remote functions at a controller for determining locomotor activity of rodents in a system of residential mazes. A second is used for monitoring and control of a system of Skinner boxes for small animal behavioral testing. The third system is used for monitoring microwave exposure experiments and generating time interval histograms of dose. Re-programming will be provided as the various experiments are developed. Analysis will be accomplished either in real-time or later in the host as a batch-type operation. (10/76-9/77)

Supporting Agency:EPA

0233 ACCELERATION OF FRACTURE HEALING BY ELECTRICAL FIELDS. Brighton, C. T.; Friedenberg, Z. B.; Black, J.; Hayes, W. C.; Fried, J. (Dept. Orthopedic Surgery, Univ. Pennsylvania, Sch. Medicine, 36th & Hamilton Walk, Philadelphia, PA 19104).

The optimum electrical parameters for accelerating fracture healing will be determined, and the mechanism of electrically-stimulated fracture healing at the cell level will be investigated. The immediate research goals are to: (1) determine the optimum current density and the optimum magnetically-induced current for osteogenesis, (2) compare ultrastructural changes in medullary canal cells in vicinity of active cathode with those in control canal, (3) map the surface charge of cell membranes of chondrocytes growing in an electrical field and compare it to that of control chondrocytes, and (4) determine tissue pO_2, CO_2, and pH changes occurring in medullary canal of the dog tibia subjected to a direct current of 20 μamps. (9/77-8/78)

Supporting Agency:HEW, PHS, NIH, NIAMDD.

0234 DEVELOPMENT OF ELECTROMAGNETIC RHEOANGIOGRAPHY. Kolin, A.; Macalpin, R. N.; Steckel, R. J.; Snow, H. D. (Dept. Ophthalmology, Univ. California, Sch. Medicine, 405 Hilgard Ave., Los Angeles, CA 90024).

This project will complete the development of a newly devised electromagnetic method for simultaneous measurement of average and phasic volume rate of blood flow, blood velocity, and vascular diameters in human subjects. The method utilizes a magnet external to the patient's body so that its magnetic field transverses the blood vessels including an electromotive force in the blood stream, which constitutes the flow signal. The induced flow signal is picked up by an ultraminiature intravascular probe that is inserted into the vessels much as a guide wire via an angiographic catheter (the probe is a loop of insulated spring wire 0.1 mm in diameter). The loop probe can be inserted into small branches of the aorta via angiographic catheter of standard size (#7 French) and will easily pass through much smaller catheters (down to #4 French). The same transducer can be utilized to detect minute variations in phasic and average artery diameter. It is proposed to perfect such transducers to permit measurements in arteries and veins down to 1 mm in diameter and to develop appropriate methods of "delivery," i.e., of conveying the sensing element to the appropriate blood vessel and assuring optimal position and orientation of the sensor relative to the external magnetic field. The proposed research will explore all the important blood vessels supplying the vital organs (such as, renal, mesenteric, internal carotid, and coronary arteries) and develop the simplest possible techniques of recording regional blood flows. The investigation will proceed from anesthetized animals to conscious patients. The work will involve improvement of the design of the flow and diameter sensors as well as of the electronic channels for amplification of the electrical flow signals for current supply to the magnet. This method has been applied to cancer research to explore the possibility of achieving enhanced radio-sensitivity of tumors as compared with the ambient normal tissues by intra-arterial administration of a vasoconstrictor. (9/77-11/77)

Supporting Agency:HEW, PHS, NIH, Natl. Heart Lung & Blood Inst.

0235 EFFECTS OF MULTIPLE RF RADIATION EXPOSURES. Krupp, J. H. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

An attempt will be made to define a radio frequency (RF) radiation effect on humoral antibody production. Such an effect would impair the ability of exposed personnel to withstand infection and develop immunity in response to challenges in the environment. Hybrid inbred mice will be exposed for prolonged periods (up to 6 wk) to RF radiation at frequencies and power levels scaled to represent equivalent human exposure. Following exposure, an antigenic challenge will be made, and the response assayed by measuring the presence of splenic plaque-forming cells. Where RF effects can be detected, further study will try to define threshold levels, thermal versus nonthermal characteristics, and relative efficiency for production of effects from continuous wave or pulsed application over extended periods. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force

0236 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P.; Johnson, C. C. (Utah Higher Education System, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The behavioral and biologic effects of resonant electromagnetic power absorption in rats will be determined in order to develop realistic exposure criteria for military personnel. The parallel-plate wave guide will be used to generate plane waves for exposure of the experimental animals.

Exposures will be made with animals oriented along the E, H, and K axes. Frequency will be established based on the frequency of peak absorption; frequencies of 0.5, 0.75, 1.0, 1.25, and 1.5 times this resonant frequency will be used. (10/77-9/78)

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

0237 DESIGN, CONSTRUCTION AND MODIFICATION OF MICROWAVE EXPOSURE SYSTEMS FOR BIOLOGICAL EXPERIMENTATION. Ali, J. S. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

An environmental control system will be installed in an X-band microwave exposure facility to regulate the air temperature and humidity in both an animal exposure chamber and a sham irradiation chamber. The exposure chamber and sham chamber will be constructed of foamed polystyrene for microwave transparency and good thermal insulation. The temperature will be controllable from -10.0 to +40.0 C with a stability of ±1.0 C and the relative humidity will be controllable from 20% to 90%. The two foam chambers will be connected to the air conditioning equipment using insulated ducts. The air conditioning equipment will have remote control inputs and recorder outputs, which will facilitate computer control. (10/76-9/77)

Supporting Agency:EPA

0238 TDR MEASUREMENT OF DIELECTRIC PARAMETERS OF BIOLOGICAL MATERIALS. Kinn, J. B. (Bioengineering Branch, EPA, Health Effects Res. Lab., Durham, NC 27711).

The broadband dielectric behavior of biologic materials including tissue and micro-organisms will be determined, and the frequency dependence of the complex permittivity will be examined. The portion most influenced by radio frequency (RF) and microwave radiation will be identified. Time domain reflectrometry (TDR) will be employed to study dielectric behavior. The incident and reflected pulse transmitted to the sample in a coaxial waveguide will be recorded with a minicomputer. The data will then be processed using a Fast Fourier Transform in a large computer yielding complex permittivity as a function of frequency. Part of the TDR data has been collected and is being processed. The remaining data will be collected and processed with subsequent examination of the RF dispersion portion of the complex permittivity. (10/76-9/77)

Supporting Agency:EPA

0239 LABORATORY INSTRUMENTATION SUPPORT. Ali, J. S. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

This project is designed to assure the operation of critical instrumentation used for chronic long-term microwave studies. Calibration of microwave instrumentation is performed routinely to guarantee accurate dosimetry. Special electronic instrumentation is designed to facilitate microwave exposures, and measurement of critical parameters and operating manuals are prepared for microwave exposure facilities. (10/76-9/77)

Supporting Agency:EPA

0240 BIOLOGICAL EFFECTS AND HAZARDS OF MICROWAVE RADIATION. Hunt, E. L.; Larsen, L. E. (U.S. Army, Walter Reed Army Inst. Res., Washington, DC).

An attempt will be made to establish meaningful criteria for delimiting human occupancy in an electromagnetic (EM) environment to achieve maximum operational effectiveness of military personnel and eliminate health risk. The interaction of radio frequency and microwave radiation (10 MHz-100 GHz) with biologic systems will be delineated. In addition, established EM dosimetry techniques will be evaluated and developed to measure and control incident and absorbed energy. Each major organ system and biologic process will be investigated where EM effects might occur at reasonably low power intensities. The military significance of the effects will be determined, and measures necessary to obviate them will be evaluated. A multidisciplinary approach will be used including methods of experimental psychology, biophysics, physiology, and engineering. Exposure parameters will be chosen for relevance to Army radiating equipment operational requirements. (10/77-9/78)

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

0241 INTERACTIONS OF AMPLITUDE MODULATED (AM) NON-IONIZING EMR WITH BIOLOGICAL SYSTEMS. Whitcomb, E. R. (Neurobiology Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

To determine if amplitude-modulated (AM) radiant energy can modify the contractility of smooth muscle, the interval histogram patterns of smooth muscle spontaneous contraction prior to and during exposure will be compared. Preliminary radiant energy studies indicated no effects by amplitude modulated radiant energy at .2, .5, 16, 600, and 2,000 Hz. (10/76-9/77)

Supporting Agency:EPA

0242 EFFECTS OF RADIO & RADIO FREQUENCIES ON BIOSYSTEMS--MICROWAVE EXPOSURE SYSTEMS FOR BIOLOGICAL EXPERIMENTS (ABBREV). Allis, J. W.; Weil, C. M. (Developmental Biology Branch, Environmental Protection Agency, Experimental Biology Div., Durham, NC 27111).

Fluorometry can provide measurements of properties of biologic membranes and biopolymers that are not attainable using other optical techniques. If such measurements can be made while a sample is irradiated with nonionizing electromagnetic radiation, changes in these biologic systems can be detected. A fluorometer will be modified to accept an exposure facility so that a sample may be irradiated over a wide range of frequencies simultaneous with fluorometric measurements. Membrane and biopolymer systems will be investigated for a variety of properties detectable by this technique. (10/76-9/77)

Supporting Agency:EPA

0243 MICROWAVE EFFECTS. Tredici, T. J. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A detailed initial ophthalmologic evaluation and follow-up will be provided for Air Force personnel who have suffered a microwave overexposure, i.e., exposure greater than twice the permissible exposure limit. Attention will be focused on the presence or absence of lenticular lesions and the possible causal relation of microwave exposure. Patients will be evaluated in the ophthalmology branch, clinical sciences division, School of Aerospace Medicine at Brooks Air Force Base following standard patient evaluation protocols. Follow-up will be established on an individual basis and reports will be made to the referring physician and medical facility. When sufficient data have been accumulated, the material will be published. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force.

0244 INTERACTIONS OF AMPLITUDE-MODULATED (AM) NON-IONIZING ELECTROMAGNETIC RADIATION WITH BIOLOGICAL SYSTEMS. Blackman, C. F. (Environmental Protection Agency, Experimental Biology Div., Durham, NC 27111).

Bacterial and mammalian cell systems will be exposed to a series of amplitude-modulated (AM) frequencies to determine the effect on various physiologic activities. A bench top radiation exposure system has been constructed that can deliver AM radiation to in vitro samples. Preliminary tests are underway with brain tissue and bacterial and mammalian cells. (10/76-9/77)

Supporting Agency:EPA

0245 CONSTRUCT A CRAWFORD CELL FOR EXPOSURE OF ANIMALS TO FM RADIATION. Weil, C. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

An exposure facility suitable for irradiating rodents at the same frequency used in frequency modulation (FM) radio broadcasting was designed and built. Recent monitoring work has shown that FM broadcasting presents a significant potential for human exposure to radio frequency microwave radiation. A rectangular coaxial transmission line facility (Crawford cell) provides a simple and economic method of exposing test animals to 3-m radiation. Eighteen rats will be simultaneously exposed to an equivalent plane wave field of approximately 10 mW/cm^2. Although construction of the exposure system has been completed, experiments have not yet commenced due to RF leakage problems as well as high ambient noise levels in the vicinity of both chambers. (10/76-9/77)

Supporting Agency:EPA

0246 INFRARED ANALYSIS OF DOSE DISTRIBUTION IN ANIMALS AND PHANTOM MODELS EXPOSED TO MICROWAVE RADIATION. Kinn, J. B.; Weil, C. M. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

The distribution of absorbed energy in a complex biologic system and in equivalent phantoms will be determined experimentally using infrared thermographic analysis of sectioned animals and equivalent phantoms. An infrared thermographic scanner has been purchased and a minicomputer/software system is being designed to collect scans. The basic picture processing software package is operational and additional software is being designed and written. (10/76-9/77)

Supporting Agency:EPA

0247 OCCUPATIONAL EXPOSURE OF U.S. NAVY VETERANS OF THE KOREAN WAR TO MICROWAVE RADIATION (RADAR). Robinette, C. D.; Silverman, C. C.; Beebe, G. W. (Natl. Res. Council, 2101 Constitution Ave. N.W., Washington, D.C. 20037).

Approximately 20,000 men who served as electronics repairmen in the U.S. Navy during the Korean War are being traced to determine whether they have elevated mortality from cancer or from other causes. Controls are about 20,000 men who served as radio and radar operators in the Navy during the Korean War. The period of follow-up extends from January 1956 through December 1974. (10/76-9/77)

Supporting Agency:not reported.

0248 TWIN-WELL CALORIMETRY SUPPORT OF IN VIVO ANIMAL STUDIES FOR WHOLE BODY EMR ABSORPTION. Kinn, J. B. (Bioengineering Branch, U.S. Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

The total energy absorbed in a complex biologic system exposed to electromagnetic fields will be determined experimentally. A twin-well calorimeter

for in vivo animal studies of total body electromagnetic radiation absorption will be employed. Four calorimeters have been constructed and used in studies involving rats, hamsters, and mice. Four additional units are being made and will be used in the above studies and in determination involving equivalent microwave phantoms. (10/76-9/77)

Supporting Agency:EPA

0249 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Sheridan, C. L.; Garrison, R. G.; Levinson, D. M. (Dept. Psychiatry, Univ. Kansas, Sch. Medicine, 39th & Rainbow Blvd., Kansas City, KS 66101).

Dose-determinate exposures of gravid mice and rats to 2,450-MHz and 915-MHz microwave energy will be performed in a multi-mode cavity in studies of lethal-dosing, teratology, longevity, and maze-learning. Corollary studies will: (1) evaluate the role of endogenous (psychogenic) heating in mammals, as induced by handling and restraint in lethality of dosing, (2) examine growth and ultrastructure of a thermophilic organism that exhibits retarded growth and hyperplasia of the plasma membrane under microwave radiation, (3) record the ethogram of an avian species previously incubated in a microwave field, (4) determine the utility of evoked thermal responses as indicators of perception of microwave energy, and (5) investigate the use of hypothermal agents in mammals to find a biodosimeter of absorbed electromagnetic energy. The effects of continuous wave and pulsed radiations of the same averaged density will be compared. (9/77-8/78)

Supporting Agency:HEW, PHS, FDA

0250 MICROWAVE DOSIMETRY IN BIOLOGICAL SYSTEMS. Weil, C. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

A broadband (0.1-3 GHz) isotropic field probe, suitable for measuring perturbed or scattered fields in the region where animal subjects are to be irradiated (in both transmission line resonant cavity and anechoic chamber exposure facilities) will be obtained. (10/76-9/77)

Supporting Agency:EPA

0251 MICROWAVE DOSIMETRY IN BIOLOGICAL SYSTEMS. Ward, G. H.; Kinn, J. (Bioengineering Branch, Environmental Protection Agency, Health Effects Res. Lab., Durham, NC 27711).

Interface hardware and control software will be developed for an infrared (IR) microscanner that will be connected to a distributed minicomputer network. The computer system will be used for data acquisition and control. The video signal from the IR microscanner will be converted to a digital signal by A/D conversion and stored in a minicomputer system for analysis. Software will be written to control the interface timing and data acquisition. Hardware interface concepts are being designed and computer hardware and A/D converter are being ordered. (10/76-9/77)

Supporting Agency:EPA

0252 EFFECTS OF LOW INTENSITY MICROWAVE RADIATION ON MAMMALIAN SERUM PROTEINS. Cleary, S. F.; Berry, E. R. (Dept. Biophysics, Virginia Commonwealth Univ., Sch. Medicine, 1200 E. Broad St., Richmond, VA 23298).

See Current Research 0201 for description of this research. (10/77-9/78)

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

0253 2450 MHZ MICROWAVE ABSORPTION IN LARGE AND SMALL ANIMALS AND ITS BIOBEHAVIORAL EFFECTS ON BIRDS AND REPTILES. Ghandi, O. M. (Utah *Higher Education System, Graduate* Sch., 310 Park Building, Salt Lake City, UT 84112).

No descriptive information is available. (3/77-9/77)

Supporting Agency:NASA

0254 BIOLOGICAL AND ECOLOGICAL EFFECTS OF ENERGY TRANSMISSION BY MICROWAVES (EFFECTS OF 2,450 MICROWAVE ILLUMINATION ON PLANT GROWTH). Ward, C. H. (Dept. Biology, Rice Univ., 6100 Main St., Houston, TX 77001).

No descriptive information is available. (3/77-9/77)

Supporting Agency:NASA

0255 CLINICAL TRIALS ON PARTIALLY PARALYZED CHILDREN TO DETERMINE EFFICACY OF IMPLANTABLE RADIO FREQUENCY NERVE STIMULATION. Anonymous. (Georgetown Univ., Sch. Medicine, 3900 Reservoir Rd. N.W., Washington, DC 20007).

No description information is available. (8/76-7/77)

Supporting Agency:Dr. Scholl Foundation, Chicago, IL

0256 STUDY DEVELOPED DISUSE OSTEOPOROSIS IN ANIMAL TROPOROSIS. Bassett, C. A. (Columbia Univ., Sch. Medicine, 630 W. 168th St., New York, NY 10032).

No descriptive information is available. (1/77-12/77)

Supporting Agency:NASA

0257 STUDIES OF MICROWAVE RADIATION AS A TOOL IN SOIL STERILIZATION AGAINST MAJOR DISEASES AND PESTS OF AGRICULTURAL CROPS. Wutoh, J. G. (Univ. Maryland, Princess Anne, MD 21853).

No descriptive information is available. (11/76-1/78)

Supporting Agency:NASA

5224 AN EXPERIMENTAL PERMEABILIZATION OF THE BLOOD-BRAIN BARRIER BY ELECTRIC FIELD APPLICATION. *(Eng.)* Dereymaeker, A. (290, Waversebaan, B-3030 Heverlee, Belgium); Gonsette, R. *Eur Neurol* 15(6): 333-339; 1977. (20 refs)

The effect of transcerebral electrolysis on the permeability of the blood-brain barrier in rabbits was investigated. A direct current ranging from 1-30 mA was applied to electrodes attached to the animal's bony skull over periods ranging from 1-20 min. The potential difference across the electrodes ranged from 10-60 V. When the transcerebral electric field was limited to 5 mA or less and when broad (1 cm^2) electrodes were used, no morphologic lesions were found in the brain parenchyma and the animal's behavior and electroencephalogram remained normal. At nontraumatizing electric field levels, the blood-brain barrier was made permeable to trypan blue dye, radioisotopic tracers, penicillin, and several epileptogenic drugs. The permeability lasted for several days. At transcerebral electric fields of greater than 5 mA, several adverse effects were observed including four-legged paresia, hypersensitivity to noise and light, loss of appetite followed by exhaustion and death, epileptoid electroencephalographic spikes, and morphologic brain lesions. When pin electrodes, which were driven into the skull, were used in place of broad electrodes, hemorrhagic lesions were observed. It is concluded that this method may be applied to clinical therapy. In this way pharmaceutical or physiologic substances, which normally do not pass the blood-brain barrier, can be brought to the brain parenchyma.

5225 THE POTENTIAL OF SATELLITE SOLAR POWER. *(Eng.)* Glaser, P. E. (Arthur D. Little, Inc., Acorn Park, Cambridge, MA 02140). *Proc IEEE* 65(8): 1162-1176; 1977. (33 refs)

The design of a satellite solar power system (SSPS) is outlined, with reference to potential environmental and biological impacts of a microwave power transmission system designed to transmit the electrical power generated by the SSPS to a receiving antenna on earth. The SSPS will incorporate several fail-safe features to assure control of microwave beam pointing and instantaneous shutoff of power to the microwave generators. Failure of the microwave beam-pointing system will not result in exceeding the international standards for microwave exposure. Possible effects, if any, on birds flying through the microwave beam will have to be established. Preliminary evidence indicates that birds can be affected at levels of microwave exposure greater than 25 mW/cm^2 of radiation in the X-band. The effects of microwave exposure on aircraft flying through the beam must also be considered. Significant human exposure is unlikely because of the shielding effects of aircraft metal fuselages and the short flight time through the beam. The extent of possible interference with aircraft communication and radar equipment will have to be established. In terms of environmental considerations, forward scattering by rain and hail will increase the field intensity outside the main microwave beam. For example, a 5-GW SSPS operating at a frequency of 3 GHz would scatter 3 mW nearly isotropically, if the storm cell height is 1 km. At a range of 10 kM, the scattered microwave beam power density would be about 2×10^{-4} mW/cm^2. Therefore, scattering by rain or hail is not expected to significantly increase sidelobe levels or broaden the main microwave beam. Microwave power densities above 20 mW/cm^2 could result in major changes in ionospheric properties, and the effects of changes in ionospheric electron density caused by microwave power densities of 20 mW/cm^2 at the SSPS operating frequency will have to be assessed in terms of possible effects on other uses of the ionosphere.

5226 EPIPHYSEAL CARTILAGE cAMP CHANGES PRODUCED BY ELECTRICAL AND MECHANICAL PERTURBATIONS. *(Eng.)* Norton, L. A. (Dept. Orthodontics, Univ. Connecticut Health Center, Farmington, CT 06032); Rodan, G. A.; Bourret, L. A. *Clin Orthop* (124): 59-68; 1977. (60 refs)

Epiphyseal cartilage from chick embryo was subjected in vitro for 1-15 min to static compressive forces or oscillating electric fields. The same stimuli were applied to suspensions of cells isolated from the epiphyses. At the end of the perturbation, 3', 5'-cyclic adenosine monophosphate (cyclic AMP) was measured in the tissue or cell extracts by radioimmunoassay. A physiologic (60 g/cm^2) static pressure reduced the cyclic AMP content in tissue and in separated cells. An oscillating electric field above 900 V/1.5 cm (5 Hz) enhanced the cyclic AMP accumulation in intact tissue, and this effect was produced only when the long axis of the bones was oriented parallel to the electric field. In isolated cells, an electric field above 750 V/1.5 cm (5 Hz) caused a decrease in cyclic AMP content. Charged matrix macromolecules and orientation of the cells within the cell matrix may have a modulating effect on the initiation of this response. It is postulated that the change in cyclic AMP is the early cellular signal in the response to an electrical or mechanical perturbation that leads to bone remodeling.

5227 THE EFFECT OF MEAT TREATED WITH SUPERHIGH FREQUENCY ENERGY AND INFRARED RAYS ON THE SECRETORY FUNCTION OF THE STOMACH. *(Rus.)* Kulakova, S. N. (Inst. Nutrition, USSR Acad. Medical Sciences, Moscow, USSR); Laktaeva, T. V. *Vopr Pitan* (4): 24-29; 1977. (10 refs)

The effects of meat prepared in commercial microwave oven (frequency 433 MHz), in infrared (IR) oven, and by a combination of the two methods on gastric secretion were studied in Pavlov's and Heidenhain's pouches of dogs fed 100 g of meat.

Meat prepared in the microwave oven caused significant increase in gastric juice secretion compared with conventionally cooked meat in dogs with Pavlov's pouch. Additional infrared treatment of the meat caused a slight increase in the secretion over that caused by microwave irradiation. Gastric juice secretion was enhanced by microwave treatment mainly during (Phase I) the first 2 hr (29.86 ± 1.38 vs. 25.09 ± 1.16) after feeding ($P<0.02$). Secretion showed a tendency toward increased values beyond the first 2 hr (12.82 ± 1.37 vs. 9.71 ± 0.98) in the control dogs fed 100 g of conventionally-cooked meat ($P<0.1$). The total acidity and the free hydrochloric acid content of the gastric juice secreted in response to microwave-prepared meat did not undergo any substantial changes. The secretion of total proteinases with the gastric juice per unit time (1 hr) was higher with meat prepared in microwave oven than in the case of conventionally-cooked meat. Meat prepared in microwave oven increased the gastric secretion in dogs with Pavlov's and Heidenhain's pouches. The findings suggest that treatment of meat with microwave and/or IR radiation caused the formation of substances, which stimulate the first phase of the gastric secretion.

5228 IMMUNOLOGICAL REACTIVITY OF THE BODY UNDER THE EFFECT OF SUPER-HIGH FREQUENCY ELECTROMAGNETIC FIELDS UNDER THE CONDITIONS OF DIFFERENT ULTRAVIOLET RADIATIONS. *(Rus.)* Shutenko, O. I.; (Kiev Medical Inst., Kiev, USSR); Vinogradova, G.; Uzhva, N. F. *Gig Sanit* (8): 48-50; 1977. (1 ref)

The effect of super-high frequency electromagnetic field (100 or 1,000 $\mu W/cm^2$ 3 hr/day) on the immunologic reactivity of male albino rats was studied under conditions of ultraviolet (UV) radiation of various doses. In rats with UV deficit, exposure to 1,000 $\mu W/cm^2$ field caused significant increase in the rate of basophil degranulation (33% vs. 1.65% in rats kept under the conditions of UV deficit), in the percentage of plaque-forming cells (4.74% vs. 0.28%), and in the phagocytic index (87.2% vs. 64.2%). The positive Ierne-Klemparskaya test, used to determine number of immunocompetent cells in the peripheral blood, is indicative of autoallergic reaction to high-frequency electromagnetic field. Irradiation with prophylactic UV dose averted the autosensitization processes and protected, to a certain degree, the immune system from the damaging action of the electromagnetic field. Irradiation with a UV dose of 1,600 mcer/cm^2 intensified the changes induced by the electromagnetic field.

5229 EFFECT OF ELECTROMAGNETIC ENERGY OF INDUSTRIAL FREQUENCY ON THE HUMAN AND ANIMAL NERVOUS SYSTEM. *(Rus.)* Popovich, V. M. (Lab. Electrical and Electromagnetic Environmental Factors, Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR); Koziarin, I. P. *Vrach Delo* (6): 128-131; 1977. (0 refs)

The physiologic and biochemical effects of electromagnetic fields of 50 Hz frequency, generated by high-voltage electric transmission lines and transformers, were studied in albino rats and in human volunteers. The animals were exposed to fields with intensities of 1-15 kV/m, 2 hr daily for 4 mo. Significant ($P<0.05$) increase was observed in the cumulative threshold index in animals exposed to 7 and 15 kV/m fields (17.3 and 19.1 vs. 11.7 in the control). The latency period of unconditioned reflexes was 67 msec and 69.6 msec in the above groups vs. 51 msec in the unexposed control rats ($P<0.05$). The chronaxy ratio of the antagonistic muscles of the leg was 0.5 and 0.4 in the groups exposed to 7 and 15 kV/m vs. 1.9 in the control ($P<0.05$). The blood cholinesterase activity increased significantly in the group exposed to 15 kV/m (150.2 µg/min vs. 130.8 µg/min in the control; $P<0.05$). Men and women (aged 23-47 yr) who were exposed to 5 kV/m fields, 2 hr daily for 30 days, or to 12 kV/m fields for 3x 30 min at 1 hr intervals for 6 days, showed no significant changes in the above parameters. Other human volunteers, exposed to a 15 kV/m field 3x 30 min daily for 6 days presented with transient headache, fatigue, irritability, and showed significantly increased bioelectric potentials evoked by rhythmic photostimulation (artificial flashing light) at 12 Hz frequency. The findings indicate that the permissible level of electromagnetic field is 5 kV/m for up to 2-hr exposure daily and 12 kV/m for 3 x 30 min exposures at 1-hr intervals.

5230 REDUCTION OF THE FUNCTIONAL POSSIBILITIES OF THE HEART UNDER THE EFFECT OF ELECTROMAGNETIC FIELD OF INDUSTRIAL FREQUENCY. *(Rus.)* Prokhvatilo, E. V. (Kiev Scientific Res. Inst. of General and Communal Hygiene, Kiev, USSR). *Vrach Delo* (7): 141-143; 1977. (6 refs)

The electroencephlographic effects of electromagnetic fields of industrial frequency (50 Hz, intensity 100, 300 or 1,000 V/m, exposure time 60 days) on the cardiac function were studied in rabbits. Exposure to 100 and 300 V/m fields had no effect on the cardiac function, while 1,000 V/m caused considerable changes: reduction of the cardiac rate from 291/min before to 266/min after 30-60 days of exposure, reduction of the force of the atrial contraction by 50% ($P<0.001$), reduction of the force of the ventricular contraction (reduction of the R wave potential from 0.38 to 0.20 mV ($P<0.001$), reduction of the T wave potential from 0.10 mV to 0.8 mV ($P<0.01$), and shift of the ST segment to below the isoelectric line. The orthostatic function test with the rabbits in upright position showed 34-46% increase of the cardiac rate (22-32% in the control), 30% reduction of the P wave potential (14-23% in the control), 39-72% reduction of the R wave potential (14-29% in the control), and 32-49% reduction of the T wave potential (25-33%) in the control). The findings indicate the deleterious effect of electromagnetic fields of industrial frequency on the contraction, repolarization, and function of the heart.

5231 ALTERNATING MAGNETIC FIELD EFFECT UPON HEALING OF ULCERS OF THE LOWER EXTREMITIES. *(Rus.)* Tiuriaeva, A. A. (Railroad Hosp. No. 2, Perm-II, USSR); Ponizovskii, V. M.; Akimov, G. L. *Vestn Khir* 119(8): 84-85; 1977. (2 refs)

Sixty-seven patients with ulcerative lesions of the lower extremities were treated with alternating magnetic field (AMF: 50 Hz, 400 Oe) in daily sessions. Of the 67 patients, 43 were over 50 yr of age. Thirty-seven patients had had ulcers for less than 1 yr, 12 for 1-3 yr, 18 for over 3 yr. Neurotrophic ulcer was diagnosed in 4 patients, trophic ulcer in 15, varicose ulcer in 48. Suppuration disappeared usually after 3-5 sessions. Granulation and epithelialization of the ulcers began after 5-9 sessions. The cicatricial tissue formed was elastic and not fused with the underlying tissues. Complete ulcer healing was achieved in 57/67 patients; AMF was most successful with varicose ulcers. Fifty-one patients were followed for 1-7 yr; permanent healing was achieved in 42/51, while 9 developed recurrences. A similar control group of 30 patients received conventional therapy: cicatrization was observed in 4 and reduction of the size of the ulcer in 15. There was no response to therapy in 11 patients. The findings indicate the high efficiency of AMF in the treatment of ulcers of the lower limbs.

5232 METHODS OF DOSIMETRY AND MEASURING IN MICROWAVE FIELDS. *(Rum.)* Vasilescu, V. (Laboratorul de biofizica, Institutul de medicina si farmacie, Bucharest, Romania); Zaciu, C. *Rev Ig [Pneumoftiziol]* 26(2): 137-144; 1977. (25 refs)

Basic principles of modeling and calculating methods to determine microwave doses in biologic matter (tissues) are reviewed. The total dose absorbed by the experimental animal determines the biologic effect of microwaves. The total dose rate absorbed as a function of time varies in animals freely moving in a cage, while the dose rate is nearly constant in immobilized animals.

5233 THE DEVELOPMENT OF METHYLCHOLANTHRENE-INDUCED TUMORS IN MICE UNDER THE ENVIRONMENTAL INFLUENCE OF VARIOUS ELECTROBIOCLIMATOLOGIC CONDITIONS. *(Ger.)* Moese, J. R. (Hygiene-Institut, Universitat Graz, A-8010 Graz, Universitatsplatz 4, Austria); Fischer, G. *Zentralbl Bakteriol [Orig B]* 164(5/6): 447-454; 1977. (15 refs)

The effects of electrostatic field (field strength 200 V/m, residual wave component 0.1%), of a Faraday cage with shielding of atmospheric electrical disturbances at 99% efficiency, and a climatized laboratory on the tumor induction rate were studied in 8-wk-old female NMRI-Han mice that received 0.1 mg of methylcholanthrene subcutaneously after a 6-wk adaptation period. The animals were examined for tumors at 2-wk intervals for 210 days. At the end of the experiment, the tumor induction rate was higher in the mice kept under conventional laboratory conditions (over 60%) and significantly lower (around 40%) in mice kept in Faraday cages or in electrostatic field with 0.1% residual wave component. No difference was apparent between the latter two conditions. The findings indicate that changes in the electroclimatologic environment may induce unspecified stress reactions, resulting in reduced immunologic dynamics.

5234 LIQUID CRYSTAL ELECTROMAGNETIC RADIATION MONITOR. *(Eng.)* Fanslow, G. E. (Dept. Electrical Engineering, Engineering Res. Inst., Iowa State Univ., Ames, IA 50011). *J Microwave Power* 12(1): 87-91; 1977. (16 refs)

A liquid crystal calorimeter designed for monitoring nonionizing electromagnetic radiation is described. Liquid crystals having color play centered at different temperatures were arranged on metal-coated and nonmetal-coated dielectric substrates. While both substrates responded to changes in ambient temperature conditions, the metallized substrate also responded to temperature changes due to absorbed radiation. The difference between the temperature indications of the two substrates was a measure of the radiation. Using an experimental liquid crystal calorimeter that measured radiation of 1-15 mW/cm^2 at a frequency of 2.45 GHz, measurements were made over an ambient temperature range of 18.89-25 C. Over this range, the approximate rise in temperature of the metallized disk was 0.59, 2.22, and 4.44 C above ambient for radiation levels of 1, 5, and 10 mW/cm^2, respectively. In its simplest form, the calorimeter can be used as a simple indicator tuned to one frequency and used for regular safety checks. An advantage of liquid crystal calorimetry for monitoring nonionizing radiation is that liquid crystals are used for both the measuring and indicating functions, excluding the need for electronic metering.

5235 EFFECT OF MICROWAVE RADIATION ON CELLS TREATED WITH MEMBRANE-INJURING SUBSTANCES. *(Eng.)* Szmigielski, S. (Center for Radiobiology and Radioprotection, Szaserow 128, 00-909, Warsaw, Poland); Kobus, M.; Janiak, M.; Rytko, J. *Exp Pathol (Jena)* 13(6): 296-301; 1977. (26 refs)

The effect of microwave radiation on cells treated with membrane-injuring substances was investigated. A continuous line of human embryonic cells (WISH) grown in vitro were pretreated with subcytotoxic concentrations of digitonin, cortisol, and purified bacterial toxins (staphylococcal beta-hemolysin or *Clostridium perfringens* alpha-toxin) and were irradiated with 3 GHz microwaves at field power densities of 5 or 40 mW/cm^2. At 40 mW/cm^2, an increase of about 2-3 C in the temperature of the culture medium was noted, while at 5 mW/cm^2 no detectable increase in temperature was observed. Irradiation with microwaves resulted in a lowering of the thymidine and glycine incorporation into cells along with changes in the intracellular amount of cyclic adenosine monophosphate (decrease in cells

exposed to 5 mW/cm^2 and increase in cells exposed to 40 mW/cm^2). Under both field power densities, viability of the cultures was normal. Pretreatment of cells with digitonin or purified bacterial toxins followed by irradiation with microwaves resulted in an enhancement of the cytotoxic effect of the membrane-injuring substances, with a lowering of cell viability, especially after exposure to power densities of 40 mW/cm^2. Cortisol did not influence the reaction of cells to microwave radiation. It is concluded that substances injuring cell membranes sensitize cell cultures to microwave radiation and may enhance the specific (nonthermal) effect of microwaves.

5236 BIOELECTRICITY AND REGENERATION: LARGE CURRENTS LEAVE THE STUMPS OF REGENERATING NEWT LIMBS. *(Eng.)* Borgens, R. B. (Dept. Biological Sciences, Purdue Univ., Lafayette, IN 47907); Vanable, J. W.; Jaffe, L. F. *Proc Natl Acad Sci* 74(10): 4528-4532; 1977. (27 refs)

Electrical currents near regenerating newt limbs were measured with a vibrating probe operating at a resonant frequency of 310-320 Hz, a peak-to-peak amplitude of 70 μm, and a time constant of 1 sec. Steady currents with local surface densities of 10-100 μA/cm^2 or more left the end of the stump during the first 5-10 days after amputation, and currents with low densities of 1-3 μA/cm^2 entered the intact skin around the stump. Large outward currents showed a strong tendency to peak over clear, newly-formed epithelium and rarely appeared over fully-pigmented mature skin. Current leaving the surface of the stump varied directly with external sodium concentration of the medium in which the regenerating limbs were immersed. When amiloride or methyl ester of lysine, which block sodium entry, were added to the medium the stump current was quickly and greatly reduced. The data indicate that the outward regenerating currents were skin-driven. Moreover, transection of the main limb nerves did not reduce these currents, pointing to the skin rather than the nerves as the pump that drove these stump currents. The outward currents were comparable in direction, density, duration, and position to artificially imposed currents previously found sufficient to induce significant regeneration of amputated adult frog limbs. This comparison suggests that endogenous stump currents play some causal role in initiating regeneration.

5237 THE ELECTRICAL ENHANCEMENT OF PERIOSTEAL PROLIFERATION IN NORMAL AND DELAYED FRACTURE HEALING. *(Eng.)* Connolly, J. F. (Dept. Orthopaedic Surgery and Rehabilitation, Univ. Nebraska Coll. Medicine, Omaha, NB 68105); Hahn, H.; Jardon, O. M. *Clin Orthop* (124): 97-105; 1977. (31 refs)

The electrical enhancement of periosteal proliferation in normal and delayed fracture healing is discussed. During experiments in which a transverse undisplaced fracture was produced in the middle third of 70 canine radii using transfixion pins to immobilize the fracture with plaster, a constant direct current averaging 20 μA was applied to the pins. Of 29 stimulated fractures tested within 5 wk, 10 had returned to a torque strength that was equivalent to 40% or more of normal. None of 30 unstimulated fractures achieved this strength level until wk 6 after fracture. The reaction to electrical stimulation appeared to be diffuse, irritative periosteal response. In other experiments, consistent nonunions were obtained by creating osteoperiosteal defects ranging in size from 0.5-2 cm in the mid ulna of mature dogs. A negative electrode was inserted into the defect site through holes drilled in the proximal and distal segments as close to the defect as possible. After stimulation of the proximal and distal ends with continuous 20 μA current for up to 13 wk, the consistent result in 12 dogs was a resorption of the bone from the distal segment with no attempt to heal or obliterate the defect, regardless of its size. It was concluded that the electrical stimulation does not provoke osteoblasts to bridge bone gaps if there is no periosteum to guide and contribute cellular components to callus formation. Two case reports of the successful use of currents between 20 and 25 μA for the treatment of patients with nonunions of the tibia are presented to illustrate the types of injury in which bone grafting procedures are liable to fail and for which electrical enhancement is a worthwhile consideration.

5238 TREATMENT OF CONGENITAL PSEUDARTHROSIS OF THE TIBIA WITH DIRECT CURRENT. *(Eng.)* Lavine, L. S. (Div. Orthopaedic Surgery, State Univ. New York, Downstate Medical Center, Brooklyn, NY 11202); Lustrin, I.; Shamos, M. H. *Clin Orthop* (124): 69-74; 1977. (22 refs)

The use of direct current for the treatment of congenital pseudarthrosis of the tibia is reported. Preliminary experiments with rabbits were conducted in which 2-4 μA of direct current was used to heal bony defects. The model placed the anode and cathode above and below the experimental bony defect, allowing current to flow across it (current-sensitive model). This current-sensitive method was then used to treat a 14-yr-old male with congenital pseudarthrosis of the tibia. Platinum electrodes were inserted just into the medullary cavity of the tibia through drill holes, with the current path traversing bony tissue on both sides of the defect. Bony union was achieved after 4 mo of treatment. This current sensitive method was also used to treat a 5-yr-old female with neurofibromatosis and a congenital pseudarthrosis of the tibia; the method failed however. Electrical stimulation was then tried in conjunction with a bone graft, utilizing bone bank cancellous bone. The ground bone bank was placed posterior to the congenital pseudarthrosis of the tibial defect, while the electrodes were placed anterior to the defect. After continuous application of current for 4 mo, there was healing. Experience to date indicates that the best results are obtained by a combination of electrical stimulation with the addition of bone graft. The electrical stimulation is provided by two mercury cells, which

provide a total of 2.70 V. This voltage is impressed upon a series combination of a variable resistor (10^6 ohms) and the treatment area. With the electrodes in place, the resistor is adjusted to yield the desired current.

5239 RESONANT GROWTH RATE RESPONSE OF YEAST CELLS IRRADIATED BY WEAK MICROWAVES. *(Eng.)* Grundler, W. (Gesellschaft fuer Strahlen- und Umweltforschung, 8042 Neuherberg, W. Germany); Keilman, F.; Froehlich, H. *Phys Letters* 62A(6): 463-466; 1977. (8 refs)

The growth behavior of microwave-irradiated yeast cultures (diploid wild strain of *Saccharomyces cerevisiae)* was monitored by visible light extinction. The temperature of the sample was 30.5-34 C, and it never varied more than ± 0.5 C during any experiment. The cultures were exposed to continuous wave microwave fields at surface intensities of 1.1-2.7 mW/cm^2. Over a frequency range of 41.83-41.96 GHz, multiple biological resonances were observed, with the growth rate either remaining constant or becoming enhanced or reduced at different frequencies. Increases up to 15% and decreases as large as 29% were observed in growth rate normalized to eliminate temperature effects. Careful temperature monitoring excluded a trivial thermal origin of the observed effects. The results confirm the existence of resonant influences of coherent millimeter waves on biologic properties and reveal the extreme narrowness of this response.

5240 ORIENTATION AND LINEAR DICHROISM OF CHLOROPLASTS AND SUB-CHLOROPLAST FRAGMENTS ORIENTED IN AN ELECTRIC FIELD. *(Eng.)* Gagliano, A. G. (Universite Paris XI, Institut Universitaire de Technologie, Cachan, France); Geacintov, N. E.; Breton, J. *Biochim Biophys Acta* 461(3): 460-474; 1977. (28 refs)

Whole or broken spinach chloroplasts, bacterial chromatophores, and chlorophyll-protein (CP) complexes in aqueous suspensions at room temperature were oriented in externally applied electric fields. The orientation was observed by monitoring the electric field-induced linear dichroism (LD). With whole chloroplasts, a detectable LD signal was observed using 50-Hz alternating voltages as low as 2-3 V across a 0.3-cm electrode gap, and nearly complete orientation was observed at fields of 30 V/cm. The wavelength dependence of the LD signals using either orienting electric fields (E) alone or magnetic fields (B) alone were similar but opposite in sign, with E and B pointing in the same direction. The chloroplasts tended to orient in such a way that the membrane planes were parallel to E. Small subchloroplast fragments, which cannot be oriented in magnetic fields of 10,000-15,000 G but can be readily oriented in electric fields, displayed linear dichroism spectra similar to those of intact chloroplasts. The CP complexes, chromatophores, and subchloroplast fragments were best oriented using short (1-10 msec) pulsed electric fields or approximately 3,000 V/cm. Oriented CP complexes exhibited LD maxima of the same sign at 685 and at 440 nm. The oriented chromatophores exhibited an LD spectrum of either positive or negative sign, depending on the wavelength. The orientation of particles in electric fields is suggested to be due to either or both of the following effects: the presence of a permanent dipole moment, which tends to align itself with the applied electric field; an anisotropic polarizability, which gives rise to an induced dipole moment when an external electric field is applied.

5241 TECHNOLOGY FOR THE HYPERTHERMIC TREATMENT OF LARGE SOLID TUMOURS AT 50°C. *(Eng.)* Dickson, J. A. (Cancer Res. Unit, Univ. Dept. Clinical Biochemistry, Royal Victoria Infirmary, Newcastle-upon-Tyne, England); Shah, S. A. *Clin Oncol* 3(3): 301-318, 1977. (44 refs)

The use of radio frequency (RF) heating for the treatment of large experimental solid tumors is reported, and a literature review is presented. A commercially available RF heating machine operating at a crystal controlled frequency of 13.56 MHz with an output of 30 W was used. Rabbit VX2 intramuscular carcinoma, which has many characteristics similar to human cancer, was used as the animal model test system. The tumor was heated by placing two paddle-shaped electrodes on opposite sides of the tumor-bearing limb. Tumors up to 22 ml in volume were rapidly heated to 50 C without damage to neighboring normal tissue. Among 15 VX2 tumors treated by RF heating at 47-50 C for 30 min, 10 regressed completely in 6-8 wk. Three rabbits suffered paralysis, and two rabbits had an open wound from skin damage; however, there was no increase in tumor volume. Skin breakdown leading to an open wound occurred in 2/6 rabbits when the same type of tumor was heated at 50-53 C for 15 min. Tumor regression did not occur in the remaining four rabbits, and the animals died with large tumors and metastases within 80 days of tumor inoculation. Heating methods such as waterbath, water cuff, heat pipe, and electrocoagulation did not compare favorably with the RF heating machine for controlled heating at tumor temperatures in the region of 50 C.

5242 AN AUTOMATED MEASUREMENT SYSTEM FOR DETERMINING ENVIRONMENTAL RADIOFREQUENCY FIELD INTENSITIES II. *(Eng.)* Tell, R. A.; Hankin, N. N.; Nelson, J. C.; Athey, T. W.; Janes, D. E. *In: Measurements for the Safe Use of Radiation. Proceedings of an NBS 75th Anniversary Symposium held at National Bureau of Standards, Gaithersburg, MD on March 1-4, 1976.* pp. 203-213; 1976. (19 refs)

A mobile automated measurement system, used by EPA for determining environmental radio frequency (RF) field intensities, is described. The system uses a spectrum analyzer interfaced to a minicomputer for data acquisition and is contained within a van for nationwide use. Special antenna systems (active vertical monopole, orthogonal dipoles, vertical

coaxial dipoles, directional log periodic antenna, and vertical and horizontal sawtooth, planar, log periodic antennae) allow isotropic field intensity measurements in selected bands between 0.5 MHz and 10 GHz. Presently the van is being used to collect environmental data in East-coast cities. As data becomes available, more refined methods are being developed for selecting the total number and location of monitoring sites within a given metropolitan area. Initial monitoring locations are chosen on the basis of RF source distributions and population densities. As the monitoring program progresses, measurements in high density West-coast cities are planned.

5243 MICROWAVE BOLUSING: A TECHNIQUE FOR IMPROVING HEATING UNIFORMITY FOR MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Robinson, J. E. (Sch. Medicine, Univ. Maryland, Baltimore, MD 21201); McCulloch, D.; Cheung, A.; Samaras, G.; Slawson, R. G. *Med Phys* 4(4): 336; 1977. (0 refs)

A microwave analogy of radiation therapy bolus techniques was developed to alter and control the shape and size of the target and improve heating uniformity. Two direct applications of this "microwave bolus" technique were studied: (1) monodirectional far field irradiation of mammary tumors on the flanks of mice; (2) parallel opposed microwave heating by dielectrically loaded applicators operating in the transverse electromagnetic mode (TEM) mode. In the first, tumors were encapsulated in 5-cm spheres, and in the second, tumors were treated in parallel slab geometry. Improvements in thermal uniformity are described.

5244 ELECTRICAL STIMULATION OF HUMAN FRACTURE HEALING BY MEANS OF A SLOW PULSATING, ASYMMETRICAL DIRECT CURRENT. *(Eng.)* Jorgensen, T. E. (Egevangen 9, 8900 Randers, Denmark). *Clin Orthop* (124): 124-127; 1977. (10 refs)

The use of slow pulsating asymmetrical direct current for the treatment of 28 patients with tibial fractures is reported. The fractures were treated with external fixation by means of a Hoffmann apparatus, with the direct current applied to the fracture site through two electrode-screws in the Hoffmann apparatus. The stimulator used to produce the current generated a pulsating alternating current of about 1 Hz at an amplitude of about 0.7 V. A slight asymmetry in the alternating current caused the fracture to be affected by a weak pulsating direct current. The magnitude of the pulsating direct current was 40 μA. Statistical analysis of the results obtained with 24 evaluable patients revealed a 30% acceleration in healing. An average of 2.4 mo was required to achieve clinical stability or the desired degree of stiffness as measured by mechanically stressing the tibia via the Hoffmann apparatus. A control group of patients required 3.6 mo to achieve the same degree of stiffness; the difference between experimental and control groups was highly significant ($p<0.001$). The frequency of skin reactions around the screws was twice as great in electrically-stimulated patients as in controls, and the intensity of the tissue reaction caused by the stimulator was such that occasionally the skin between the electrodes became erythematous and tender. Reversing the polarity of the electrodes periodically (once/wk or once/day) reduced the frequency of skin irritation. A 5-yr followup of one 84-yr-old man revealed that some of the tibial bones developed thickened cortices and that some of the comminuted fractures showed prominence of bone at the fracture. The screw canals in the bone had filled in, some with tiny exostoses. No destructive process was apparent on x-ray.

5245 THE INFLUENCE OF MICROWAVE RADIATION ON NORMAL AND NEOPLASTIC CELLS (ABSTRACT). *(Eng.)* Szmigielski, S. (Medical Acad., Warsaw, Poland); Janiak, M.; Kobus, M.; Luczak, M. *Folia Histochem Cytochem* 15(2): 164; 1977. (0 refs)

The effects of microwave radiation (3,000 MHz) of varying density (nonthermal, subthermal, and thermal) on the metabolism of normal cells and simian virus 40 (SV40) transformed fibroblasts were investigated. In one series of experiments, cells were treated with membrane-damaging substances (digitonine, phospholipase, sphingomyelinase) in subcytotoxic concentrations prior to irradiation. Nonthermal irradiation (5 mW/cm^2) caused a temporary increase in cell metabolism and function. However, higher densities (20 and 40 mW/cm^2) caused inhibition of both cell metabolism and culture growth; the process was more marked in the SV40-transformed cells. Cell damaging substances in subtoxic doses increased the sensitivity of cultures to subthermal and thermal microwave radiation.

5246 MICROWAVE HEATING PATTERNS IN SIMPLE TISSUE MODELS. *(Eng.)* Hand, J. W. (MRC Cyclotron Unit, Hammersmith Hosp., Ducane Road, London W12 OHS, England). *Phys Med Biol* 22(5): 981-987; 1977. (12 refs)

The effects of microwave radiation on two spherical models of differing sizes are examined theoretically. The models consisted of a spherical core of material having the electrical properties of muscle, surrounded by two spherical shells, with the inner shell having electrical properties similar to those of fat and the outer shell having properties resembling those of skin. The spheres were assumed to be in air and to be irradiated by plane waves. An examination of the distributions of heating potential along the diameters of a 40-mm diameter sphere (representative of a mouse) exposed to 2.45 GHz radiation revealed that the heating potential was distinctly nonuniform and that the maximum heating potential occurred at a point within the central core of the model. Calculations for other frequencies showed that both the position and the magnitude of the hot region depended on the frequency of the microwave radiaton. At 800 MHz, for example, maximum heating still occurred in the muscle region, although it was at

a position close to the front of the sphere and its magnitude was only marginally greater than that at the front surface. Experiments with mouse cadavers rolled into spheres and irradiated with 2.45 GHz radiation confirmed that maximum heating potential occurs in the central region of the sphere. Calculations of the distribution of heating potential for a sphere of 260 mm diameter (representative of a larger animal or part of a human torso) over a frequency range of 200 MHz to 2.45 GHz revealed that the heating potential distributions had their maxima at the front surface and, in general, the heating potential decreased exponentially into the spheres. As the frequency decreased, the penetration into the sphere was greater than that predicted by a plane model. It is suggested that if a therapeutic application requires human tissue to be heated at depth, a heating potential distribution such as that produced by plane wave irradiation at 2.45 GHz is disadvantageous, since skin and subcutaneous tissues will receive more thermal energy than the region of interest.

5247 RESPONSE OF GALLUS CHICKS TO ELECTROSTATIC FIELDS (MEETING ABSTRACT). *(Eng.)* Graves, H. B. *In: The 17th Handford Biology Symposium: Developmental Toxicology of Energy-related Pollutants held October 17-19, 1977, Richland, WA.* Batelle and U.S. Energy Research and Development Admin. pp. 40; 1977. (0 refs)

The ontogeny of behavioral and electrophysiologic responses of domestic chicks to 60 Hz, high-intensity electrostatic fields were evaluated during long- and short-term exposures. Measurements included hatching times, activity patterns, oxygen consumption, heart rate, growth, and brain-wave activity. Results suggest that birds can detect an electrostatic field and that both motor development and electrophysiologic parameters are affected; however, responses are small and transient.

5248 EFFECT OF CONVENTIONAL AND MICROWAVE HEATING ON *PSEUDOMONAS PUTREFACIENS, STREPTOCOCCUS FAECALIS* AND *LACTOBACILLUS PLANTARUM* IN MEAT TISSUE. *(Eng.)* Crespo, F. L. (Departamento de Tecnologia y Bioquimica de los alimentos, Facultad de Veterinaria, Cordoba, Spain). *J Food Protection* 40(9): 588-591; 1977. (24 refs)

The effects of conventional heating and microwave heating on selected microbial strains inoculated into sterile beef were compared. Patties (50 g) of inoculated and incubated ground beef were subjected to different temperature treatments in a conventional electric oven maintained at 176 C and in a microwave oven operating at a 2,450 MHz frequency. The final internal temperatures required to produce two-decimal reductions in *Pseudomonas putrefaciens* (Pp), *Lactobacillus plantarum* (Lp), and *Streptococcus faecalis* (Sf) were 51, 57, and 62 C, respectively, for conventional heating and 63, 78, and 74 C, respectively, for microwave heating. To achieve four-decimal reductions in Pp, Lp, and Sf final internal temperatures of 57, 62, and 70 C, respectively, were required for conventional heating, and temperatures of 73, 87, and 81 C, respectively, were required for microwave heating. The data indicate that microwave heating to the same internal endpoint temperatures was less effective than conventional heating for microbial destruction. The difference in heat sensitivity between conventional and microwave heat was most apparent for Lp, which was not particularly heat resistant when heated by conventional means.

5249 INFLUENCE OF ROTATING MAGNETIC FIELD OF 200 GAUSS ON SPLENECTOMIZED MICE. *(Cze.)* Petz, R. (Ustav hematologie a krevni transfuze, 128 20 Prague 2, U nemocnice 1, Czechoslovakia); Viktora, L. *Vnitr Lek* 23(2): 141-145; 1977. (14 refs)

The hematologic effects of exposure to rotating magnetic field (180-200 G, 4-5 rpm, >5 wk was studied in splenectomized SPF-ICR mice. Unexposed splenectomized and intact mice were used as controls. Exposure to the magnetic field caused significant increase in the erythrocyte count during the first 3 wk, and the leukocyte count increased even after the 5th wk. The thrombocyte count decreased but normalized shortly after exposure, while the reticulocyte count increased throughout the experiment. The investigation of hematopoiesis in the bone marrow at the end of the exposure revealed enhanced erythropoiesis and lymphopoiesis, depression of the granulocytopoiesis, and reticulocyte formation. The findings confirm the stimulating effect of the magnetic field on hematopoiesis and indicate that the effect of relatively weak magnetic fields is more pronounced in splenectomized animals than in intact ones.

5250 OCULAR MEDICAL SURVEILLANCE ON MICROWAVE AND LASER WORKERS. *(Eng.)* Hathaway, J. A. (US Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD 21010); Stern, N.; Soles, E. M.; Leighton, E. *J Occup Med* 19(10): 683-688; 1977. (14 refs)

A statistical analysis of over 800 medical surveillance ocular examinations on microwave and laser workers is presented. The number of years of work with microwave equipment varied from less than 1 yr to 35 yr. Of 823 workers subjected to ocular examinations, 705 were microwave workers. The results of slit-lamp examinations were analyzed using multiple regression statistical techniques to determine the influence of microwave and laser exposures on the presence or absence of opacities, vacuoles, and posterior subcapsular iridescence. No lenticular or retinal defects were noted that could be attributed to work with either microwave or laser radiation. Increased incidences of minute lenticular defects were noted with increasing age. A high variability in the recording of such defects at different locations was attributed to differences in the subjective evaluation of the individual

examiners. It is concluded that periodic medical surveillance of microwave and laser workers is nonproductive, and suggestions are made to limit medical surveillance for these workers to preassignment, postaccident exposure, and termination eye examinations.

5251 TECHNIQUES IN MICROWAVE AND RADIOFREQUENCY HEATING OF TISSUES (ABSTRACT). *(Eng.)* Hand, J. W. (Hammersmith Hosp., London W12 OHS, England). *Int J Radiat Biol* 32(4): 381; 1977. (0 refs)

The band of frequencies in the electromagnetic spectrum used in heating tissue at depth is discussed. The methods used to heat tissues are described, and the advantages and disadvantages of such methods outlined. The possibility of producing microwave-induced internal hot-spots in a target whose dimensions are comparable to the wavelength of the radiation and the relevance of this to the heating of small animals are discussed. The advantages of microwave contact applicators are outlined, and two such devices described. Some of the problems associated with temperature measurement in the presence of electromagnetic fields are stated, and new kinds of thermometers that enable reliable temperature measurements to be made in such an environment are briefly described.

5252 STUDIES OF ENHANCED BONE HEALING VIA ELECTRICAL STIMULI: COMPARATIVE EFFECTIVENESS OF VARIOUS PARAMETERS. *(Eng.)* Hassler, C. R. (Battelle, Columbus Lab., 505 King Ave., Columbus, OH 43201); Rybicki, E. F.; Diegle, R. B.; Clark, L. C. *Clin Orthop* (124): 9-19; 1977. (16 refs)

A rabbit calvarium model was used for studying the effects of applied electric currents on osseous tissue. Total currents ranging from 3-1,400 μA were applied using brush-type electrodes of either platinum or tantalum oxide. Direct current as well as unidirectional rectangular pulses, sine waves, and bidirectional rectangular pulses were used with pulse repetition rates or frequencies ranging from 1-60 Hz. The standard stimulation protocol was of 3-wk duration. There was no specific advantage of direct current over alternating currents at frequencies of up to 60 Hz, and there was no clear-cut advantage of one repetition rate over another. A plot of percent bone growth versus calculated power for the cathode, as determined by densitometry measurements of the postnecropsy radiograph, revealed a rapid increase in bone growth with increases in power dissipation; this increase reached a maximum at a power dissipation of about 35 μW. After values of about 100 μW, bone growth approached control levels. Radiographic densitometry results at the anode revealed a decreasing healing rate with increasing power dissipation. Experiments where the stimulation protocol was shortened from the normal 3-wk healing period revealed that when animals were stimulated for only the first 7 days of the experiment, healing was well below control. Also, applying the same amount of electrical energy within a shorter period of time did not produce the same beneficial effects of the 3-wk protocol. Experiments with tantalum oxide electrodes illustrated that augmented healing of bone can be produced when electrochemical reactions are reduced. However, higher power dissipations appear to be required with tantalum oxide electrodes than with platinum electrodes to effect the same degree of healing.

5253 MICROWAVE DIELECTRIC PROPERTIES OF TISSUE: SOME COMMENTS ON THE ROTATIONAL MOBILITY OF TISSUE WATER. *(Eng.)* Schwan, H. P. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19174); Foster, K. R. *Biophys J* 17(2): 193-197; 1977. (12 refs)

Microwave dielectric permittivity and conductivity data for biologic tissue are reviewed over the frequency range of 0.1-10 GHz. The high frequency dielectric properties of muscle predict that the tissue water exhibits a Debye dipolar absorption centered at 20 GHz at room temperature, identical to that of pure water. Increases in tissue conductivity of canine muscle, skin, and liver observed at frequencies above 1 GHz correspond to a free water content of roughly 70% of the tissue weight, comparable to the known water content of these tissues. From a dielectric point of view, the tissue is apparently equivalent to a suspension of nonconducting solid in ordinary bulk water at these high frequencies, contradicting the hypothesis that most of the cell water has motional properties greatly different from those of pure liquid.

5254 DIFFERENTIAL RESPONSE TO ELECTRICAL STIMULATION: A DISTINCTION BETWEEN INDUCED OSTEOGENESIS IN INTACT TIBIAE AND THE EFFECT ON FRESH FRACTURE DEFECTS IN RADII. *(Eng.)* Harris, W. H. (266 Beacon St., Boston, MA); Moyen, B. J-L.; Thrasher, E. L.; Davis, L. A.; Cobden, R. H.; MacKenzie, D. A.; Cywinski, J. K. *Clin Orthop* (124): 31-40; 1977. (26 refs)

The effects of continuous direct current (CDC) stimulation (20 μA) on osteogenesis in intact tibia and on fresh fracture defects in radii of experimental animals were investigated. Studies on osteogenesis in the medullary canal of intact tibia in young and old rabbits showed that the insertion of a non-activated electrode resulted in osteogenesis and that osteogenesis induced by the electrical current exceeded that induced by the dummy electrode. Both young and mature rabbits responded similarly. In mature rabbits, stainless steel electrodes were more effective than platinum. In dogs, an active platinum cathode induced significantly more bone than a dummy platinum electrode. The spontaneous healing capacity and/or healing rate were determined for three different fresh surgically-created defects in the proximal radius of mature mongrel dogs, and the effect of electrical stimulation on these three models was evaluated and compared with the behavior of the contralateral radius

containing the same defect. In a 0.5-mm transverse gap in the radius, which was not immobilized and which did not spontaneously unite, electrical stimulation did not induce a greater incidence of healing. In a 10-mm defect immobilized with a plate and screws, which regularly united spontaneously, no x-ray evidence of acceleration of fracture healing was noted. No evidence of electrically-stimulated osteogenesis was found in two dogs with a plate-and-screw immobilized 20-mm defect, which did not unite spontaneously.

5255 BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION (RADIOWAVES AND MICROWAVES)--EURASIAN COMMUNIST COUNTRIES, MARCH 1976. *(Eng.)* Adams, R. L.; Williams, R. A. (Dept. Defense, Defense Intelligence Agency, Washington, DC 20301). [available from the Dept. Defense, Defense Intelligence Agency, Washington, DC 20301, Document No. DST-1810 S-074-76]. (0 refs)

Research being conducted by Eurasian Communist countries on the biologic effects of radiowave and microwave radiation is outlined. Most of the research involves animals or in vitro evaluations, but active programs of a retrospective nature designed to evaluate the effects on humans are also being conducted. Major systems, system components, or processes currently under study in the Eurasian Communist countries include the blood, cardiovascular system, cells, central nervous system, digestive system, glandular system, metabolic effects, reproductive system, visual system, and internal sound perception. The last of these areas of research has potential for the development of a number of antipersonnel applications. Sounds and possibly even words, which appear to be originating intracranially, can be induced by signal modulation at very low average power densities. Animal experiments reported in the open literature have demonstrated the use of low-level microwave signals to produce death by heart seizure or by neurologic pathologies resulting from crossing the blood-brain barrier; the bulk of research being done in this area is in the USSR. Evaluation of the research being conducted by the Eurasian Communist countries is often difficult because details of exposure in terms of frequency, duration, and intensity are quite variable and sometimes poorly reported. The Eurasian Communist investigators tend to place greater importance on the potential nonthermal effects of nonionizing radiation than do their Western counterparts, and information regarding the precise nature of the exposure under consideration is often difficult to establish. Studies that report on nonthermal effects deal largely with subjective responses, relying on reports of headache, sleepiness, loss of appetite, and the like. The presence of nonthermal effects, in addition to thermal effects, at higher intensities has also been postulated by Eurasian Communist investigators, but no detailed investigative support for this possibility has been noted. No Eurasian Communist research activity has been identified that can clearly or directly relate to any military offensive weapons program.

5256 THERMAL RESPONSES TO HIGH-FREQUENCY ELECTROMAGNETIC RADIATION FIELDS. *(Eng.)* Frazer, J. W.; Merritt, J. H.; Allen, S. J.; Hartzell, R. H.; Ratliff, J. A.; Chamness, A. F.; Detwiler, R. E.; McLellan, T. (Radiation Physics Branch, Radiobiology Div., USAF Sch. Aerospace Medicine, Aerospace Medical Div., AFSC, Brooks Air Force Base, TX 78235). 19 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A032179]. (17 refs)

Male rhesus monkeys were exposed to high frequency (26 MHz) radiation in a rectangular coaxial transmission line for 6 hr/day over a 5-day wk at power levels of 500, 750, and 1,000 mW/cm^2 to assess their thermal response to such exposures. Experiments were run where the 6-hr exposures were interrupted every 30 min for rectal temperature measurements, and where the 6-hr exposures were uninterrupted with rectal temperatures obtained immediately before and after irradiation. An immediate rise in skin and rectal temperature, with subsequent cooling, was noted. Rectal temperature reached an equilibrium after about 1.5 hr of exposure. This equilibrium was maintained throughout the remainder of the exposure period. At power levels of 500, 750, and 1,000 mW/cm^2, the rectal cooling rates were 0.36, 2.64, and 3.54 C/hr; the corresponding skin cooling rates were 1.74, 2.46, and 1.75 C/hr, respectively. Such cooling rates are sufficient to bring the core and skin temperature to normal values in an hour or less, indicating that thermoregulatory mechanisms were not impaired by 6 hr of irradiation even at the 1,000 mW/cm^2 level and that the monkeys were able to easily dissipate the heat load following cessation of radiation.

5257 MAGNETIC FIELD EFFECTS ON RADICAL PAIR INTERMEDIATES IN BACTERIAL PHOTOSYNTHESIS. *(Eng.)* Blankenship, R. E. (Dept. Biochemistry, Univ. Washington, Seattle, WA 98195); Schaafsma, T. J.; Parson, W. W. *Biochim Biophys Acta* 461(2): 297-305; 1977. (27 refs)

The effects of magnetic fields on the formation and decay of excited states in the photochemical reaction centers of *Rhodopseudomonas sphaeroidea* (strains R-26 and 2.4.1) were investigated. In chemically reduced reaction centers, a magnetic field decreased the fraction of the transient state (P^F) that decays by way of the bacteriochlorophyll triplet state (P^R). At room temperature, a 2-kG field decreased the quantum yield of P^R by about 40%. In carotenoid-containing reaction centers, the yield of the carotenoid triplet state, which forms via P^R, was reduced similarly. The effect of the field depended monotonically on field strength, saturating at about 1 kG. The effect decreased at lower temperatures when the yield of P^R was higher. Magnetic fields did not significantly affect the formation of the triplet state of bacteriochlorophyll in vitro, the photooxidation of P-870 in reaction centers at moderate redox potential, or the decay kinetics of states P^F and P^R. The magnetic field effects support the view

that state ^{1}F is a radical pair which is born in a singlet state but undergoes a rapid transformation into a mixture of singlet and triplet states.

5258 PERFORMANCE AND SAFETY STANDARDS FOR ELECTROSURGICAL DEVICES. *(Eng.)* Emergency Care Research Institute (Emergency Care Res. Inst., 5200 Butler Pike, Plymouth Meeting, PA 19462). 156 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-265 893]. (refs)

The feasibility of testing and achieving requirements of proposed performance and safety standards for electrosurgical devices was studied. Three commercial electrosurgical units were examined; the units operated over frequencies ranging from 500 kHz to 3 MHz at maximum power outputs of 65-375 W in one or more of the following modes: cutting, coagulation, blending, hemostasis. The test results indicated that the requirements of the proposed standards could be tested in commercially available units. All units met a great majority of the requirements of the standard; however, the standard proposed certain requirements that call for features that were not universally incorporated in present units. Examples included audible indicators of activation and a prohibition of multiple-energized active electrodes. Failures to conform to the proposed performance requirements involved the limitation on electrosurgical leakage power from the dispersive electrode, sustained short-circuit operation, and provision for electromagnetic compatibility. In addition to the testing information, lists of invited reviewers of the drafts of proposed standards, of persons requesting copies for review, of attendees at public review meetings, and of persons and organizations submitting written comments following review are also provided. A list of electrosurgical device manufactures is also included, and extensive bibliography is given.

5259 HEMATOLOGICAL AND BIOCHEMICAL EFFECTS OF ELF FIELDS. *(Eng.)* Sheppard, A. R.; Eisenbud, M. *In: Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency.* (New York: New York Univ. Press): pp. (5) 1-44; 1977. (64 refs)

Studies on the hematologic and biochemical effects of direct current (DC) and alternating current (AC) electromagnetic fields in the extremely low frequency range are reviewed. Evidence that environmentally relevant field strengths can affect blood composition, biochemical synthesis, or metabolism comes from a few, scattered experiments. Reports of an AC electric field effect include the following: changes in plasma protein and steroid levels as well as in body weight of rats exposed continuously at 15 kV/m (60 Hz), alterations in white blood cell counts observed in mice and rats at 100 kV/m (50 Hz) and in humans at 15 and 20 kV/m, and altered calcium efflux from chick and cat brains exposed to a field (in air) of 10 V/m or 56 V/m (6 and 16 Hz). Magnetic field effects include elevations of serum triglyceride levels in men exposed for 10 or 22 hr at 1 G (45 Hz), metabolic decreases in nerve cell organelles (synaptosomes) exposed to 50 and 100 G (60 Hz), and steroid changes in monkeys exposed to 200 G (DC). Other biochemical effects reported involve the influence of electric fields on brain tissue, cell organelles, frog red blood cells, and fibroblast cells in cultures; however, these effects were observed at field strengths much greater than those encountered environmentally. There are many reports illustrating that DC, and perhaps AC, currents have an important role in bone growth and repair. There is also one report of tumors related to electrical stimulation of bone. With the exception of bone studies and, to a lesser extent, neural studies, none of the above areas has been adequately investigated. The reported effects have not yet been corroborated by an independent replication, nor has experimental work advanced to the point where response thresholds, a dose-response relation, or frequency dependence are known.

5260 PHYSIOLOGICAL AND BEHAVIORAL EFFECTS IN NON-HUMAN SPECIES. *(Eng.)* Sheppard, A. R.; Eisenbud, M. *In: Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency.* (New York: New York Univ. Press): pp. (7) 1-45; 1977. (66 refs)

Studies on physiologic and behavioral effects produced in experimental animals exposed to electric and magnetic fields in the extremely low frequency range are reviewed. Topics covered include central nervous system effects in monkeys and cats; the effect of external electrical fields on internal electric fields in animal brain tissue; the effect of combined electric and magnetic field on behavioral and physiologic processes in monkeys; electroencephalographic and electrocardiographic changes in animals exposed to 100 kV/m, 50-Hz electric fields; electric field effects on neurons; the effect of electric and magnetic fields on the mitotic cycle in slime mold; the effect of electric fields on mouse fertility; the effects of alternating electric fields (60 Hz) on the activity of caged mice; magnetic field effects on the psychological behavior of rats, electric and magnetic field effects on animal migration, navigation, and communication; electric field effects on marine animals; the effects of electromagnetic fields on the conditioned behavior of pigeons and rats; the effects of electric or magnetic fields on the frowth and development of chicks; patterns of electrical activity during early embryological development in animals; multigenerational studies of rats exposed to combined electric and magnetic fields; the effects of extremely low frequency fields on mutagenesis in *Drosophila* and *Escherichia coli*; the effect of low level direct currents on nerve tissue regeneration; and electric field effects on amoeba.

5261 PHYSIOLOGICAL AND BEHAVIORAL EFFECTS IN HUMANS. *(Eng.)* Sheppard, A. R.; Eisenbud, M. *In: Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency.* (New York: New York Univ. Press): pp. (6) 1-23; 1977. (28 refs)

Studies on human physiologic and behavioral changes associated with exposure to extremely low frequency electric and magnetic fields are reviewed. Topics covered include perception of low level electric and magnetic fields; perceptual, behavioral, and physiological responses in a magnetic field; psychomotor function and cognitive skills in magnetic fields; the effects of zero magnetic fields; physiologic changes in electrical substation workers; electric discharge effects; effects on biologic (circadian) rhythms; correlations between human behavior and geomagnetic storms; and the phenomenon of dowsing in relation to magnetic perception. A study on the perception of low level electric and magnetic fields by humans indicates that human reaction times may be sensitive to external electric fields in the frequency range of 2-12 Hz at a field strength of 4 V/m. In a zero magnetic field experiment where human subjects were exposed to a magnetic field attenuated to 1/1,000 of the geomagnetic field for a period of 10 days, flicker fusion threshold was found to decrease in frequency linearly with time during the test period. Soviet studies on electric substation workers in a 400-500 kV switchyard (50 Hz) revealed physiologic effects manifested by vagotonic changes in the cardiovascular system, a weakening of thermal regulation processes, a lowering of resistance to the action of electric currents, changes in the functional mobility of the neuromuscular apparatus of the hand, and a weakening of neurodynamic processes in the cortex of the brain. In terms of behavioral changes, a statistical correlation has been found between admissions to psychiatric hospitals and changes in the geomagnetic field.

5262 SOIL MICROORGANISM POPULATION DYNAMICS IN WEAK ELF ELECTROMAGNETIC FIELDS. *(Eng.)* Rosenthal, G. M. (Biological Sciences Collegiate Div., Univ. Chicago, Chicago, IL 60637). 36 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035957]. (4 refs)

Soil samples from a pine plantation and a meadow were exposed in the laboratory to an electric field of 1 V/m (root mean square) and a magnetic field of 1 G (root mean square) at a frequency of 60 Hz for up to 16 wk. The microbial population of soil samples exposed to extremely low frequency (ELF) fields was periodically compared with that of soil samples not exposed to the ELF field that served as the control for this study. Soil samples were assayed at 0, 2, 4, 8, and 16 wk for total number of aerobes, anaerobes, and fungi as well as for microorganisms having specific biochemical functions such as nitrification, denitrification, urea decomposition, cellulose decomposition, and sulfate reduction. The results indicated no significant effects of the extremely low frequency fields on the concentration of microorganisms in the soil. Differences in microorganism concentration that were observed could be ascribed to the soil type and sampling variations.

5263 THE PROBLEM OF CLINICAL HYPERTHERMIA. *(Eng.)* Nelson, A. J. (Radiotherapy Centre, 21 McCourt St., Leederville, Western Australia); Holt, J. A. *Australas Radiol* 21(1): 21-30; 1977. (18 refs)

The use of very high frequency (433 MHz) radiation-induced hyperthermia in conjunction with other treatment modalities for the management of various types of human cancers is reported. In a study of 27 patients with secondary cancer in the bone (21 breast cancers, 5 prostate cancers, and 1 Hodgkin's disease) where very high frequency (VHF) radiation was used in combination with chemotherapy or radiotherapy, all patients were relieved of pain after the first treatment, and all but one patient showed improvement in well being and weight gain. Another study involving the use of VHF hyperthermia in combination with ionizing radiation (average, 2,200 rads in 4-5 wk) for the treatment of 12 patients with liver metastases revealed that hyperthermia in combination with individual doses of 50-80 rads of radiation resulted in an enhancement effect equivalent to 200 rads or more. All patients had complete and fairly rapid pain relief. The liver decreased in size during the course of treatment and was subsequently undetectable by clinical palpation in 10 cases. Seven patients survived 3-18 mo (average, 10 mo). A study involving the use of VHF-induced hyperthermia in combination with radiation for the treatment of 52 patients with advanced ear, nose, and throat cancer revealed that hyperbaric radiotherapy was twice as effective as conventional supervoltage therapy in obtaining survivals at 1 and 2 yr as well as in achieving primary clearance of the tumor and in maintaining recurrence-free survival. Whereas the average dose of conventional supervoltage radiation to achieve similar results was 6,000 rads in 6 wk, only 4,800 rads over 8 wk was needed in conjunction with VHF-induced hyperthermia. This latter combination resulted in complete healing in 94% of the patients.

5264 EXPOSURE OF JAPANESE QUAIL EMBRYOS TO 2.45-GHZ MICROWAVE RADIATION DURING DEVELOPMENT. *(Eng.)* McRee, D. I. (Natl. Inst. Environmental Health Sciences, Post Office Box 12233, Research Triangle Park, NC 27709); Hamrick, P. E. *Radiat Res* 71(2): 355-366; 1977. (17 refs)

Japanese quail embryos were exposed during the first 12 days of development to 2.45 GHz microwave radiation at an incident power density of 5 mW/cm^2 and a specific absorption rate of 4.03 mW/g. When the temperature of the exposure environment was 37 C (the optimum hatching temperature) 93% of the quail embryos were killed. This result can be explained by the increase in temperature of the

embryos to 39.5-40 C, since this temperature was sufficient to kill control embryos as well. When the developing embryos were exposed under the same conditions in an environment maintained at a temperature of 35.5 C, no adverse effects on the development of quail were observed. No gross deformities were observed in the exposed quail when examined and sacrificed at 24-36 hr after hatching. No significant changes in total body weights or weights of the heart, liver, gizzard, adrenal gland, or pancreas were observed in the neonates from eggs exposed to microwaves. In terms of hematologic effects, no statistically significant changes in hematocrit, total white blood cells, red blood cells, lymphocytes, heterophils, basophils or eosinophils were measured. A statistically significant increase in hemoglobin (4%) and a decrease in monocytes were observed, however, in microwave-exposed quail. The importance of these changes on the viability of the neonate quail is not known.

5265 THE DESIGN OF A MONOPOLE RADIATOR TO INVESTIGATE THE EFFECT OF MICROWAVE RADIATION IN BIOLOGICAL SYSTEMS. *(Eng.)* Bigu-del-Blanco, J. (Anatomy Dept., Queen's Univ., Kingston, Ontario, Canada); Romero-Sierra, C. *J Bioeng* 1(3): 181-184; 1977. (6 refs)

The design of a microwave monopole radiator is described. The monopole radiator is essentially a stainless steel hollow hypodermic needle that allows both for the irradiation of deep biological structures by simple needle injection and for the simultaneous chemotherapeutic treatment of tissue. The applicator is connected to a low power, frequency-tunable microwave generator. The microwave signal can be modulated, if required, either internally or externally. Monopole impedance matching to the surrounding tissue is attained by means of a slide-screw tuner placed between the monopole and the rest of the microwave circuitry. Experiments involving both relatively large rabbit specimens and saline solutions irradiated at a frequency of approximately 10 GHz gave very similar results, within experimental error, in terms of normalized microwave reflected power measurements. Provided that a reasonable matching (power transfer) between the monopole and tissue occurs, no undesirable effects such as tissue burning at the tissue-monopole interface will occur.

5266 EXTREMELY LOW FREQUENCY ELECTRIC FIELD INDUCED CHANGES IN RATE OF GROWTH AND BRAIN AND LIVER ENZYMES OF RATS. *(Eng.)* Noval, J. J.; Sohler, A.; Reisberg, R. B.; Coyne, H.; Straub, K. D.; McKinney, H. (Dept. Surgery, Temple Univ. Sch. Medicine, Philadelphia, PA 19140). 17 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035959]. (23 refs)

Male Sprague Dawley rats were exposed to 45-Hz vertical electric fields varying from 0.1-100 V/m (root mean square) over periods of 30-40 days. The experiments were conducted in especially equipped, air-conditioned railroad cars that provided shielding from ambient extremely low frequency fields. The exposed rats gained weight at rates of 20-30% slower than control rats and had less abdominal fat deposits than controls. A subcortical neuron effect was evidenced by a consistent decrease in activity of the neuronal enzyme choline acetyltransferase in the brainstem of rats exposed to the 45-Hz fields; cerebral levels of this enzyme were unchanged. Adrenal weights were unchanged in exposed rats, but the liver enzyme, tryptophan pyrrolase, was elevated in many, possibly indicating that the extremely low frequency fields were able to produce a low level of stress response in the rats. Irradiated rats exhibited normal activity and eating and drinking behavior during maintenance in these fields.

5267 HIGH-VOLTAGE ELECTRIC FIELD COUPLING TO HUMANS USING MOMENT METHOD TECHNIQUES. *(Eng.)* Spiegel, R. J. (Southwest Res. Inst., San Antonio, TX 78284). *IEEE Trans Biomed Eng* 24(5): 466-472; 1977. (15 refs)

A numeric procedure is developed to calculate induced current and normal electric field distributions on humans situated at various positions in the right-of-way of a 765-kV transmission line. The numeric technique was based on the method of moments in which the human body is modeled as a collection of straight cylindrical segments with lengths and radii comparable to that section of the body being modeled. It was shown that for a man standing on the ground at a place where the vertical electric field was maximum, the induced electric fields on the hands and top of the head (150 kV/m) were of the same order of magnitude as the electric field recognition level (236 kV/m). Therefore, the electric fields were large enough to possibly be perceived by the person. For an unprotected lineman located 1.5 m from an energized conductor, the induced electric fields on his hands, feet, and head were of the same order of magnitude as the recognition level also. However, the induced field (1,000 kV/m) on his hand nearest to the energized conductor was about half that of the corona-forming level (1,968 kV/m). The unprotected lineman can be expected to have induced field levels on his hands large enough to be felt, and these induced field levels may be of sufficient magnitude to produce a corona at the ends of the finger tips.

5268 GALVANOTROPIC ORIENTATION OF GOLDFISH *(CARASSIUS AURATUS)*. *(Eng.)* Wolf, D. J. (Ph.D. dissertation, Graduate Coll. Univ. Illinois at Urbana-Champaign, 1976); 186 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-9243]. (71 refs)

Studies on the galvanotropic orientation of goldfish *(Carassius auratus)* are reported. Goldfish oriented toward the cathode at low intensities and toward the anode at high intensities following 15 sec of direct

current stimulation. The precision or orientation was a linear function of stimulus intensity. The partition of neurosensory control over goldfish galvanotropic orientation reflected the biphasic character of the behavior. A mechanism dependent on the intact spinal cord controled the cathodic orientation seen at low intensities. The anisotropic electrical properties of vestibular sense cell activity appeared to be related to anodic orientation at high intensities. The precision of anodic orientation of bilaterally labyrinthectomized fish was significantly poorer than that of intact animals or animals with large brain ablations. Bilateral irrigation of the otic canals with local anaesthetic solution also produced a long lasting deficit of anodic orientation precision. *Carassius auratus* is not electrosensitive in the ordinary sense; the threshold for galvanotropic orientation of goldfish is about 0.1 V/cm, or roughly 1,000,000 times higher than that for truly electrosensitive species. An estimate of the current through a large fish (15 cm) in tap water at a tank voltage of 20 V was roughly 2.0 mA in the present studies (using 1,274 ohm/cm as the specific resistivity of the fish). If the cross section of the labyrinthine organs is about 1% of the cross section of the fish, then a current of 2.0 mA through the animal corresponds to about 20.0 μA through the labyrinth. Since reliable reactions were seen at somewhat lower tank voltages, it is concluded that labyrinth currents of a few μA may evoke galvanotropic orientation.

5269 EXPERIMENTAL AND THEORETICAL DETERMINATION OF ABSORBED MICROWAVE DOSE RATE DISTRIBUTIONS IN PHANTOM HEADS IRRADIATED BY AN APERTURE SOURCE. *(Eng.)* Ho, H. S. (Health, Education, Welfare, Public Health Service, Food & Drug Admin., Bureau Radiological Health, Div. Biological Effects, 5600 Fishers Lane, Rockville, MD 20852); Faden, J. *Health Phys* 33(1): 13-21; 1977. (7 refs)

A thermographic technique was used to determine absorbed microwave energy distribution in phantom monkey and human heads irradiated by a 2,450-MHz aperture source. Brain tissue spheres simulating both a monkey (3.3 cm radius) and a human head (7.0 cm radius) were used along with a bone and brain tissue equivalent geometric model of a monkey head. Maximum power (up to 100 W) was applied to the aperture source for 30 sec; and then one-half of the model was quickly (within 5 sec) placed in front of a thermographic camera for polaroid picture taking (within 5 sec). Cross-sectional temperature rise patterns for both the 7-cm radius and 3.3-cm radius brain spheres were in qualitative agreement with previous theoretic calculations. The temperature rise patterns in the phantom monkey head were similar to the pattern of the 3.3-cm brain sphere. However, the pattern in the monkey was more irregular. Temperature rise and absorbed dose rate patterns of the spheres and the phantom monkey heads were drastically different from heating patterns obtained with a plane wave source. The calculated high concentration of absorbed energy in the center of a 3.3-cm radius brain sphere resulting from a plane wave source was not observed in the aperture-heated cases. Nevertheless, penetration of microwave energy into the phantom monkey head was sufficient to cause heating in the brain region. It is expected that by changing the aperture size or the radiation frequency, the pattern of microwave absorption can be modified.

5270 EXTREMELY LOW FREQUENCY (ELF) VERTICAL ELECTRIC FIELD EXPOSURE OF RATS: IRRADIATION FACILITY. *(Eng.)* Mathewson, N. S.; Oliva, S. A.; Oosta, G. M.; Blasco, A. P. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014). 68 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035955]. (12 refs)

An extremely low frequency (ELF) vertical electric field irradiation facility consisting of six identical exposure chambers is described. The facility was developed for biological research related to the United States Navy's proposed ELF communications system, which is designed to establish worldwide submarine fleet communications. The facility is designed to study the possible bioeffects of ELF on 96 rats equally divided among the six exposure chambers and individually housed in specially modified nonmetallic cages. These cages were designed to minimally perturb the exposure field and to provide accurate means to measure food and water consumption. Each exposure chamber could be independently operated up to field strengths of 1,000 V/m (root mean square) at any sinusoidal ELF frequency. At 45 Hz, the frequency chosen for this research, chamber cross-talk is less than -60 dB, and the vertical electric field uniformity within the exposure area is within ± 5%.

5271 IN VITRO AND IN VIVO INHIBITION OF VIRUS MULTIPLICATION BY MICROWAVE HYPERTHERMIA. *(Eng.)* Szmigielski, S. (Center for Radiobiology and Radioprotection, Warsaw, Poland); Luczak, M.; Janiak, M.; Kobus, M.; Laskowska, B.; de Clercq, E.; de Somer, P. *Arch Virol* 53(1/2): 71-77; 1977. (19 refs)

The effects of microwave hyperthermia (41 and 43 C) on virus multiplication were investigated in vitro (herpes simplex virus type 1 (HSV-1)-infected primary rabbit kidney cultures) and in vivo (mice infected with HSV-1 or vaccinia virus). Microwave irradiation was performed at a frequency of 3 GHz. Animals were irradiated at a mean field power density of 40 mW/cm^2 for 2 hr daily; for cell culture experiments, the field power density was regulated so that the temperature of the culture medium could be maintained at 41 or 43 C during the irradiation period. In vitro, hyperthermia applied for 3 or 12 hr after infection led to a marked decrease in virus yield in cell cultures, with heating at 43 C inhibiting virus multiplication to a greater extent than heating at 41 C. Heating of the cells for 3 hr prior to infection was without effect, and prolonged hyperthermia over the whole postinfection period