, France.* p. 31; 1980 (no refs).

Ninety-five persons occupationally exposed for mor than 10 yr to radio frequency radiation (0.3-30 MHz) f radio transmitter stations were carefully examine during their hospitalization. The following examina tions were performed: medical, ophthalmologic neurologic, psychiatric, psychologic, gynecologic i women, chest x-rays, electrocardiogram, urin analysis, 17-ketosteroids/24 hr urine, blood sedimer tation rate, blood count, protein-bound iodine, bloo *proteins and their fractions*, plasma lipoprotein (electrophoresis), glucose tolerance test, and beta carotene. In the serum, total lipids and cholestero bilirubin, thymol turbidity, glutamic pyruvic an glutamic oxaloacetic transaminases, lacti dehydrogenases, urea nitrogen, creatinine, sodium potassium, calcium, chloride, alkaline phosphatase and iron were analyzed. Intensity of the elec tromagnetic field was repeatedly measured. In som working places the intensity exceeded values per missible in Poland (50 V/m for 8 hr/day). The result of examinations were compared with controls an statistically evaluated. No signs of damage due t electromagnetic radiation were found in the examin ed persons

6853 **BIOELECTRICAL BRAIN ACTIVITY IN EMPLOYEES EXPOSED TO VARIOUS FREQUENCY ELECTROMAGNETIC FIELD (MEETING ABSTRACT).** *(Eng.)* Bielski, J. (Dept. Hygiene and Work Safety, Agricultural Univ., Poznan, Poland); Sawinska, A.; Pianowska, J. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 31; 1980 (no refs).

Bioelectrical activity of the brain of employees operating radio and television installations (range of 3,000-7,000 MHz frequency microwaves and 0.1-2 l

neurasthenic syndromes with vegetative disturbances appeared. Anomalous EEGs were found in 28%. EEGs with low voltage surface leads of alpha or flat type and deep leads with single, short series of slow theta waves were recorded. Industrial employees exposed to an electromagnetic field of 7-30 MHz frequency and 30-200 V/m intensity also demonstrated neurasthenic syndromes with vegetative disturbances but with a greater intensity than in the former group. Anomalous EEGs were found in 69%. EEGs with low voltage or flat surface leads and high voltage deep leads with numerous series of slow theta waves and with single sharp waves ("spikes") were recorded. This study demonstrated that an electromagnetic field, even when it is not very intense, adversely affects general health conditions, in particular the bioelectrical activity of the brain. The greater number of anomalous EEGs and the increased intensity of EEG changes observed in industrial workers as compared to radio and television employees may indicate a more harmful influence on brain activity of longer waves characterized by lower frequency as compared to microwaves of very high frequency.

6854 CATARACTS FOLLOWING USE OF CATHODE RAY TUBE DISPLAYS (MEETING ABSTRACT). *(Eng.)* Zaret, M. M. (Zaret Foundation, 1230 Post Rd., Scarsdale, NY 10583). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 32; 1980 (no refs).

The development of cataracts, in relation to the use of cathode ray tube generated displays, that exhibit characteristics resembling nonionizing radiation injury is reviewed. Case reports are presented that clearly indicate (1) that both cumulative and additive effects occur, (2) that there is a time-related delay before the appearance of lens pathology, and (3) that the cataractogenesis, if discovered and recognized at any early stage, may become arrested in forme fruste by protection from continuing exposure. Case studies are presented that led to the direct implication of previously unsuspected nonionizing radiation wavebands at etiologic or contributory cataractogenic factors. Examples of epidemiologic investigations are provided. The significance of clustering is detailed. An analysis is made of the spectral emissions from typical cathode ray tube displays under normal and malfunction operating conditions. The rationale for determining, beyond any reasonable doubt, the irrelevance of applying conventional nonionizing radiation health-safety criteria is discussed. Finally, a detailed pragmatic methodology whereby this problem can be investigated epidemiologically and ultimately solved is presented.

ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* Phillips, R. D. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 32; 1980 (no refs).

The biologic effects of long-term (2 yr), chronic (20 hr/day, 7 days/wk) exposure to 60-Hz electric fields (30 kV/m) on two filial generations of miniature swine are being studied. Fifty-one females (F_0 population) were started on exposure at 18 mo of age. After 4 mo of exposure, the F_0 gilts were bred with unexposed boars to produce offspring (F_1) that were exposed from conception through adulthood (24 mo). Prior to and throughout the exposure period, the animals are subjected to routine clinical examinations and to a battery of tests to assess for effects of exposure. In addition, data were collected on pregnant sows and their 100-day-old fetuses for teratologic, neurophysiologic, and clinical pathologic examinations. No adverse biologic effects were observed in reproduction, growth, development, hematology, serum chemistry, immunology, cytogenetics, or mortality in the F_0 during the first 12 mo of exposure or in the F_1 during the first 6 mo of exposure. Significant changes were observed among exposed animals in behavior (open-field test and 7-choice maze) and in one neurophysiologic test (synaptic transmission). The behavioral and neurophysiologic effects may reflect the animals response to chronic stimulation by electric-field exposure.

6856 NON-LINEARLY LOADED INSULATED PROBES FOR THE MEASUREMENT OF ELECTRIC FIELD DISTRIBUTION IN BIOLOGIC MEDIA (MEETING ABSTRACT). *(Eng.)* Bozzetti, M. (Facolta di Ingegneria, Istituto Elettrotecnico, Universita Degli Studi di Bari, Via re David, 200, 70125 Bari, Italy); Corsi, F.; DeLeo, R. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 34; 1980 (no refs).

An analysis of the behavior of a nonlinearly loaded antenna immersed in a biologic medium and illuminated by an electromagnetic field source external to the body operating at two different ultrahigh frequencies was performed. The Volterra series approach was used to evaluate the power scattered by the antenna at some close intermodulation frequency components. A sensitivity study was performed to optimize the design of the probe and the whole system. The results showed that these nonlinearly loaded probes are suitable for electromagnetic field measurements in biologic bodies. The main characteristics exhibited by this measurement system are: 1) a sensitivity in the electric field

the probe up to about 10 cm at 960 MHz, and 4) independence of the probe response on the biologic tissue dielectric characteristics.

6857 MICROWAVES DOSIMETER DESTINED TO SAFETY PROTECTION AGAINST RADIATION (MEETING ABSTRACT). *(Eng.)* Pellissier, J. P. (Groupe Effets Biologiques des Micro-ondes, Lyon, France); Pre, A.; Deschaux, P.; Santini, R. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 34; 1980 (no refs).

Different forms of an appliance that measure the quantity of energy, expressed by J/cm², that is absorbed by an irradiated body are described. The simplest model has its own power source and can be fixed to the small pocket of a jacket. Another model has in addition an optical and sonorous alarm. It is also able to order the switch-off of a relay when the density of microwaves power, at the appliance level, exceeds a preregulated threshold.

6858 PENETRATION DEPTH AND SPATIAL RESOLUTION OF ATRAUMATIC PROBES FOR MICROWAVES (MEETING ABSTRACT). *(Eng.)* Nguyen, D. D. (Centre Hyperfrequences et Semiconducteurs, No. 287, LA-CNRS, 59655 Villeneuve D'Ascq cedex, France); Robillar, M.; Chive, M.; Leroy, Y.; Audet, J.; Bolomey, J. C.; Pichot, C. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 35; 1980 (no refs).

The electrical properties of probes that are used for biomedical applications (e.g., microwave thermography, local hyperthermia) that have an open rectangular waveguide filled with a dielectric are described. Numeric methods were used to calculate the reflection coefficient and the near field configuration in lossy materials. The results were compared with experimental measurements and with analytical expressions. Systematic studies, in the frequency range 1-9 GHz, showed that the matching of the probe and the penetration depth depend not only on the characteristics of the living tissue but also on those of the probe.

6859 THERMAL IMAGING AT 9 GHz MICROWAVES (MEETING ABSTRACT). *(Eng.)* Mamouni, A. (Centre Hyperfrequences et Semiconducteurs, No. 287, LA-CNRS, 59655 Villeneuve D'Ascq cedex, France); Sozanski, J. P.; *30-July 4, 1980 in Jouy en Josas, France.* p. 35, 198 (no refs).

An original system of microwave thermal imaging described and the results of preliminary tests a presented.

6860 THERMAL EQUIVALENT O MICROWAVES IN LIVING CELL (MEETING ABSTRACT). *(Eng.)* Dardalhon, M. (Se tion de Biologie, Institut Curie, 26 rue d'Ulm, 752 Paris, France); Berteaud, A. J.; Averbeck, D. *I Abstracts of the Proceedings of the Internation Symposium on the Biologic Effects of Ele tromagnetic Waves held June 30-July 4, 1980 in Jou en Josas, France.* p. 36; 1980 (no refs).

The global temperature of the cellular system aft treatment with microwaves was studied *Saccharomyces cervisiae* zygotes. Two haplo strains of different mating types that gave rise t stable heterozygote diploid cells were used. The radiations were performed at frequencies 9.4 GHz, 1 GHz, and 73 GHz using power levels between 1 an 60 mW/cm². Estimations of equivalent temperature were achieved by comparing the results to those ot tained after conventional heating. The results show ed that a power density of 10 mW/cm² was equivale to a global rise in temperature of the cells by 0.5-1 depending on the frequency used. The heating pr duced goes through a maximum at 17 GHz (about 1 at 10 mW/cm²), indicating that it is essentially due t the dielectric absorption of the microwaves by free loosely bound water molecules in the cytoplasm This approach makes it possible to obtain a quan titative, precise, and reproducible estimation of thermal equivalent of microwaves at the unicellul level.

6861 NEW NON-INTERFERING THEF MOMETRIC NEEDLE PROBES FOR I SITU THERMAL DOSIMETRY DURING ELEC TROMAGNETIC IRRADIATION PRODUCING HYPEF THERMIA (MEETING ABSTRACT). *(Eng.)* Samsel, M (Laboratoire de Thermologie Biomedicale, Facult de Medecine, Universite Louis Pasteur, 11 ru Humann, 67085 Strasbourg cedex, France; Gautherie, M. *In: Abstracts of the Proceedings of th International Symposium on the Biologic Effects Electromagnetic Waves held June 30-July 4, 1980 Jouy en Josas, France.* p. 36, 1980 (no refs)

Various prototypes of needle thermometric probes noninterfering with hyper- or radio frequency elec tromagnetic waves, were designed to control and ac curately monitor deep tissue temperature durin local electromagnetic hyperthermia for cancer treat

method used to measure temperature, and they are inexpensive and disposable. Investigations have been carried out on phantoms, postoperative specimens, and in vivo on patients, to evaluate the characteristics and reliability of the probes and to specify conditions for their clinical use.

6862 FIELD INTERACTION WITH NERVE- AND MUSCLE CELLS WITHIN 1 Hz AND 30 MHz (MEETING ABSTRACT). *(Eng.)* Bernhardt, J. H. (Institut fur Radiologie, Universitat Erlangen, Nurnberg, W. Germany). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 37; 1980 (no refs).

By using several biophysical approximations and considering man as spherical or spheroidal homogeneous model, limiting order-of-magnitude values for external electric and magnetic field strengths that may be hazardous for human beings were calculated. Danger may occur by excitation processes below 10 kHz for field strengths exceeding these limiting values; for frequencies larger than 10 kHz, thermal effects are predominant before excitation occurs. This critical frequency increases to about 50 to 100 kHz for single pulses. The external electric field strength necessary for causing action potential in the central nervous system exceeds by far the corona forming level. Furthermore, by comparing the electrically and magnetically induced currents with the natural currents in man caused by brain and heart electrical activity, a "lower boundary line" can be estimated. Direct effects on the central nervous system from electric or magnetic field strengths that under-cut this boundary line may be excluded. Other mechanisms may be responsible for demonstrated biologic effects.

6863 THERMIC REPARTITION AT PROXIMITY OF A SPHERICAL HOT SPOT SITUATED IN A CYLINDRICAL PHANTOM (MEETING ABSTRACT). *(Eng.)* Ducourtieux, J. P. (Laboratoire des Radiations Ionisantes A, UER des Sciences, 87060 Limoges cedex, France); Bonfanti, J. C.; Bernard, M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 37; 1980 (no refs).

Temperature distribution after microwave hyperthermia of a spherical hot spot situated in the center of a cylindrical phantom model was studied. The cylindrical phantom was constructed to simulate a cylindrical anatomic zone with the hot spot simulating a deep cancerous tumor. Temperature repartition was

6864 COMPARATIVE STUDIES OF HYPERFREQUENCY APPLICATORS (2,450 MHz, 434 MHz) ON PHANTOMS AND POST-OPERATIVE SPECIMENS, WITH A VIEW TO USING MICROWAVE HYPERTHERMIA FOR CANCER TREATMENT (MEETING ABSTRACT). *(Eng.)* Guerquin-Kern, J. L. (Faculte de Medecine, Laboratoire de Thermologie Biomedicale, 11 rue Humann, 67085 Strasbourg cedex, France); Samsel, M.; Palas, L.; Gautherie, M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 38; 1980 (no refs).

The thermal effects of electromagnetic waves on biologic tissues have been simulated using two different physical models: 1) on excised animal tissues and postoperative specimens (e.g., after mastectomy) and 2) on original phantoms made of transparent gels and resins with known dielectric and thermal properties corresponding to those of biologic tissues. The deep thermal pattern was measured in the specimens with an infrared camera just after microwave radiation and in the phantoms with real-time display during electromagnetic irradiation by films of cholesteric liquid crystals. The results obtained with various prototypes of applicators working at 2,450 MHz and 434 MHz demonstrated the importance of the geometric configuration of the applicator and the necessity of a surface cooling system when hyperthermia is localized within a given target volume.

6865 THEORETICAL AND EXPERIMENTAL CONSIDERATIONS OF A RADIO FREQUENCY SYSTEM FOR TISSUE HEATING (MEETING ABSTRACT). *(Eng.)* Hand, J. W. (MRC Cyclotron Unit, Hammersmith Hosp., Du Cane Rd., London W12 OHS, England); Ledda, J. L.; Cobbett, F. C.; Hopewell, J. W. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 38; 1980 (no refs).

The induction of heating (27.12 MHz) in tissues was studied with the aid of mathematic models. Circular "pancake" coils and rectangular coils were considered and particular interest was given to such variables as the dimensions of the coils and their distance from the tissues. A method of reducing the toroidal nature of the heating patterns induced by coils of circular geometry was presented. The problems associated with the measurement of temperature during electromagnetically-induced hyperthermia may be reduced by using very fine thermocouples while the fields are turned off. A controller that periodically up-dates information on temperature in the absence of electromagnetic heating fields was developed. It can be programmed

system was tested in phantoms and anesthetized pigs and relevant results are presented.

6866 THEORETICAL SIMULATION OF ELECTROMAGNETIC WAVE PENETRATION AND ITS APPLICATION (MEETING ABSTRACT). *(Eng.)* Priou, A. (ONERA-CERT-DERMO, B.P. No. 4025, 31055 Toulouse cedex, France); Fournet-Favas, C.; Gimonet, E.; Guerquin-Kern, J. L.; Samsel, M.; Gautherie, M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 39; 1980 (no refs).

Theoretical simulations of the depth of penetration of electromagnetic waves at 434 MHz (free waveiength 69 cm) were studied with respect to the surface conditions (with or without cooling) and to the number of applicators (1 or 2 or crossed applicators). Experimental studies were also conducted to design compact and low-weight applicators and to improve the coupling of electromagnetic waves to the material to be treated.

6867 *IRRADIATION SYSTEMS FOR STUDYING* NONTHERMAL BIOLOGICAL EFFECTS OF HIGH FREQUENCY MICROWAVES (MEETING ABSTRACT). *(Eng.)* Keilmann, F. (Max-Planck-Institut fur Festkorperforschung, 7000 Stuttgart 80, W. Germany); Grundler, W. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 39; 1980 (no refs).

The control of irradiation frequency and intensity (the latter with emphasis on standing waves) was discussed. Thermal transport analysis revealed that a moderate irradiation intensity (10 mW/cm²) did not lead to microthermal effects inside living cells (i.e., cannot noticeably raise the temperature or generate a significant temperature gradient), provided these cells are suspended in water (or agar) that is held at a constant temperture. At high frequencies microwave absorption in water is so strong that to produce a homogeneous irradiation intensity, the sample must be thin in at least one dimension. A thin planar layer is a practical design, where one surface can be used for thermostatting by heat conduction through a suitable solid and the other surface can be designed, e.g., by use of a semipermeable membrane, to accomodate various biologic requirements like sterilization, filling, nutrition, and perspiration.

6868 TEMPERATURE INDEPENDENT EF

Drechsel, R.; Kowal, H. *In: Abstracts of the Pr ceedings of the International Symposium on t Biologic Effects of Electromagnetic Waves held Ju 30-July 4, 1980 in Jouy en Josas, France.* p. 40; 198 (no refs).

V-79 chinese hamster cells were exposed to lo temperature hyperthermia by heating the cells either a water bath or by 915-MHz microwave radi tion. In initial studies, cells were seeded in a 35-m petri dish that was positioned at the end of a TE energized, open ended waveguide. The bottom the dish, to which the cells were attached, was contact with a circulating water bath (±0.1 C). At ap proximately 600 mW/cm² of incident power and temperature of 41 C, no difference was observed cell survival when exposed cells were compared wit control cells (0-W) at 41 C. At approximately 2.00 mW/cm², however, a statistically significar decrease in survival was observed, even though th cell temperature was maintained at 41 C. Because ir cident power densities in this system could only b approximated and because the site and externa position of the petri dish introduced the possibility unknown reflections, a second exposure system wa designed. In this system, cells were placed inside saline-filled waveguide using a 50-lambd micropipette. The saline was circulated to contr *temperature. The micropipette was too small to ir* terfere with the propagated TE_{10} mode. Field attenua tion between antenna and specimen were accurate calculated. The results obtained from this system wi be compared with those obtained in the initia studies.

6869 MICROWAVE HYPERTHERMIA DELIVER SYSTEMS (MEETING ABSTRACT). *(Eng* Kowal, H. (Roswell Park Memorial Inst., Buffalo, N 14263); Kantor, G.; Johnson, R. J.; Subjeck, J. R. *In Abstracts of the Proceedings of the Internation Symposium on the Biologic Effects of Elec tromagnetic Waves held June 30-July 4, 1980 in Jou en Josas, France.* p. 40; 1980 (no refs).

Hyperthermia produced by 915-MHz and 434-MH microwave sources was used to treat in vivo tumors Various types of applicators were developed to effec tively direct the radio frequency (RF) beam to specific treatment area. Direct contact, air cooled dielectric filled waveguides and infinite plane direc tional antennas were the two basic designs that me the requirements of RF beam containment and pa tient treatment. The development, applicator effi ciency, microwave power requirements, and energy deposition in tissue will be discussed as a function o 915 and 434 MHz.

Onde Electtromagnetiche, CNR, Firenze, Italy); Paoletti, P. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 41; 1980 (no refs).

Experiments on microwave heating of fresh frozen plasma, banked plasma, cryoprecipitates, and hemodiagnostic sera were conducted to compare the biologic reliability of microwave heating with that of traditional warming techniques. A microwave bridge and a commerical microwave oven were used as warmers. Total protein and electrophoretic patterns of the selected hemoderivatives were analyzed, as well as some coagulating factors and agglutination reactions. The results confirmed the reliability of the microwave heating.

6871 COMPARATIVE STUDY OF MICROWAVE DIATHERMY AT 434 MHz, 915 MHz, AND 2,450 MHz (MEETING ABSTRACT). *(Eng.)* Kantor, G. (Div. Electronic Products, BRH, FDA, Rockville, MD 20857); Witters, D. M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 41; 1980 (no refs).

Heating patterns induced by diathermy in planar phantoms and associated stray radiation were compared at 434 MHz, 915 MHz, and 2,450 MHz. Three circular applicators with aperture diameters of about 15 cm were selected for study. The 915-MHz and the 2,450-MHz applicators are direct contact BRH prototypes, the former with an annular choke and the latter with an annular choke covered with a 2.5-cm thick absorber to minimize leakage radiation. The 434-MHz applicator is commercially available. The heating patterns were obtained by placing the applicators symmetrically on top of a planar phantom of simulated fat and muscle tissues. The 434-MHz diathermy evaluation was hindered by the extremely low rate of energy deposition. The measurements showed that the 434-MHz patterns were broader and the depth of penetration into muscle tissue was somewhat greater than for 915 MHz and 2,450 MHz. The leakage radiation at 5 cm from the applicator phantom boundary, when delivering 235 W/kg to simulated muscle, was considerably less than 10 mW/cm^2 for the 915-MHz and 2,450-MHz applicators. Leakage measurements for the 434-MHz applicator indicated that this design needs to be modified in order not to greatly exceed 10 mW/cm^2 of leakage for high power diathermy settings.

6872 EFFECTS OF MICROWAVE HEATING ON METHIONINE AND GLUCOSE SOLUTIONS (MEETING ABSTRACT). *(Eng.)* Airaudo, C. B. (Laboratoire de Bromatologie, Faculte de Pharmacie, Dietetique et Analyse Appliquee a l'Expertise, 27 bd. Jean Moulin, 13385 Marseille cedex 4, France); Gayte-Sorbier, A. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 42; 1980 (no refs).

The effects of microwave heating (of various exposure durations, 0-20 min) and its interaction with the effects of dry or liquid medium and pH (0-14) on the behavior of a methionine and glucose solution were studied. The results were compared with those produced by microwave heating of methionine or glucose alone and with the results obtained by conventional heating of the same solutions. The formation of methionine sulfoxides and of 1-amino-deoxy-2-ketose (methionine glucose), but not of methionine sulfone, was observed. The formation of methionine glucose is tightly bound to the disappearance of methionine; extreme pH conditions may lead to the complete loss of the amino acid. Residual rates of the initial nutriments were presented, and the nutritional consequences of the observed phenomenon were discussed. It is concluded that conventional microwave heating does not seem to involve more important losses of methionine and glucose than conventional heating.

6873 THERMAL IMAGING USING MICROWAVE RADIOMETRIC SYSTEMS APPLIED TO DETECTION AND PROGNOSIS OF BREAST, CEREBRAL AND THYROID TUMORS (MEETING ABSTRACT). *(Eng.)* Gautherie, M. (Laboratoire de Thermologie Biomedicale, Faculte de Medecine, Universite Louis Pasteur, 11 rue Humann, 67085 Strasbourg, France); Moyses, B.; Leroy, Y.; Mamouni, A.; Moschetto, Y.; Sozanski, J. P. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France*. p. 44; 1980 (no refs).

Various clinical investigations were carried out with an original, highly sensitive microwave radiometer operating at 9 GHz. This device allowed direct display of thermal profiles on an oscilloscope screen and the possible reconstruction of thermographic images. Three groups of patients with benign or malignant tumors were investigated: 1) breast tumors (comparison with mammography and echotomography), 2) cerebral tumors (comparison with computed axial tomographic scanner and arteriographic findings), and 3) thyroid tumors (comparison with scintigraphy and echotomography). Microwave thermography seemed to provide significant information on metabolism and thermal conditions of subcutaneous

6874 TEMPERATURE-TIME PROFILE IN RATS SUBJECTED TO SELECTIVE MICROWAVE IRRADIATION OF THE BRAIN (MEETING ABSTRACT). *(Eng.)* Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Lin, M. F. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 44; 1980 (no refs).

Real-time cortical and colonic temperature changes in rats irradiated for 20 min by a 2,450 MHz contact radiator at the head were measured. Microwaves were delivered to the radiator at 10-μsec pulses, at pulse repetition rates of 25-500 parts/sec, and at energy rates of 1-5,000 mW, corresponding to incident power densities of 0.5-3,250 mW/cm². Lower power densities yielded a small cortical temperature increase below that for the body core whereas higher power densities produced a greater cortical temperature rise. Even at an incident power density as high as 3,250 mW/cm² (specific absorption rate of 260 mW/g in the brain), the cortical temperature increased by less than 3.0 C, while the colonic temperature rose by 0.5 C. The cortical temperature rose rapidly during the initial transient period of irradiation, but it became nonlinear and achieved a steady-state level around 39 C. It is concluded that the brain temperature was lowered by thermoregulatory processes involving blood circulation, temperature, and mass differences between the brain and the nonirradiated body of the anesthetized rat, and that the irradiated brain received significant protection from the nonirradiated body.

6875 WHOLE-BODY EXPOSURE IN THE NEAR ZONE OF HF ELECTROMAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202). *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 45; 1980 (no refs).

The induced field and absorbed energy in a prolate spheroidal model of the human body and in a spherical model of the human head exposed to uniform near zone high frequency (HF) fields having different normalized field impedances are reported. The results showed that in the HF frequency region, the magnetically induced contribution to energy absorption was much larger than the contribution due to the external electric field. This was true even for field impedances of 07.7 kohms, where the ratio of external electric to magnetic field strengths was 100 to 1. The specific absorption rate (SAR) varied over four orders of magnitude for normalized impedances ranging from 0.1 to 100. The SAR decreased as the square of normalized impedance between 0.1 and 1.0 and it approached a baseline for normalized im- strength with normalized impedances less than would be substantially less than that required field with normalized impedances greater than u

6876 INTERNAL DOSIMETRY OF THE MOUSE EXPOSED TO 2,450 RADIOFREQUENCY (MEETING ABSTRACT). (Kinn, J. B. (Bioengineering Branch, Experim Biology Div., Health Effects Res. Lab., Research Triangle Park, NC 27711). *In: Abstrac the Proceedings of the International Symposiu the Biologic Effects of Electromagnetic Waves June 30-July 4, 1980 in Jouy en Josas, France.* 1980 (no refs).

CD-1 mice were exposed to 2,450-MHz radio frec cy radiation in an anechoic chamber and the ab tion characteristics were determined. The w body specific absorption rate (SAR) was meas using twin-well calorimetry, and the internal pa body SAR was measured using thermography ar ternal temperature probes. Analysis was made c mice specimens. The energy distribution withi mouse specimen was averaged over specific a e.g., brain, abdomen, and hypothalamus. The tion between whole-body dose and int dosimetry, hot spot location, and variability of due to orientation of animal and field were disc ed.

6877 DETECTION OF INTRACRANIAL LESI WITH THE HELP OF MICROW RADIOMETRY (MEETING ABSTRACT). *(Eng.)* Ro J. (Laboratoire de Biophysique, 18, rue Lion 54000 Nancy, France); Thouvenot, P.; Mamoun Leroy, Y. *In: Abstracts of the Proceedings of th ternational Symposium on the Biologic Effec Electromagnetic Waves held June 30-July 4, 19 Josas, France.* p. 46; 1980 (no refs).

Microwave radiometry was applied to the dete of intracranial lesions in 16 patients, and the re were compared with those obtained by radiol scintigraphy, and surgery. Three recently dev sensors were tested: a radiometer operating at 9 and thermographs operating at 63.30 GHz an GHz. Thermal repartition in intracranial lesions determined in five normal subjects. menangiomas, three gliomas, and one metas resulted in hyperthermia. Hypothermia was ob ed in one frontal glioma, probably linked to peri edema. One deep glioma resulted in diffuse hy thermia. Recent cerebral softening was observe induce hyperthermia, whereas older softening not introduce any thermal perturbation.

2.5 GHz (MEETING ABSTRACT). *(Eng.)* Nguyen, D. D. (Centre Hyperfrequences et Semi-conducteurs, No. 287, LA-CNRS, Universite de Lille, 59655 Villeneuve D'Ascq cedex, France); Chive, M.; Leroy, Y. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 46; 1980 (no refs).

A noninvasive microwave thermographic technique that permits simultaneous heating and temperature measurement by radiometry was designed and the feasibility of such a system was tested. Three methods were proposed: 1) an alternate process, for which switching was carried out to make a temperature measurement during the operation; 2) a simultaneous process that achieved the two operations at the same time; and 3) a sampling process that used pulsed signals. The problems encountered, mainly due to intermodulation effects, were solved, and a prototype was designed that operated at 2.5-GHz, with a 16-WCW power generator and a high sensitivity radiometer. The initial results obtained with this system for animal tissues are presented.

6879 MEASURING AND MODELING HUMAN ERYTHROCYTES BEHAVIOUR AT MICROWAVE FREQUENCIES (MEETING ABSTRACT). *(Eng.)* Bianco, B. (Laboratorio per i Circuiti Elettronici, CNR, Genova, Italy); Drago, G. P.; Marchesi, M.; Martini, C.; Morando, M.; Morgavi, G.; Ridella, S.; Mela, G. S. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 47; 1980 (no refs).

Results of microwave spectroscopy of human blood are presented. With the aid of a recently developed accurate measurement technique, complex dielectric constants of several mixtures of erythrocytes and plasma (in various concentrations) obtained from healthy male volunteers were measured, in the frequency range of 100-2,000 MHz. The measured values were compared with those obtained with a blood model (i.e., a mixture of saline solution [plasma] and cells, in turn composed of mixtures of hemoglobin ellipsoids and another solution). The percent of water bound to hemoglobin, its relaxation frequency, and the normality of the saline solution of cytoplasm were also derived, through an optimization procedure. The results were in reasonable agreement with those obtained by other techniques. The results of an error analysis are also presented.

6880 APPLICATION OF TIME DOMAIN REFLECTROMETRY TO THE STUDY OF DIELECTRIC PROPERTIES OF BIOLOGICAL porelle et Frequentielle, Universite de Bordeaux, Bordeaux, France); Bose, T. K. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 47; 1980 (no refs).

A new probe to be used in conjunction with "time domain reflectrometry" (TDR) for the measurement of dielectric properties of biologic substances was developed. This probe allows dielectric measurements to be made both in vivo an in vitro. The time domain method permits precise determination of dielectric loss curve over a frequency range extending from 10 kHz to 10 GHz with a single measurement. The authors suggest that this probe will lead to important contributions in the area of cancer research, particularly in microwave heating.

6881 STUDY AND MODELING OF COAXIAL PROBES FOR THE PERMITTIVITY MEASUREMENT OF IN VIVO BIOLOGICAL SUBSTANCES IN MICROWAVES (MEETING ABSTRACT). *(Eng.)* Castelain, A. (Centre Hyperfrequences et Semi-conducteurs, No. 287, LA-CNRS, Universite de Lille, 59655 Villeneuve D'Ascq cedex, France); Dujardin, B.; Bliot, F.; Robert, J.; Escanye, J. M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 48; 1980 (no refs).

A more complete theoretical approach of microcoaxial probes allowing relatively easy numeric simulations is presented. Numeric results were obtained in a wide range of complex permittivity $\varepsilon^* = \varepsilon' - j\varepsilon''$ ($2 < \varepsilon' < 80$; $2 < \varepsilon'' < 40$), indicating the contributions due to the geometric parameters, the frequency, and the electrical properties of the medium under study. Experimental results are presented, obtained on polar liquids with dielectric properties similar to those of biologic tissues and on mixtures used as phantoms in microwave hyperthermia studies. A generally good agreement was obtained between experimental and numeric results in a wide frequency range (1-12 GHz).

6882 CLINICAL USE OF HYPERTHERMIA WITH RADIATION (MEETING ABSTRACT). *(Eng.)* Johnson, R. (Roswell Park Memorial Inst., Buffalo, NY 14263); Krishnamsetty, R. M.; Yakar, D.; Subjeck, J.; Kowal, H.; Wojtas, F.; Clay, L.; Dannels, J. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 50; 1980 (no refs).

Eighty tumors were treated with radiation and hyper-

ment, including the incidence of thermal damage, thermal pain, and the tolerance of patients to immobilization for treatment. Clinical thermal distributions were obtained for 2,450, 915, and 434 MHz microwaves. A design with measurements of normal tissue and tumor temperature, pO_2, and pH were assessed during hyperthermia. A second protocol involved treatment of patients with multiple, metastatic cutaneous lesions to investigate the effect of immediate and delayed postradiation hyperthermia in the 42-C range on the thermal enhancement ratio of tumor and normal tissue by assessing regrowth response. The results of this protocol are presented together with a discussion on the difficulties of obtaining adequate data from patients with advanced disease and multiple cutaneous metastases. The third protocol investigated in three groups of patients the tumor enhancement factor resulting from postradiation 43-C hyperthermia. The first group of patients had either two or more tumors within 4 cm of the skin that were multiple or large enough to be divided into control and experimental areas. The control areas were treated with 400 rad fractions 2x/wk to a total dose of 4,000-4,800 rads and the experimental areas were treated with the same dose followed by immediate postradiation hyperthermia with 915 or 434 MHz microwaves. Whenever possible, the heat was applied specifically to the tumor by either defining the heat field or by cooling the superficial skin. A second group of patients who had previous radiation and were unsuitable for surgery were given radiation together with postradiation heat. The responses obtained with 915 and 434 MHz heat and radiation as compared with radiation alone are presented.

6883 INFLUENCE OF HYPERTHERMIA ON THE BLOOD FLOW IN A CHEMICALLY INDUCED RHABDOMYOSARCOMA OF THE C3H MOUSE (MEETING ABSTRACT). *(Eng.)* Robert, J. (Laboratoire de Biophysique, 18 rue Lionnois, 54000 Nancy, France); Escanye, J. M.; Thouvenot, P.; Marchal, C. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 50; 1980 (no refs).

Local blood flow was measured by radioactive xenon inhalation technique in C3H mice bearing rhabdomyosarcoma who were treated with local hyperthermia induced by microwaves at 432 MHz. Blood flow was studied near the tumor and tissue and before, during, and after the daily hyperthermia treatment. Hyperthermia resulted in increased blood flow near the tumor and muscle.

6884 FACTORS AFFECTING MICROWAVE-

the Symposium on the Biologic Effects of tromagnetic Waves held June 30-July 4, 1980 in en Josas, France. p. 51; 1980 (no refs).

To determine the upper limits of time temperature for microwave irradiation without comitant damage to nervous tissue, selec heating of the rat head was produced by shiel the remainder of the body with Eccosorb. In u studies, microwave radiation at 2,450 MHz delivered with a type A applicator. The integrity o blood-brain barrier was studied using horsera peroxidase. Animals were injected intraveno with 1.8 mg/10 g body wt 30 min prior to sacri Rats were studied at brain temperatures of 40, 4 45 C. In animals with normal body temperature (3 the blood-brain barrier was disrupted with sev combinations of brain temperature elevation duration. Efforts to duplicate these findings wi second applicator consisting of dielectric-loa rectangular waveguide were unsuccessful. It found that the initial rate of power deposition lower, due to dielectric breakdown and increa power reflection. A third applicator was construc consisting of a corrugated waveguide that dielectric-loaded. With this applicator, it was po ble to disrupt blood-brain barrier integrity with same combinations of time and temperature that been established previously with the type A plicator. It is concluded that the high initial rat energy deposition possible with the type A and rugated waveguide applicators was required disrupt blood-brain barrier integrity. These findi indicate that, in addition to the level and duratio brain temperature elevation, initial power deposi rate is important in producing barrier disruption

6885 TREATMENT OF URINARY BLADD CARCINOMA WITH LOCAL HIGH F QUENCY HYPERTHERMIA (MEETING ABSTRA *(Eng.)* Harzmann, R. (Dept. Urology, Univ Tubing Calwerstrasse 7, D-7400 Tubingen, W. Germa Bichler, K. H. *In: Abstracts of the Proceedings of International Symposium on the Biologic Effect Electromagnetic Waves held June 30-July 4, 198 Jouy en Josas, France.* p. 51, 1980 (no refs).

Techniques were sought for homogeneous hyp thermia of the bladder wall as well as information the effects of hyperthermia on healthy and tumor bladders in rabbits and dogs. Phantom trials led the development of a transurethral high-freque application technique. Healthy animal bladd showed a transient mucosal edema as a result hyperthermia. Transurethrally hyperthermized (4 tumors in rabbit bladders necrotized subtotally, w smaller, and metastasized more seldom than treated tumors. Local hyperthermia of

tumor remission as a result of tumor necroses and stroma hyalinosis. Local hyperthermia is an adjuvant, palliative therapeutic technique.

6886 PRELIMINARY CLINICAL RESULTS OF LOCAL HYPERTHERMIA BY RADIO-FREQUENCY WAVES IN THE TREATMENT OF VISCERAL TUMORS (MEETING ABSTRACT). *(Eng.)* Israel, L. (Centre Hospitalier Universitaire Avicenne, 93000 Bobigny, France); Besenval, M. *In: Abstracts of the Proceedings of the International Symposium on the Biologic Effects of Electromagnetic Waves held June 30-July 4, 1980 in Jouy en Josas, France.* p. 52; 1980 (no refs).

Forty-five patients with metastatic cancer not responsive or refractory to standard therapeutic procedures were treated by local hyperthermia using radio frequency waves (13.56 MHz). Each session lasted 45-150 min and the total number of sessions ranged from four to nine over a 3-wk period. Temperatures in normal subcutaneous tissue were recorded by a thermocouple and reached 42-43 C. Intratumoral temperatures of 4 to 7.5 C above those of normal tissue were achieved. Temperatures recorded at the tumor periphery were equivalent to those of normal tissue. Of the 33 evaluable patients, 12 showed objective regression, 9 no change, and 12 progression. Regressions occurred 2 wk after the end of hyperthermia and were observed in 35% of the intra-abdominal tumors and 15% of the intrathoracic tumors. Stabilization of disease from 1 to 4.5 mo occurred in 23% of intrathoracic tumors and 21% of intra-abdominal tumors. Subjective improvement was noted even in patients who did not exhibit an objective response: i.e., alleviation of pain in 7/16, weight gain in 4/22, and improvement in specific tumor related symptoms in 5/8. The toxicity associated with the procedure was nil at 1-yr follow-up.

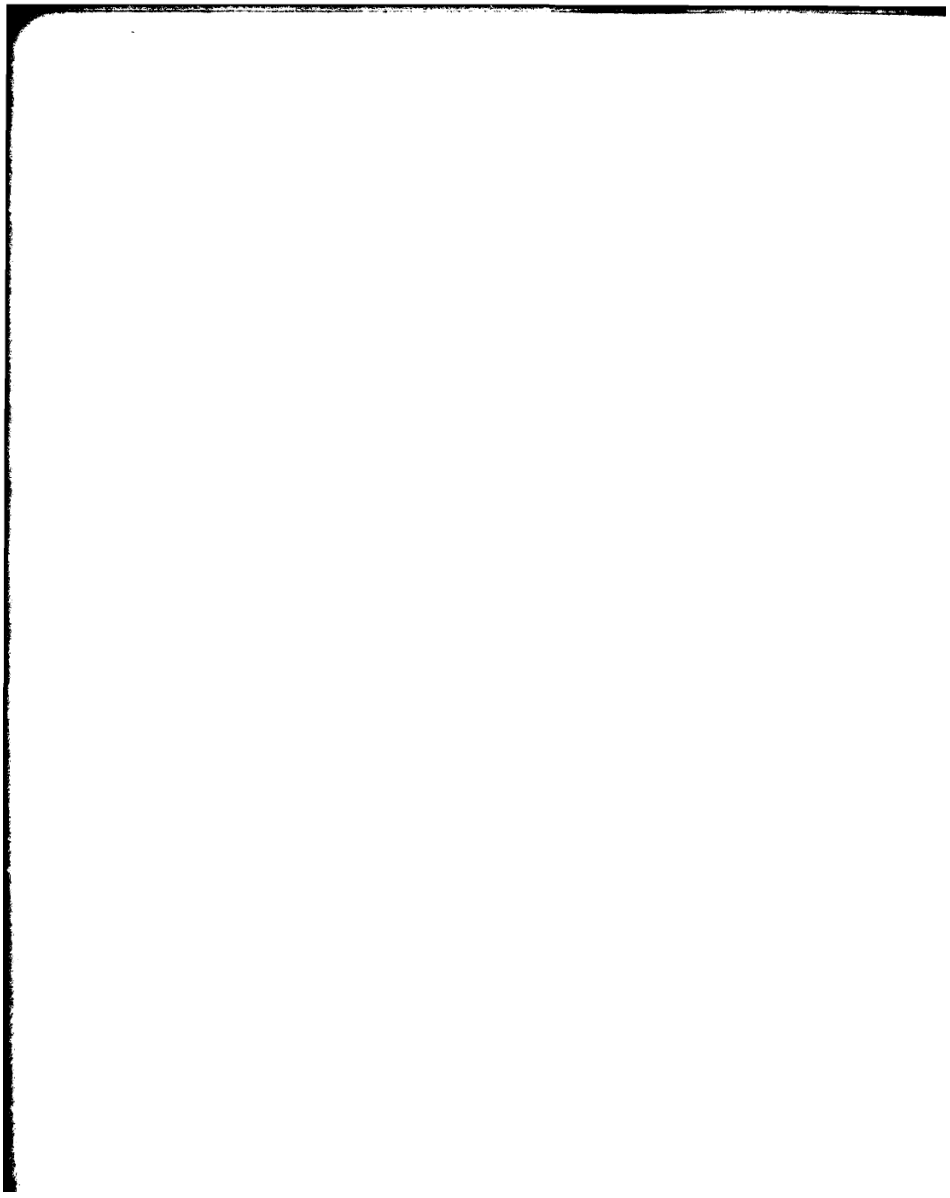
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