(72 hr) seriously impaired cell viability. In mice inoculated intranasally with HSV-1, microwave hyperthermia applied immediately after infection resulted in a significant decrease in the mortality rate ($p<0.001$). Microwave hyperthermia applied immediately after vaccinia virus infection in mice led to a significant decrease in the number of tail lesions ($p<0.001$). Irradiation prior to infection or delayed until 3 days after virus challenge did not exhibit an appreciable effect. The data suggest that microwave hyperthermia interferes directly with the virus multiplication cycle both in vitro and in vivo.

5272 EFFECT OF MICROWAVE OR WATERBATH HYPERTHERMIA ON TUMOR GROWTH. *(Eng.)* Sparks, F. C. (VA Hosp., Sepulveda, CA); Breeding, J. H. *Surg Forum* 28: 141-143; 1977. (4 refs)

The effect of whole-body microwave hyperthermia versus that of whole-body waterbath hyperthermia on local tumor growth in 10-wk-old BALB/c mice was investigated. At 14 days after subcutaneous inoculation with line 26 colonic carcinoma, a total of 24 mice were divided randomly into three groups to receive either no treatment (controls) or hyperthermia (41.5 C for 60 min), which was produced either by microwave heating (2.45 GHz) or by immersion to the neck level in a waterbath. At 16 days after tumor implantation, the mean tumor volume in control mice had increased by 56% as compared with 32% ($p<.05$) for microwave-treated mice and 24% ($p<.05$) for waterbath-treated mice. At 23 days after tumor implantation, eight of eight mice treated with microwaves ($p<.05$) and seven of eight mice treated by waterbath immersion ($p<.05$) were alive compared with three of eight survivors in the control group. The effects of hyperthermia on tumor size and animal survival were transient. It is concluded that the effect of whole-body hyperthermia on tumor growth and animal survival was achieved equally well by either waterbath or microwave radiation.

5273 EDITORIAL COMMENT: BIOELECTRICAL EFFECTS ON BONE AND CARTILAGE. *(Eng.)* Brighton, C. T. (No affiliation given). *Clin Orthop* (124): 2-4; 1977. (0 refs)

Topics covered at a symposium on the effects of electrical stimulation on bone and cartilage are outlined. Both laboratory and clinical studies involving different electrical parameters, different electrode materials, and different application techniques are discussed. Specific investigations described include a comparison of constant direct current to various pulsed currents in a rabbit calvarium model; an evaluation of the application of constant direct current to various bone and periodontal defects in animals; the use of electret film to induce callus formation in experimental animals; clinical studies on the application of constant direct current to nonunions, congenital pseudoarthroses and fresh fractures; the treatment of tibia fractures with asymmetrical pulsed direct current using stainless steel electrode-screws; and the treatment of patients with nonunions and congenital pseudoarthroses using electromagnetic fields pulsed at an extremely low frequency.

5274 THE CLASSIC FUNDAMENTAL ASPECTS OF FRACTURE TREATMENT. *(Eng.)* Yasuda, I. (No affiliation given). *Clin Orthop* (124): 5-8; 1977. (1 refs)

The role of electricity in callus formation is discussed. Experiments investigating the production of electricity by bone under mechanical stress are reviewed, and it is concluded that force leads to callus formation through the production of electricity in bone. In an experiment designed to investigate whether callus could be produced by electrical stimulation, a direct current of 1 μA was applied continuously for 3 wk to Vitallium electrodes that were inserted through the cortex into the medullary canal of a rabbit femur. At the end of the 3-wk period, a ridge of callus was observed, which ran between the electrodes both inside and outside the periosteum. There was more newly-formed bone on the inside of the periosteum in the region of the negative electrode than in the region of the positive electrode. The fact that less bone was formed at the positive electrode is an important finding in that it links together the electronegative property of bone under a mechanical stimulus with the formation of bone at the negative electrode during external electrical stimulation.

5275 THE INFLUENCE OF ELECTRIC POTENTIALS ON PLATED BONES. *(Eng.)* Weigert, M. (Dept. Orthopaedics and Traumatology, Urban Hosp., Berlin, W. Germany); Werhahn, C. *Clin Orthop* (124): 20-30; 1977. (39 refs)

Experiments investigating the effect of electric potentials on plated bones are reported. Each of 27 rabbits treated with bilateral tibial osteotomy and compression plates received 3-15 μA of constant direct current to one tibia for 21 days. The breaking strengths of the electrically-stimulated tibiae were higher in 19 animals (70.4%), the same in two animals, and lower in six animals when compared with unstimulated tibiae. The mean value of the additional maximum stress required to break the stimulated tibiae was 0.73 kg. When 15 other rabbits were similarly treated, with electrical stimulation applied to only one tibia in each animal, there was an increase in endosteal and periosteal callus formation and greater vascularization of the callus (on microangiography) in the stimulated tibiae as compared with nonstimulated tibiae. The fissure gap at the osteotomy site was smaller in stimulated tibiae compared with unstimulated tibiae, and bone in the fissure was of the mature lamellar type only in stimulated tibiae. Uptake of fluorochromes was greater in stimulated than in unstimulated tibiae. When both tibiae in each of five rabbits were doubly fixed with compression plates and a simulated piezoelectric potential (15 mV, 5-8 μA, 0.33 Hz) was

applied to one tibia of each animal for periods ranging from 136-156 days, stimulated tibiae in three of five animals showed a 20% higher calcium and phosphate content of the stress-protected cortex as well as in increased uptake of fluorochromes in comparison with unstimulated tibiae.

5276 ELECTRICAL STIMULATION OF OSTEOGENESIS IN PERIODONTAL DEFECTS. *(Eng.)* Jacobs, J. D. (Dept. Orthodontics, Baylor Coll. Dentistry, Dallas, TX 75246); Norton, L. A. *Clin Orthop* (124): 41-52; 1977. (17 refs)

The effect of artificially-produced direct negative current on osteogenesis in pathologic defects found in the periodontium of dogs was investigated. Galvanic or thermocouple generators designed to deliver a current in the nanoampere range were implanted submucoperiosteally in the area of periodontal osseous defects in five dogs, with the negative electrodes extending into the osseous defects. The galvanic unit produced a constant direct current of 3-6 nA, while the thermocouple generator produced an oscillating direct current of approximately 0-20 nA. Clinical and radiographic evaluation revealed no significant changes in the depth of the defects. When the animals were sacrificed after 45 days of treatment, histologic measurements suggested that endosteal apposition was enhanced in all experimental sites in comparison with controls. Clinically, no gross adverse tissue reactions were observed during the experiment or at surgical re-entry. Further investigation is needed to determine the magnitude of current that best enhances osteogenesis in pathologic defects of alveolar bone.

5277 ELECTRICAL CALLUS AND CALLUS FORMATION BY ELECTRET. *(Eng.)* Yasuda, I. (Dept. Orthopedic Surgery, Kyoto Second Red Cross Hosp., Kamikyo-ku, Kyoto, Japan). *Clin Orthop* (124): 53-56; 1977. (10 refs)

In vitro and in vivo experiments dealing with electrically-induced callus formation are reported. When Vitallium electrodes were inserted through drill holes into the femur of a rabbit and were connected to a 1.5-V battery in series with a 1 megohm resistor, a continuous current of 1 μA or less over a period of 3 wk produced a ridge of callus between the electrodes, which ran subperiosteally along the cortex and endosteally along the medullary canal. The amount of callus increased as the electrical current was increased and was significantly greater at the cathode than at the anode. As the current was increased from 1 μA to 100 μA, the quality of callus changed from osseous to cartilagenous or fibrous. When stainless steel electrodes were wound around the rabbit femur, a well-shaped callus formed between the electrodes when a current of 1 μA was applied over a 3-wk period. When the cathode was wound around the femur and the anode was placed in muscle, the callus began at the cathode and grew toward the anode in an arc-like manner. In vitro experiments in which excised rabbit or human bone fragments in normal saline solution were subjected to a current of 1 μA also resulted in callus formation, which was similar in quality but less in quantity than that observed during in vivo experiments. When electret film was either simply laid on the femur of rabbits or was wrapped around the femur, the amount of callus formed was greater in the latter case than in the former. The amount of callus reached a maximum after 2 wk in the former case, with the callus gradually decreasing and becoming transformed into hard body tissue thereafter. When the electret film was wrapped around the femur, callus formation was especially noted on the flexor side of the femur, and the shape of the callus formed around the electret resembled a bridge above the electret. The bridge-like callus was bony hard after 4 wk.

5278 THRESHOLD LIMIT VALUES FOR CHEMICAL SUBSTANCES AND PHYSICAL AGENTS IN THE WORKROOM ENVIRONMENT WITH INTENDED CHANGES FOR 1976. *(Eng.)* American Conference Governmental Industrial Hygienists (P.O. Box 1937, Cincinnati, OH 45201). *Med Bull* 36(2/3): 135-202; 1977. (0 refs)

Threshold limit values for occupational exposure to chemical substances and physical agents are presented. The threshold limit value for occupational microwave exposure (100 MHz-100 GHz) where power densities are known and exposure time is controlled is as follows: for average power density levels up to but not exceeding 10 mW/cm^2, total exposure time shall be limited to the 8-hr workday (continuous exposure); for average power density levels ranging from 10 mW/cm^2 up to but not exceeding 25 mW/cm^2, total exposure time shall be limited to no more than 10 min for any 60-min period during an 8-hr workday (intermittent exposure); for average power density levels in excess of 25 mW/cm^2, exposure is not permissible. These threshold limit values represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect. These values should be used as guides in the control of exposure to microwaves and should not be regarded as a fine line between safe and dangerous levels. For repetitively pulsed sources, the average power density may be calculated by multiplying the peak power density by the duty cycle (pulse duration in seconds multiplied by the pulse repetition rate in hertz).

5279 PHYSICAL PROPERTIES OF BIOLOGICALLY ACTIVE LOW-FREQUENCY ELECTROMAGNETIC FIELDS. *(Ger.)* Pfutzner, H. (Institut fur Grundlagen und Theorie der Elektrotechnik, Technische Universitat Wien, A- 1040 Vienna, Gusshausstrasse 21, Austria). *Elektrotechnik und Maschinenbau* 94(7): 281-286; 1977. (20 refs)

A systematic review of 250 studies on the biologic effects of fields with a maximum frequency of 1 MHz shows an abundance of data on the effects of static electric and magnetic fields, in contrast to the smaller number of studies devoted to alternating magnetic and electromagnetic fields. Static electrical fields with potentials of up to 500 V/m

are believed to have no biologic effect. A functional relationship is found between field intensity and frequency of alternating electric fields in relation to their biologic effect. A hypothetical curve showing the lowest effective field potential as a function of frequency is presented with the minimum biologic effect seen in the frequency range of 3-10 Hz. The effects of magnetic fields have been studied mainly for intensities that are not typical for either the natural or technical environments. The effect and its tendency are not proportional to the field intensity.

5280 TREATMENT OF NONUNION WITH CONSTANT DIRECT CURRENT. *(Eng.)* Brighton, C. T. (Dept. Orthopaedic Surgery, Univ. Pennsylvania Sch. Medicine, Philadelphia, PA); Friedenberg, Z. B.; Mitchell, E. I.; Booth, R. E. *Clin Orthop* (124): 106-123; 1977. (44 refs)

The use of a constant direct current (10-20 μA) for the treatment of nonunions in 57 patients (37 males and 20 females; average age, 37.3 yr) is reported. The average duration of nonunion was 3.3 yr. Cathodes were either drilled obliquely through one cortex until they came to rest in the nonunion site, or they were inserted directly into the nonunion site without passing through the cortex. The anode was attached to the skin with adhesive tape. The current was applied continuously for periods ranging from 9-12 wk. While a current of 10 μA per cathode, which was used to treat the first 16 patients, proved sufficient to heal small bones such as medial malleoli, it was not adequate for larger bones. Thereafter, a current of 20 μA/cathode was used. Also, the number of cathodes inserted into each nonunion site was increased so that two to four were used in each nonunion. Of the 57 patients treated with electricity, 39 (68.4%) achieved solid bony union, and 35 patients (61.4%) were healed on the first trial. Of 46 patients who were treated adequately with electricity, 39 (84.8%) achieved solid bony union, and the percentage of patients who went on to union on the first trial of electrical treatment was 76.1%.

5281 ELECTRET INDUCED CALLUS FORMATION IN THE RAT. *(Eng.)* Inoue, S. (Dept. Orthopedic Surgery, Gifu Coll. Dentistry, Murakami Memorial Hosp., 1-6 Wakamiya-cho, Gifu, Japan, 500); Ohashi, T.; Yasuda, I.; Fukada, E. *Clin Orthop* (124): 57-58; 1977. (7 refs)

Electret-induced callus formation in the rat is reported. A 7-mm wide Teflon film strip of electret (material with a permanent electrical polarization) was wrapped around the intact mid-femoral shaft of the right femur in 10 Japanese white rats. The mid-femoral shafts of the opposite femora were wrapped with regular (non-charged) Teflon film strips to serve as controls. After 3 wk, 9 out of 10 animals showed callus formation on the electret side. None of the animals showed callus formation on the control side. In 6 out of 10 of the animals, the callus was wedge-shaped with the apex of the wedge pointing proximally on the flexor surface of the femur and extending proximally over the electret film. Histologic examination of the callus on the femur disclosed that the tip of the wedge-shaped bony callus was covered with thick fibrous connective tissue and young hypertrophic fibrous tissue. The callus itself consisted of cancellous bone. In some animals the new bone was covered only with a thin layer of fibrous tissue, but the bony callus itself contained normal-appearing marrow next to the original femoral cortex. This model of electret-induced callus formation should lend itself to the histo-biochemical study of electrically-induced osteogenesis.

5282 SURVIVAL OF CANINE KIDNEYS AFTER TREATMENT WITH DIMETHYLSULFOXIDE, FREEZING AT -80°C, AND THAWING BY MICROWAVE ILLUMINATION. *(Eng.)* Guttman, F. M. (Lady Davis Inst.-Jewish General Hosp., 5750 Cote des Neiges, Montreal, H3T 1E2, Canada); Lizin, J.; Robitaille, P.; Blanchard, H.; Turgeon-Knaack, C. *Cryobiology* 14(5): 559-567; 1977. (36 refs)

The survival of canine kidneys after treatment with dimethylsulfoxide (DMSO), freezing, and microwave thawing was studied. Kidneys removed from adult mongrel dogs were perfused with Perfudex plus DMSO (1.4 molar), modified Collins' solution with DMSO (1.4 molar), or modified Sacks' solution with DMSO (1.4 molar). Control kidneys were reimplanted in the groin with an end-to-end arterial anastomosis, an end-to-side venous anastomosis, and a tunneling uretero-vesical anastomosis. Control kidneys showed little toxicity and life-sustaining conservation. Experimental kidneys were frozen for 15 min to -80 C and were then thawed to 0 C over a period of about 90 sec in a 2,450 MHz microwave oven with a power output of 1.35 kW. The kidney was then autografted into the groin of the donor dog in a standard manner. Among 16 experimental dogs, eight survived for prolonged periods (12-14 mo) on a single frozen-thawed kidney for an overall success rate of 50%. In contrast, when conduction thawing in a saline bath was attempted only 1 of 13 kidneys survived.

5283 MONITORING AND DIAGNOSIS OF PULMONARY EDEMA BY MICROWAVES: A PRELIMINARY REPORT. *(Eng.)* Bragg, D. G. (Dept. Radiology, Univ. Utah Medical Center, Salt Lake City, UT 94132); Durney, C. H.; Johnson, C. C.; Pedersen, P. C. *Invest Radiol* 12(3): 289-291; 1977. (4 refs)

Initial studies using microwave energy for the monitoring of early pulmonary edema are reported. The experiments were performed on two anesthetized dogs monitored before and during artificially induced pulmonary edema. Microwave frequencies varying from 300-950 MHz were used, with most measurements utilizing 915-MHz microwaves. The microwave monitoring system consisted of a microwave generator, a directional coupler, a network analyzer, and a microwave antenna or applicator. The incident power

density produced by the applicator in free space at 915 MHz was less than 10 $\mu W/cm^2$ (more than 1,000 times lower than the applicable safety standard). Excellent correlation was obtained between changes in microwave reflection and pulmonary physiologic indicators of developing pulmonary edema. In particular, the amplitude changes in the microwave signal directly paralled the plotted curve of increasing left atrial pressure and long preceded abnormalities observed on serial chest radiographs and auscultatory findings.

5284 DISINFECTING EFFECT OF PULSED ELECTRICAL DISCHARGES ON BINARY BACTERIAL SUSPENSION. *(Rus.)* Zhuk, E. G. (No affiliation given). *Zh Mikrobiol Immunobiol* (7): 150-151; 1977. (0

The disinfecting effect of pulsed electrical discharges (energy dose 2,650 J) on aqueous suspensions of *Escherichia coli* (5,000 cells/ml), STI anthrax vaccine spores (5,000 cells/ml), and their binary mixture was studied. Bactericidal effect was achieved with 14.5-22.1 impulses in the single cultures and with 20.2-23.8 impulses in the binary suspension. Sporicidal effect was achieved with 37.7-57.7 impulses in single culture and with 40.4-62.4 impulses in binary suspensions. Lethal energy doses were 3.8×10^3 erg for *E. coli* and 14.4×10^3 erg for anthrax bacillus spores in single suspensions. For the binary suspension containing the same numbers of cells, the lethal dose was 6.4×10^3 erg, regardless of species. The findings indicate that *E. coli* reduces the survival of STI spores and increases the efficiency of the pulsed discharges in binary suspensions due to the increased total cell surface.

5285 FAILURE OF CHRONIC EXPOSURE TO NONTHERMAL FM RADIO WAVES TO MUTATE *DROSOPHILA*. *(Eng.)* Mittler, S. (Dept. Biological Sciences, Northern Illinois Univ., DeKalb, IL 60115). *J Heredity* 68(4): 257-258; 1977. (12 refs)

The possible mutagenic effects of frequency-modulated (FM) radio waves on *Drosophila* flies were investigated. Female flies heterozygous for Bar eye were isolated and tested for lethals, and nonlethal strains were placed in a radio transmitter building, which was 45 m away from the base of a 300-foot antenna fed by a 50,000-W FM transmitter operating at a frequency of 98.5 MHz. The flies were exposed to a field strength of 0.3 V/m for 4,020 hr over a 32-wk period. Lethals were determined by isolating a mated heterozygous Bar female that produced no Bar-eye males among the offspring from matings with at least 10 wild-type eye males. These lethals were retested by isolating at least six heterozygous Bar females from each of the suspected lethals; if, in the next generation, they all proved to be lethals, the original classification of a lethal was kept. There was no significant difference in percentage of lethals from stocks exposed to nonthermal FM radio wave radiation (0.853%) and the percentage of lethals among control flies (0.895%) not exposed to FM radio waves. Chronic exposure to 0.3 V/m of 98.5-MHz FM radio waves does not appear to be mutagenic to *Drosophila*.

5286 MICROWAVE FIXATION OF FETAL SPECIMENS. *(Eng.)* Petrere, J. A. (Dept. Toxicology, Parke, Davis and Co., Ann Arbor, MI 48106); Schardein, J. L. *Stain Technol* 52(2): 113-114; 1977. (4 refs)

Microwave fixation of whole rat and rabbit fetal specimens is described. Rat or rabbit fetuses were killed painlessly, opened at the abdomen and at the back of the neck, and placed in 10% buffered neutral formalin in plastic boxes. Optimal fixation results were obtained when the boxes were irradiated in a microwave oven for 2.0-2.5 min in the case of rabbits and 2.5-3.0 min in the case of rats. Rat fetuses irradiated for at least 2.5 min had adequately fixed viscera and produced well-stained skeletal specimens. Irradiation for more than 3 min made the tissue brittle and caused it to disintegrate when macerated. Exposures for longer than 3 min in the case of rabbit fetuses were also unsatisfactory. Although the technique does not rival the speed of ethanol fixation, the condition of the viscera is superior and the skeleton much more flexible. Microwave fixation saves a week of time with rats and almost 2 wk with rabbits when compared with routine formalin fixation methods.

5287 INFLUENCE OF INJECTED PHYSCHOACTIVE DRUGS ON CYCLIC AMP LEVELS IN MOUSE BRAIN AND LUNG FOLLOWING MICROWAVE IRRADIATION. *(Eng.)* Palmer, G. C. (Dept. Pharmacology, Univ. South Alabama, Coll. Medicine, Mobile, AL 36688); Jones, D. J.; Medina, M. A.; Stavinoha, W. B. *Neuropharmacology* 16: 435-443; 1977. (65 refs)

The actions of various classes of psychotropic drugs on the steady-state in vivo levels of adenosine cyclic 3',5'-monophosphate (cyclic AMP) in the cerebral cortex, diencephalon, and lung of male Swiss mice subsequently sacrificed by 500 msec of 2,450-MHz microwave radiation (6 kW) were investigated. Chlorpromazine, chlorpromazine sulfoxide, para-hydroxy-amphetamine, caffeine, papaverine, pargyline, and amitriptyline caused an increase in the cyclic AMP level in the cerebral cortex, while alpha-methyl para-tyrosine produced a decrease in cerebral cortex cyclic AMP, and reserpine elicited no change. In the diencephalon, cyclic AMP was elevated by reserpine, chlorpromazine, and caffeine and was depressed by alpha-methyl para-tyrosine and chlorpromazine sulfoxide; the remaining agents caused no change. The following agents raised cyclic AMP in pulmonary tissue: reserpine, alpha-methyl para-tyrosine, papaverine, chlorpromazine, chlorpromazine sulfoxide, and amitriptyline. The cyclic nucleotide content of the lung was reduced by amphetamine, para-hydroxy-amphetamine, pargyline, and D-lysergic acid diethylamide. These studies indicate that the microwave method of tissue inactivation is a useful tool for evaluating drug action with respect to the steady-state levels of metabolically labile compounds. The results also indicate that, in vivo, psychoactive drugs influence steady-state levels of cyclic AMP

in a manner that can differ from their action in vitro and that the same drug does not affect the cyclic nucleotide levels in an identical manner in different regions within the brain or lung.

5288 A NON-OPERATIVE SALVAGE OF SURGICALLY-RESISTANT PSEUDARTHROSES AND NON-UNIONS BY PULSING ELECTROMAGNETIC FIELDS: A PRELIMINARY REPORT. *(Eng.)* Bassett, C. A. L. (Orthopaedic Res. Lab., Columbia Univ. Coll. Physicians and Surgeons, New York, NY 10032); Pilla, A. A.; Pawluk, R. J. *Clin Orthop* (124): 128-143; 1977. (91 refs)

The therapeutic use of extermely low frequency pulsed electromagnetic fields for the nonoperative salvage of surgically resistant pseudarthroses and nonunions is reported. The electromagnetic field was induced by a quasi-square wave generator, which powered an "O"-shaped treatment coil that was applied to the patient to produce a pulsing electromagnetic field at right angles to the long axis of the bone. The pulse was asymmetrical with a rapidly rising leading edge (less than 10^{-6} sec). The total pulse width was approximately 300 μsec, and the duty cycle was approximately 5:1. The peak induced current density was about 10 μA/cm^2 tissue. Among 29 patients (17 recommended for amputation after at least one surgical repair failure), the overall success rate, including patients treated with inadequate pulse characteristics and those who failed to follow the protocol, was over 70%. An analysis of 43 additional patients treated with pulsed electromagnetic fields revealed that most patients required two facing coils for maximum repair rate. With this change, the percentage of success increased to an overall rate of 85%. The described electromagnetic technique appears to be both safe and effective and can be applied with or without surgery on an out-patient basis.

5289 EFFECTS OF LOW-LEVEL MICROWAVE RADIATION ON GERMINATION AND GROWTH RATE IN CORN SEEDS. *(Eng.)* Bigu-Del-Blanco, J. (Anatomy Dept. Queen's Univ., Kingston, Ontario, Canada); Bristow, J. M.; Romero-Sierra, C. *Proc IEEE* 65(7): 1086-1088; 1977. (5 refs)

The effect of microwave radiation on the germination and growth rate of corn seeds *(Zea mays)* was investigated. Specimens were irradiated in an anechoic chamber for 22-24 hr with continuous wave 9-GHz microwave radiation at power density levels ranging from 10-30 mW/cm^2. Anechoic chamber temperature of 23 (± 1) C and humidity of 70% were kept constant. Gross differences were observed between irradiated and control seedlings at power density levels as low as 10 mW/cm^2. Irradiated specimens had a dried and wrinkled rugose texture and were totally arrested in growth. Control seedlings remained healthy. The growth differential continued for 1-2 wk but eventually disappeared. Since temperature increases of up to 4 C were observed when corn seedlings inside plastic bags were irradiated with power density levels of up to 30 mW/cm^2, nonirradiated seeds were incubated at comparable temperatures to investigate the effect of temperature elevation on seed growth. No temperature effect was observed, and the incubated seeds remained healthy and germinated as well as control seeds. Measurements of moisture loss showed that irradiated seedlings lost about five times as much moisture as control seedlings during the treatment. It is concluded that the microwave-induced growth inhibition was probably due to a loss of turgor resulting from water loss since full turgor is necessary for the growth of plant cells.

5290 BIOLOGICAL EFFECTS OF MICROWAVES (BOOK REVIEW). *(Eng.)* Blackman, C. F. (Health Effects Res. Lab., U.S. Environmental Protection Agency, Research Triangle Park, NC). *Am Sci* 65(5): 636; 1977. (0 refs)

A review of *Biological Effects of Microwaves* is presented. The book is highly valuable as an introduction to the complexities of microwave bioeffects research and covers subjects ranging from the operation of radiation-generating equipment to the parameters affecting the penetration and interaction of radiation with living systems. The book also offers reviews and comparisons of Soviet, Polish, and American research philosophies and results. Areas of microwave research that require more work to confirm and extend preliminary results are identified and highlighted.

5291 RADIO-FREQUENCY ELECTROMAGNETIC RADIATION FROM PORTABLE AND MOBILE TELECOMMUNICATION TRANSMITTERS. *(Eng.)* Thiel, J. F. *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. 199-202; 1976. (7 refs)

Measurements made on commonly available mobile and portable telecommunications systems indicate that individuals may be exposed to levels of electromagnetic radiation comparable to the current radiation protection guide, if they are at distances of less than 1 m from the antenna. At distances of 50 cm or less from antennas whose input power is 100 W, power densities (electric field strength equivalent of free space) in excess of 1 mW/cm^2 can be found. As one approaches the loading coils on antennas shorter than one quarter wave length, power densities in excess of several hundred mW/cm^2 are found. A magnetic field intensity equivalent to a free space power density of 2.5 mW/cm^2 was found at approximately 5 cm from the base of an antenna on a 2-W walkie-talkie operating in the very high frequency-high band. With the apparent increase and authorization of the land mobile radio spectrum, which includes the 406-512 MHz and 806-960 MHz frequency band as well as numerous bands below 300 MHz, consideration should be given to the applicability and interpretation of the current radiation protection guide. There exists a need for measurement standards in order to appropriately evaluate personal exposure, both in terms of occupational

risk and general public health risks. Effects of electromagnetic radiation on safety systems and flammable and volatile materials need to be evaluated.

5292 NON-IONIZING ELECTROMAGNETIC RADIATION STANDARDIZATION. *(Eng.)* Baird, R. C.; Sanders, A. A. *In: Measurements for the Safe Use of Radiation. Proceedings of an NBS 75th Anniversary held at National Bureau of Standards, Gaithersburg, MD on March 1-4, 1976.* pp. 417-425; 1976. (15 refs)

Activities of NBS relating to the standardization of nonionizing electromagnetic radiation are reviewed. NBS has developed accurate measurement and calibration techniques, which will be fully implemented by August 1976 when a new anechoic (reflection-free) chamber will be completed. The chamber will be adequate for free space calibration down to about 500 MHz. A series of transverse electromagnetic mode transmission cells will be employed to extend the calibration capabilities down to very low frequencies. The NBS is also developing stable transfer standards suitable for measurement assurance programs (MAP), and a pilot MAP with uncertainties of about ± 0.5 dB (±12%) is anticipated during 1977. There is still a need for probes with better characteristics for use as transfer standards, and NBS is currently developing a three-axis dipole-diode probe. Existing probes can be used for interim MAP's, and the overall accuracy can be improved later as better transfer standards become available.

5293 INTERNAL EM FIELD AND ABSORBED POWER DENSITY IN HUMAN TORSOS INDUCED BY 1-500-MHZ EM WAVES. *(Eng.)* Chen, K.-M. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., East Lansing, MI 48824). *IEEE Trans Microwave Theory Techniques* 25(9): 746-756; 1977. (12 refs)

A tensor integral equation method is used to obtain numeric results on the internal electromagnetic (EM) field and absorbed power density inside a human torso induced by both vertically and horizontally polarized EM waves of frequencies ranging from 1-500 MHz. The induced fields inside the torso are dependent on the frequency and torso geometry with a hot spot occurring in the neck area. For the case of vertical polarization, the normalized maximum induced electric field in an adult torso 1.7 m in height reaches a sharp maximum and the relative absorption area attains a weak peak at around 80 MHz. This implies that a resonance occurs in a human torso when the torso height is about 0.453 times the free-space wavelength of the incident EM wave. For horizontal polarization, the induced electric field appears to have two local maxima at 170 and 230 MHz. The absorbed power for the horizontal polarization case tends to increase monotonically with the frequency first and remains constant for frequencies higher than 170 MHz. At frequencies below 100 MHz, the induced field in an adult torso is stronger for the vertical polarization case than for the horizontal polarization case; however, the opposite is true for frequencies above 170 MHz. The theoretic results on induced fields inside a typical adult torso were compared with published experimental results, and good qualitative agreement was found.

5294 METHODS FOR THE EVALUATION AND CALIBRATION OF MICROWAVE SURVEY INSTRUMENTS. *(Eng.)* Swicord, M. L.; Bassen, H. I.; Herman, W. A. *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. 99-105; 1976. (2 refs)

Facilities operated by the BRH of the FDA for the evaluation and calibration of microwave survey instruments are described. The facilities include an anechoic chamber with a precisely positionable cart for measuring gain and chamber standing waves. The operable frequency range is 900 MHz to 10 GHz. A laser provides a means of aligning antennas. The absolute calibration of distance and microwave power are performed by the NBS. The radiated electric field strength is then established by BRH as a primary standard using precise antenna gain measurement methods. An instrument evaluation facility includes an absorber-lined temperature chamber, a probe/slot-source positioning system, and devices for measuring the polarization response, modulation response, and the linearity of the microwave survey instruments.

5295 FUNCTIONAL RELATIONSHIP OF THE ATMOSPHERIC SPECTRUM OF ELECTRICAL DISCHARGES AND THE BIOLOGICAL ACTIVITY OF LIVING ORGANISMS. *(Rus.)* Zhgenti, T. G. (Tbilisi State Univ., Tbilisi, USSR); Kevanishvili, G. Sh. *Soobshch Akad Nauk Gruz SSR* 86(3): 617-620; 1977. (10 refs)

Calculations with respect to the spherical cell model have demonstrated that the low-frequency component of natural electromagnetic waves, when passing through living organisms are transformed into elastic vibrational energy of the membrane structure. This low-frequency electromagnetic radiation is present everywhere on earth and constitutes a direct source of mechanical energy. Such energy transfer is a necessary condition of life on Earth.

5296 CLINICAL EXPERIENCES WITH LOW INTENSITY DIRECT CURRENT STIMULATION OF BONE GROWTH. *(Eng.)* Becker, R. O. (Veterans Admin. Hosp., Syracuse, NY); Spadaro, J. A.; Marino, A. A. *Clin Orthop* (124): 75-83; 1977. (24 refs)

Over a 3-yr-period, the use of low intensity direct current stimulation of bone growth in 13 patients with a variety of non-unions and pseudarthroses is reported. In all, 17 attempts to stimulate bone

growth in 13 patients were made and included five non-unions of long bones that were non-infected, five infected long bone non-unions, and seven non-unions of joint fusions or synostosis that were not infected. Direct currents ranging from 100-200 nA/cm were applied via a pure silver wire cathode inserted directly into the non-union site and a carbon anode applied to the skin surface. Overall, 10 out of 17 attempts to stimulate bone growth were successful; on a patient basis, the success rate was 9 out of 13. Preliminary data indicate that a range of total energy from 0.6-2.5 J is maximally effective.

5297 PRELIMINARY CLINICAL EVALUATION OF THE EFFECT OF SMALL ELECTRICAL CURRENTS ON THE HEALING OF JAW FRACTURES. *(Eng.)* Masureik, C. (Dept. Maxillo, Facial and Oral Surgery, Sch. Dentistry, Univ. Pretoria, Pretoria, South Africa); Eriksson, C. *Clin Orthop* (124): 84-91; 1977. (5 refs)

A clinical investigation was conducted to evaluate the effect of small electrical currents on the healing of mandibular fractures. A group of 40 control patients were treated by the normal technique of closed reduction, while another group of 40 patients were treated with electricity in addition to closed reduction. A direct current of 10 or 20 μA was delivered through a platinum electrode to the jaw fracture site (negative electrode). The positive pole of the constant direct current generator was joined to an aluminum or copper plate, which was placed on the anterior chest of the patient to complete the circuit. The electrode was left in position for a period of 10-14 days. Out of 40 patients receiving electrical stimulation, 36 had a mobility after 2 wk that ranged from good to excellent; whereas, out of 40 control patients, 35 had poor to fair mobility after 2 wk. At 6 wk after reduction, there appeared to be little difference in mobility between controls and patients receiving electrical stimulation. Serum phosphatase and calcium were regularly measured in both groups. In electrically-stimulated patients, a decrease in serum phosphatase with time was associated with an increased healing rate.

5298 THE ELECTRICAL INDUCTION OF CALLUS FORMATION AND EXTERNAL SKELETAL FIXATION USING METHYL METHACRYLATE FOR DELAYED UNION OF OPEN TIBIAL FRACTURE WITH SEGMENTAL LOSS. *(Eng.)* Inoue, S. (Dept. Orthopedic Surgery, Gifu Coll. Dentistry, Murakami Memorial Hosp., 1-6 Wakamiya-cho, Gifu, Japan, 500); Ohashi, T.; Imai, R.; Ichida, M.; Yasuda, I. *Clin Orthop* (124): 92-96; 1977. (10 refs)

A case of a 44-yr-old man with delayed union of an open tibial fracture with segmental loss is presented in which electricity was applied to the bone defect through two screws that were connected to a methyl methacrylate skeletal fixation device. The screw closest to the fracture site was the cathode, and the other was the anode. Originally, the patient had undergone iliac bone grafting in the defect of the tibia. However, gradual resorption of the bone graft occurred. Electrical stimulation was employed; a 1.5-V battery was used to apply 20 μA of constant direct current to the tibia. The fracture developed electrically-induced callus formation around the cathode. Callus extended to the anode, and solid bony union ensued. The patient is presently walking without any external support.

5299 MODEL FOR SOME NONTHERMAL EFFECTS OF RADIO AND MICROWAVE FIELDS ON BIOLOGICAL MEMBRANES. *(Eng.)* Barnes, F. S. (Dept. Electrical Engineering, Univ. Colorado, Boulder, CO 80309); Hu, C-L. J. *IEEE Trans Microwave Theory Techniques* 25(9): 742-746; 1977. (18 refs)

A mathematic model of mechanisms by which nonthermal effects can occur in biologic materials exposed to microwave and radio frequency fields is presented. Both shifts in ion concentrations across a membrane and the orientation of long chain molecules are shown to be possible. Where a high pulsed field of 1 kV/cm in free space is incident on a high-water-content dielectric material with a membrane at a right angle to the field, ion currents of approximately 10^8 ions/sec are calculated. Since experiments on chemotaxis indicate that a few thousand molecules may be important in affecting the response of a white blood cell, it is not inconceivable that exposures at this level of the order of 10 μsec could mean significant biologic changes in the performance of a cell. At a power level of 10 mW/cm^2 and at a field strength in a high-water dielectric medium enclosed membrane of 4.4 V/cm, an ion flow of approximately 400 ions/sec is calculated for a cell with a 10^{-6}-cm^2 surface area. Therefore, to obtain 500-1,000 molecules/cell would require an exposure of a few seconds. A model for the torques applied to long chain molecules oriented in biologic materials exposed to moderate electric fields is also presented.

5300 INVESTIGATIONS ON THE EFFECT OF AN ELECTROSTATIC FIELD FREE OF RESIDUAL WAVES ON THE MOTILITY OF THE MOUSE. *(Ger.)* Fischer, G. (Hygiene-Institut, Universitat Graz, Universitatsplatz 4, A-8010 Graz, Austria). *Zentralbl Bakteriol [Orig B]* 164(5/6): 439-446; 1977. (8 refs)

The effects of electrostatic field with a residual wave component of 1% (field potential 4,500 V/m), of pure residual wave component (32 Vs/s, field strength 120 V/m/ss), and of electrostatic field free from residual waves (900 V, field strength 4,500 V/m), and of Faraday cage on the motility of 6-wk-old NMRI-Han female mice were studied in a 20-day experiment. After a 20-day adaptation period, the motility was measured by means of electric eyes in the cages, whose beams were interrupted by the moving animals. Compared with the motility measured in the Faraday cage, the motility measured in the pure electrostatic field without residual waves

was only insignificantly higher, while electrostatic field with the residual waves and pure residual wave component caused a significant increase in motility. There was no significant difference in motility between animals kept in electrostatic field without residual wave component and in those exposed to the residual wave component only. The findings suggest that the stimulating effects attributed to the electrostatic field are due to the residual wave component.

5301 LABILE INTERMEDIARY METABOLITES IN RAT BRAIN DETERMINED AFTER TISSUE INACTIVATION WITH MICROWAVE IRRADIATION. *(Eng.)* Medina, M. A. (Dept. Pharmacology, Univ. Texas Health Science Center at San Antonio, San Antonio, TX 78284). *Brain Res* 132(1): 149-152; 1977. (13 refs)

Labile intermediary metabolites in the brain were determined after exposure of male Sprague-Dawley rats to 6 kW (5.5 kW of power to the rat head) microwave radiation for a 0.6-sec period, which ensured adequate inactivation of brain tissue. A comparison of different metabolite levels in the whole brain after microwave irradiation with those reported after use of a freeze-blowing method revealed adenosine triphosphate, adenosine diphosphate, adenosine monophosphate, phosphocreatine, pyruvate, and lactate levels of 2.80 ± 0.05, 0.352 ± 0.024, 0.052 ± 0.005, 3.37 ± 0.16, 0.121 ± 0.012, and 1.26 ± 0.08 μmol/g wet weight, respectively, after microwave irradiation as compared with corresponding levels of 2.45 ± 0.05, 0.561 ± 0.022, 0.041 ± 0.001, 4.05 ± 0.07, 0.091 ± 0.001, and 1.23 ± 0.07 μmol/g, respectively, after freeze-blowing. With the exception of the lactate values, all of the other metabolite concentrations in the microwave-treated group were significantly different from those of the freeze-blown group. However, the pattern of differences was not that which would be observed under anoxic conditions as a result of incomplete enzyme inactivation by microwave irradiation. The differences are probably due to the analytical techniques employed in the different laboratories. The concentrations of metabolites in the deeper brain areas (cerebellum, medulla-pons, midbrain) were not significantly different from those observed in the more superficial cerebrum after microwave irradiation with the exception of the adenosine diphosphate value (0.515 ± 0.027 μmol/g) for the midbrain versus that for the cerebrum (0.360 ± 0.035 μmol/g). Uniform inactivation allows more valid comparison of regional substrate levels and any alteration produced by drugs or chemicals.

5302 NEUROPHYSIOLOGICAL ESTIMATES OF HUMAN PERFORMANCE CAPABILITIES IN AEROSPACE SYSTEMS. *(Eng.)* Adey, W. R. (Univ. California, Brain Res. Inst., Los Angeles, CA 90024). 143 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A038208]. (112 refs)

The effects of weak low frequency electric fields on calcium efflux from isolated chick and cat brain were studied as part of a project to determine neurophysiologic estimates of human performance capabilities in aerospace systems. Freshly isolated chick cerebral hemispheres were equilibrated with a calcium Ringer's solution containing radiolabeled calcium ion for 30 min. Washed tissue portions were then exposed to sinusoidal electric fields at either 1, 6, 16, or 32 Hz with electric gradients of 5, 10, or 56 V/m in air for each frequency over a 20-min period. Calcium efflux was then measured in 0.2 ml of supernatant and compared with efflux from unexposed control samples. A frequency sensitive tuning curve showed a sharply reduced efflux of 15-20% at 6 Hz and 16 Hz. Similar but smaller reductions occurred at 56 V/m. The threshold gradient was around 10 V/m, but insignificant trends occurred at 5 V/m. No effects were seen at 100 V/m. There are thus both frequency and amplitude windows for this effect. Cat visual, auditory, suprasylvian, and sensorimotor cortex tested at 1, 6, 16, 32, and 75 Hz also showed significantly decreased effluxes at 6 Hz and 16 Hz; nonsignificant trends were observed at all other frequencies. At 10 V/m, nonsignificant trends occurred at frequencies of 6 and 16 Hz. Oscillating extremely low frequency fields at 6-32 Hz reduce calcium efflux; whereas, it was previously shown that weak very high frequency fields, which are amplitude modulated at the same frequencies, increase efflux. Both effects can be explained by an excitation model in cerebral neurons, with longitudinal calcium binding to membrane surface macromolecules being the initial step before classic secondary transmembrane events. Initial steps in calcium binding and release would involve cooperative interactions with fixed charges on surface polyanions. Intrinsic electroencephalogram signals are sufficient to elicit these effects and may relate to a second signaling system.

5303 HUMORAL IMMUNITY OF JAPANESE QUAIL SUBJECTED TO MICROWAVE RADIATION DURING EMBRYOGENY. *(Eng.)* Hamrick, P. E. (Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709); McRee, D. I.; Thaxton, P.; Parkhurst, C. R. *Health Phys* 33(1): 23-33; 1977. (39 refs)

Fertile Japanese quail *(Coturnix coturnix japonica)* eggs were exposed to continuous wave microwave radiation at an intensity of 50 W/m^2 and a frequency of 2,450 MHz. The calculated absorbed power density was 4.03 W/kg. The eggs were exposed throughout the first 12 days of the normal 17.5-day incubation period. After hatching, exposed and control quail were reared in the conventional laboratory manner. The weights of the exposed males at the ages of 4 and 5 wk were 12 and 7%, respectively, less than those of control males. These differences approached statistic significance ($p \leq 0.05$). At 5 wk of age, the quail were challenged with sheep red blood cells (SRBC) and the levels of anti-SRBC antibodies were determined. The levels of specific anti-SRBC antibodies, determined 4 days after antigen challenge, were of the same magnitude for both exposed and control quail. Following this assessment of humoral

immunity, the quail were sacrificed and the bursa and spleen were removed for weight comparisons with controls. The weights were not altered significantly by the microwave exposure. The findings indicate that embryonic exposure under the above conditions did not impair the development of humoral immunity in juvenile quail.

5304 LIGHTNING-STRIKE DISASTER AMONG CHILDREN. *(Eng.)* Myers, G. J. (Dept. Pediatrics, Univ. Rochester Sch. Medicine and Dentistry, 601 Elmwood Ave., Rochester, NY 14642); Colgan, M. T.; VanDyke, D. H. *JAMA* 238(10): 1045-1046; 1977. (7 refs)

A lightning strike involving 47 children and counselors (ages, 3-21 yr) is described. The children had taken shelter under some trees; they were dressed in wet bathing suits or light clothing and were either barefooted or wearing sandals. A lightning bolt struck the trees, knocking 16 children to the ground. Four children required hospital admission. A 14-yr-old girl, who was standing next to a tree, suffered immediate cardiorespiratory arrest. On the third hospital day, her electroencephalogram was silent, and she died on the seventh hospital day. Autopsy revealed extensive brain softening, pulmonary edema, bronchopneumonia, a large diaphragmatic myocardial infarction, and acute fatty liver changes. A 7-yr-old girl who was rendered unconscious developed subsequent seizures and fixed postures of hyperextended arms, flexed wrists, tightly clenched hands, and rigidly extended legs. There has been little neurologic improvement and no apparent recognition of her surroundings 20 mo after the accident. A 15-yr-old girl, who showed flaccid paralysis of both legs and absent reflexes on initial examination, had recurrent fear reactions for several days. Her parparesis slowly improved, and she now walks in braces. The fourth admitted victim was a 10-yr-old boy with a small second-degree burn over his left groin and a larger first-degree burn over the right chest and abdomen. Injury from lightning may result from direct strike, side flash where the current discharges from a vertical object through the air to a nearby vertical object, or stride potential where a person standing near the point of lightning strike develops a potential difference between the legs. Immediate cardiorespiratory resuscitation of the lightning victim is the most important aspect of management. Regarding prevention, a person caught in the open with no shelter available should curl on the ground on his side with his handle close together to reduce contact points or he should squat with his feet together.

5305 EFFECTS OF NON-IONIZING RADIATION GIVEN PRIORITY STATUS BY CONGRESS. *(Eng.)* Harris, P. (Affiliation not given). *Microwaves* 16(8): 9-10; 1977. (0 refs)

The National Academy of Sciences is expected to be given a mandate by Congress during the fall of 1977 to conduct a comprehensive study of the current state of knowledge on the health effects of nonionizing radiation. Included in this study will be an evaluation of current radiation standards and a look at likely hazards of emerging technologies. The Academy is also developing a proposal to study the impact on over-the-air communications systems and on other microwave utilizing systems that would result from taking regulatory action on nonionizing radiation. A criteria document for occupational exposure to radiofrequency and microwave radiation is being planned by NIOSH; the agency is also updating an extensive bibliography of world literature on the subject. One concern of NIOSH is the possibility of cancer induction by Tacan systems. A Tacan repairman, who had been diagnosed as having carcinoma of the pancreas, recently filed for workman's compensation. An Army microwave research program is being conducted that includes investigations of frequency-dependent energy absorption in physical models, animals, and in organ-specific experiments. The Navy is conducting a probe of microwave and extremely low frequency radiation in support of its Project Seafarer Communications System. At congressional hearings, such agencies produced a consistent pattern of testimony indicating that research into nonionizing radiation is in its infancy compared with ionizing radiation research.

5306 ELEVATION IN RAT BRAIN HISTAMINE CONTENT AFTER FOCUSED MICROWAVE IRRADIATION. *(Eng.)* Hough, L. B. (Dept. Pharmacology, Univ. Michigan, Ann Arbor, MI 48109); Domino, E. F. *J Neurochem* 29(2): 199-204; 1977. (21 refs)

Male albino Holtzman rats were maintained in 12-hr light-dark cycles and were either decapitated at room temperature or subjected to microwave irradiation (1.3 kW) followed by decapitation 2-4 hr into the light cycle. The microwave radiation was focused and pulsed on the rat's head so that the rats were killed by 3-6 sec of microwave heating (brain temperature, 70-80 C). Rat brain histamine content after microwave irradiation nearly tripled in comparison with decapitated controls (124 ± 5 versus 42 ± 8 ng/g). Histamine assays at various times after decapitation revealed that histamine levels were not changed up to 30 min after decapitation and were reduced by 50% after 60 min. If brain histamine values found after decapitation represent the remainder of a rapidly depleting metabolic pool, then microwave treatment of rat brain after decapitation should not elevate the histamine content. However, the histamine content after such treatment was elevated, and histamine levels after microwave irradiation of isolated brain were indistinguishable from those in the brains of rats killed by microwave heating. If microwave treatment caused a redistribution of histamine from pellet to supernatant, the pellet produced by heating and centrifuging brain homogenates from decapitated rats should contain histamine in sufficient quantity to account for the microwave-decapitation discrepancy. However, pellets had less than 7 ng/g histamine, whether from decapitated or microwave-treated animals. Microwave irradiation did not enhance the formation of histamine after intraventricular histi-

dine administration, indicating a lack of microwave-induced histidine decarboxylation. Although the elevation in rat brain histamine after focused microwave irradiation is probably not artifactual, the mechanism responsible for this phenomenon remains obscure.

5307 MICROWAVE THERMOGRAPHY. *(Eng.)* Cronin, M. P. (No affiliation given). *Appl Radiol* 6(3): 139-140, 158-159. (0 refs)

The value of microwave thermography in detecting breast cancer was studied. Nearly 2,000 patients were examined with this method at Faulkner Hospital, Boston, over a period of 1.5 yr. A total of 26 cancers were found by microwave thermography and confirmed by biopsy. The true-positive rate of conventional infrared thermographic technique was 77%, while the true-negative rate was 68%. With microwave thermography the results were almost identical in terms of percentages, but the cases detected by the two techniques were different. When infrared and microwave thermography were combined, the detection rate rose to 96%. The basic difference between the two techniques is that microwave detectors can see down to a depth of 10 cm, as compared with only 10 μm with infrared detectors. The microwave receivers are capable of detecting temperature changes of about one-tenth of one degree. With xeromammography, the true-positive rate is 89% and the true-negative rate is 92%. However, neither thermographic method has yet been shown capable of detecting early cases of cancer.

5308 RELATIONSHIP BETWEEN THE FREQUENCY OF HYPERTONIC CRISES AND CHANGES OF THE SOLAR ACTIVITY AND THE EARTH'S MAGNETIC FIELD INTENSITY. *(Rus.)* Bardov, V. G. (A. A. Bogomolets Kiev Medical Inst., Kiev, USSR); Gabovich, R. D.; Nikberg, I. I. *Gig Sanit* (8): 111-115; 1977. (7 refs)

Correlations were studied between sunspot activity and related changes in the intensity of the earth's magnetic field and the frequency of hypertensive crises on the basis of 187,031 hypertensive crises recorded during the 1968-1973 period in the Kiev area. Diurnal distribution of the hypertensive crises was studied in 34,078 cases as a function of the astrophysical changes. No correlation was found between the sunspot activity and the frequency of hypertensive crises in data representing monthly and decade averages. However, significant correlation (a factor of about 0.2) was obtained for diurnal periods. Considerable increase was found in the frequency of hypertensive crises on days following chromospheric outbursts, which generate magnetic storms on the earth. Other parameters of solar activity showed no correlation with hypertensive reactions. Sharp increase was found in the incidence of hypertensive crises at the beginning of weak to moderate magnetic storms and on the eve of powerful to highly powerful storms, and this rise was followed by a decline. Sharp increase was seen in the frequency of hypertensive crises not only in connection with magnetic storms but also with sudden disturbances and variations of the magnetic field intensity, i.e., increases or decreases of field intensity by over 60% of the intensity on the previous day. These findings are significant for the prophylaxis and treatment of hypertensive crises.

5309 HYPERTHERMIA BY LOCAL EM HEATING AND LOCAL CONDUCTIVITY CHANGE. *(Eng.)* Guru, B. S. (Engineering Div., Universal Electric Co, Owosso, MI); Chen, K.-M. *IEEE Trans Biomed Eng* 24(5): 473-477; 1977. (7 refs)

Theoretic calculations and experiments with saline models were performed to determine the effect of local electromagnetic (EM) heating and local conductivity change on the absorbed power in a local region of a biological body. When the frequency of the EM field was in the range of 1-100 MHz, an increase in the conductivity of the local region usually caused a decrease, instead of an increase, of the absorbed power in that local region. In the microwave frequency range, the absorbed power density in the local region increased initially and then decreased as the conductivity of the local region was continuously increased. This suggests the existence of an optimum conductivity for the most effective local EM heating. However, microwave radiation will not be effective if the local region is deep inside the body because of its shallow penetration depth.

5310 THE PATHOPHYSIOLOGY OF ACUTE ELECTRIC INJURIES. *(Eng.)* Hunt, J. L. (United States Army Inst. Surgical Res., Brooke Army Medical Center, Fort Sam Houston, TX); Mason, A. D.; Masterson, T. S.; Pruitt, B. A. *J Trauma* 16(5): 335-340; 1976. (5 refs)

Animal experiments on the pathophysiology of acute electrical injuries are reported. In a pilot study with adult mongrel dogs shocked with 60-Hz alternating currents at potentials ranging from 125-1,000 V, cutaneous injury was observed at each voltage, but deep muscle injury was minimal unless 500 V or more were used. Sprague-Dawley rats were shocked with 250 V by placing electrodes to the distal end of one fore and one hind paw. The shock was continued until the current arced. An inverse relationship was observed between voltage and the time of shock application necessary for current arcing. Amperage measurements during electric shock revealed a slow initial rise followed by a rapid elevation, which peaked and then precipitously fell to zero when the current arced. Regardless of the amount of voltage, the most extensive cutaneous and deep tissue injury occurred when the animal was shocked a sufficient length of time for the current to arc. The extent of tissue injury both beneath and adjacent to the contact site was directly proportional to the surface area of the electrode. The volume of tissue transversed by the electric current was more closely related to the extent of tissue injury than the

internal resistance of the individual tissues. If the electrodes were in close enough proximity so that their spheres of heat injury overlapped, all interposed tissue in the extremity was coagulated, and the limb was mummified. The rate of tissue temperature rise paralleled the rate of increased amperage. The average preshock subcutaneous temperature was 37 C. When the shock was maintained long enough for the current to arc, tissue temperature adjacent to the contact site always exceeded 60 C. Arteriograms revealed that vascular occlusion occurred immediately at the time of injury, and there was no arteriographic evidence of delayed or progressive vascular occlusion. Although muscle injury occurred at the time of initial thermal insult, progressive or de novo muscle necrosis was not seen.

5311 CATARACTS AND AVIONIC RADIATIONS. *(Eng.)* Zaret, M. M. (Dept. Ophthalmology and Physiology, New York Univ. Sch. Medicine, New York, NY); Snyder, W. Z. *Br J Ophthalmol* 61(6): 380-384; 1977. (16 refs)

Nine cases of hertzian radiation-induced cataracts among personnel working in operational aviation environments, where they were irradiated repeatedly at subliminal nonthermal field intensities, are reported. The cases included three radar technicians, five air traffic controllers, and one airline pilot. The resultant ocular pathology evolved slowly over a period of years in a way similar to other forms of radiation injury. At the time of examination, all of the lesions had progressed to a relatively late state, exhibiting not only capsular cataract but also vesiculation and opacification of the proximal subcapsular lens substance. Histologic findings of scattered areas of degenerated lens fibers abnormally adherent to the internal edge of the capsule correlated with slit-lamp signs of honeycomb capsulopathy, the earliest clinically recognizable stage of hertzian radiation cataractogenesis.

5312 A STUDY OF THE EFFECT OF ELF ELECTROMAGNETIC FIELDS UPON *DROSOPHILA MELANOGASTER.* *(Eng.)* Bender, H. A. (Drosophila Res. Lab., Dept. Biology, Univ. Notre Dame, Notre Dame, IN). 18 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035956]. (1 refs)

Drosophila melanogaster (fruit flies) were exposed to 20 V/m (root mean square) and 2 G (root mean square) at continuous wave frequencies of 45 and 75 Hz for a period of 48 hr as part of a confirmation study to determine biologic effects of extremely low frequency electromagnetic environments. The classical Muller-5 technique for the detection of sex-linked lethals was employed to study mutation rate. The sample size was sufficient to detect a moderate as well as a strong mutagenic effect of the fields tested. No indication of a mutagenic effect was found, suggesting that such weak ELF electromagnetic fields have no mutagenic effect at least within the limits of the sensitivity of the Muller-5 technique. Sufficient dosages were not tested to demonstrate a dose-related effect.

5313 AN ECOLOGICAL SURVEY OF PLANTS EXPOSED TO ELF ELECTROMAGNETIC FIELDS. *(Eng.)* Rosenthal, G. M. (Biological Sciences Collegiate Div., Univ. Chicago, IL 60637). 42 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035958]. (0 refs)

A survey of vegetation near the antennae at the Wisconsin Test Facility was made during the summer of 1971 as part of a program to determine possible biologic effects of extremely low frequency (ELF) electromagnetic environments similar to those envisaged in the vicinity of the Navy's proposed ELF communication system (Projects Sanguine and Seafarer). The antenna array at the facility includes a 14-mile long north-south antenna and a 14-mile long east-west antenna positioned so that they cross at their midpoints. Both antennae operate at a maximum current level of 300 A in the ELF range. Since July 1969, the test facility was operated on a 5-day week, 6 hr/day test schedule at a frequency of either 45 or 75 Hz. An analysis of the vegetation survey data collected in 1971 revealed a normal pattern of species composition, species distribution, and community structure. No indication of any effect from the ELF field was noted.

5314 EFFECT OF MAGNETIC FIELDS ON YEAST CELLS. *(Ger.)* Schaarschmidt, B. (FB Biologie, Institut fur Biophysik (WE 01) der Freien Universitat, 1000 Berlin 33, Habelschwerdter Allee 30, W. Germany). *Naturwiss Rundsch* 30(10): 365-366; 1977. (33 refs)

The effects of static magnetic field (maximum intensity 6,000 A/cm) on yeast cell cultures were studied. The lowest effective dose was about 4,000 A/cm. While there was no differences from the control in dry weight, the magnetic field caused a 12% reduction in the number of yeast cells, which had increased weight and volume. The magnetic field increased the aerobic metabolism by 20% and the anaerobic metabolism by 15%. No dose-effect relationship was established. Previous exposure to the magnetic field had no influence on the inactivation of the yeast cells by x-rays, but the reactivation rate was considerably higher than in the culture not exposed to the magnetic field. Exposure to the magnetic field following the x-ray exposure had no influence on reactivation.

5315 USE OF SUPER-HIGH FREQUENCY TO HEAT UP DEEP-FROZEN ERYTHROCYTES. *(Rus.)* Zaliubovskaia, N. P. (I. I. Mechnikov Kharkov Inst. Microbiology, Vaccines and Sera, Kharkov, USSR); Kiselev, R. I.; Deviatkov, N. D. *Probl Gematol Pereliv Krovi* 22(8): 56-57; 1977. (0 refs)

The biochemical effect of thawing deep-frozen erythrocytes by high-energy magnetron radiation (600 W, 2,400 MHz) was studied. The erythrocytes were deep-frozen in polyethylene oxide (molecular weight of 4,000) to -196 C at a rate of 40 C/sec and were stored at -196 C for 0.5-24 hr before thawing. Erythrocytes deep-frozen in the same manner but thawed in water bath at 40 C in 40-50 min were used for control. The high frequency thawing took 40-60 sec. After high-frequency thawing the free hemoglobin (Hb) level was 432 mg% vs. 340 mg% in the control, and the electrophoretic mobility was 1.17 ± 0.003 μsec/V/cm vs. 1.21 ± 0.002 μsec/V/cm in the control. There were no differences between the erythrocytes thawed by high-frequency radiation and the control in Hb fractions, adenosine triphosphate concentration, and glycolytic activity of the erythrocytes, nor in erythrocyte vitality. The findings indicate the suitability of this method for thawing deep-frozen erythrocytes; however, the field intensity should be increased to 800-1,000 W to minimize the thawing time.

5316 CURRENT PROBLEMS OF THE BIOLOGICAL EFFECT OF MICROWAVES. *(Rum.)* Vasilescu, C. (Laboratorul de biofizica, I.M.F., Bucharest, Romania); Zaciu, C. *Rev Ig [Pneumoftiziol]* 26(1): 75-80; 1977. (17 refs)

Studies on the biological effects of microwaves are reviewed. While millimeter waves are absorbed by the superficial layers of the skin, the depth of penetration of centimeter waves is 2-4 cm, and that of decimeter waves is even more. Exposure to high-intensity microwave fields causes hyperthermia, which may be fatal to animals under certain circumstances. Exposure to low-intensity microwave radiation causes reversible morphologic and physiologic changes in experimental animals (cutaneous nerve fiber changes, fine structural changes in the brain cortex, manifesting in a depression of the conditioned reflexes and reduced sensitivity to auditory stimuli, and degenerative changes in the parenchymatous organs). Long-term exposure (more than 12 mo) may produce irreversible changes.

5317 PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS FOLLOWING TWO LONG-TERM EXPOSURES OF MICE TO MICROWAVE FIELDS (Meeting Abstract). *(Ger.)* Koessler, F. (No affiliation given); Lange, F.; Kupfer, J.; Rothe, R. *Z Gesamte Hyg* 23(4): 250; 1977. (0 refs)

The physiologic and biochemical effects of exposure to microwave fields (2 mW/cm^2, 6 hr/day, 9 or 12 wk) were studied in mice. The investigation of the spontaneous motor activity showed a training effect both in the control group and in the exposed group, but it was more pronounced in the latter. The hemoglobin levels showed a slight decline in the control, but they remained constant in the exposed groups. Exposure for 9 or 12 wk had no effect on the body weight, erythrocyte and leukocyte counts, blood sugar level, differential blood picture, electrophoresis, total oxalate transaminase and creatine phosphokinase. The findings indicate that the exposure had no deleterious effect on physiologic and biochemical parameters.

5318 IMPROVING THE THERAPEUTIC EFFECT OF INDUCTOTHERAPY OF THE LUMBAR REGION IN DERMATOLOGY. *(Rus.)* Skripkin, Iu. K. (Dept. Dermatology and Venerology, N. I. Pirogov Second Moscow Medical Inst., Moscow, USSR); Borisenko, K. K.; Korotkii, N. G. *Sov Med* (7): 67-71; 1977. (17 refs)

The effectiveness of inductothermia (15.56 MHz, 150-200 μA, 10-20 min qod, 10-20 sessions) was studied in 48 patients with psoriasis and 32 patients with lichen planus. All patients received dopegyt (2x ½ tablets/day) starting on the day before the initiation of inductothermia, and 19 patients also received reserpine and raunatin (1-3 tablets/day). Clinical effect was observed usually after the first 3-5 sessions, manifesting in considerable alleviation of pruritus, of inflammation, and of neurotic symptoms, and in an improvement of the general condition of the patients. Clinical cure and considerable improvement was seen in 56 patients; improvement in 21. Inductothermia was suspended in three patients due to pyoderma.

5319 EFFECT OF ELECTRICAL STIMULATION OF THE BLADDER NERVE IN THE NEURON–CAPILLARY RELATION IN THE BLADDER GANGLION IN FROGS. *(Rus.)* Pastukhov, V. A. (Lab. Morphology of the Central Nervous System, I. P. Pavlov Inst. Physiology, USSR Acad. Sciences, Leningrad, USSR). *Fiziol Zh SSSR* 63(8): 1206-1209; 1977. (7 refs)

The effect of pulsed electrical stimulation (10 or 70 impulses/min, pulse time 0.5 msec, amplitude 10 V, length of stimulation 15 min) of the vesical nerve of *Rana temporaria* was studied, and the relationship between neurons and capillaries investigated. Both high-frequency and low-frequency stimulation caused significant increase of the capillary lumen after a temporary reduction. The diameter of the capillaries and the volume of the neuron increased in most cases, leading to an increased capillary-neuron contact surface or to the reduction of the distance between the capillaries and neurons. Shrinkage of the neuron and increase of the distance between neurons and capillaries were seen in some cases following high-frequency stimulation.

5320 ENERGY FLUX ALONG HIGH VOLTAGE TRANSMISSION LINES. *(Eng.)* Hart, F. X. (Dept. Physics, Univ. South, Sewanee, TN 37375); Marino, A. A. *IEEE Trans Biomed Eng* 24(5): 493-495; 1977. (2 refs)

A mathematic calculation of the ground level energy flux profile of a modern three-phase extremely high-

voltage overhead transmission is presented. The method of images was used to find the electric field of the conductor distribution as well as the magnetic field. A graphic analysis of the average Poynting vector as a function of distance from the center line for a proposed Pannell Road-Sterling-Volney 765-kV transmission line revealed that the extremely low frequency (ELF) energy flux does not decrease to the level of the United States microwave exposure standard (10 mW/cm^2) until about 108 m from the center line. The corresponding distance for the Soviet microwave exposure standard (0.1 mW/cm^2) is about 210 m. While the United States microwave standard is based exclusively on physiologic considerations involving tissue heating, the Soviet microwave protection level postulates other possible mechanisms. The extent to which such mechanisms are also operative at a frequency of 60 Hz and the existence of mechanisms peculiar to the ELF region are both presently undetermined.

5321 A REPORT ON THE PROBLEMS OF THE DANGERS INVOLVED IN THE AREA OF ELECTROMAGNETIC RADIATION. *(Ger.)* Potschkat, G. (Institut fur Rundfunktechnik, Munich, W. Germany); Kienast, D. *Rundfunktechnische Mitteilungen* 21(3): 97-107; 1977. (13 refs)

Theoretic and model studies of the possible dangers of electromagnetic radiation in the vicinity of high-power transmitters are described. In electromagnetic fields, voltage can be induced between a conductive object and ground, as well as between sections of the conductor. Depending on the field intensity, the induced voltage can be high enough to cause skin burn and electric shock upon contact. Model tests simulating moving objects (motor vehicles) revealed that the induced voltage in the vehicle reaches 20 V at frequencies of up to 1 MHz and a reference field potential of 10 V/m. At similar reference field potentials, the maximal active power calculated was 675 mW for frequencies of 10 MHz and 57 mW for 1 MHz.

5322 INTRODUCTION. *(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. (1) 1-7; 1977. (19 refs)

An introduction to a scientific literature review on the effects of electric and magnetic fields in the extremely low frequency range (0-300 Hz) is presented. Emphasis in the review is placed on 50 and 60 Hz electric fields, which cover the range of exposure near electric power transmission lines (several thousand V/m and magnetic fields less than 1 G) and fields of the same frequencies, which are typical of exposures from electric appliances and machinery (less than a few hundred V/m and magnetic fields greater than 1 G). The literature reviewed in the report involves diverse biologic systems, various methods of electric or magnetic field exposure, and many different responses. Although there are cases where independent investigators have come to similar conclusions (for example, implying the importance of the extended cell membrane or discovering effects on the central nervous system), the overall picture remains incoherent. In part, the problem results from important differences in experimental design, which prohibit direct comparisons of the findings of different investigators. More work of high quality is required to augment the evidence that has resulted from several outstanding experimental inquiries.

5323 ENVIRONMENTAL EXPOSURES. *(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 (3) 1-9; 1977. (15 refs)

Environmental exposure to natural and man-made electric and magnetic fields in the extremely low frequency range is discussed. At a frequency of 50-60 Hz, the electric field of the natural background is of the order of 10^{-4} V/m and the natural alternating current magnetic background is about 10^{-8} G. Man-made fields are stronger than those of natural origin by many orders of magnitude. Typical 60-Hz fields vary from 3×10^{-3} V/m in rural areas to 10^{-1} V/m outside an electrified building to 10^{-1}-10^{-2} V/m near electric appliances. Persons spending much time near high voltage equipment or working for power companies maintaining such equipment may be acutely exposed for several days a week to fields of several thousand V/m. Typical values for ambient 60-Hz magnetic fields range from about 10^{-3} to about 10 G, depending on proximity to appliances. Stronger magnetic fields occur near large magnets, electrical furnaces, or other equipment using high currents. The potential use of cryogenic or superconducting transmission facilities would introduce another localized source of strong magnetic fields.

5324 SPECIAL TOPICS. *(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. (8) 1-32; 1977. (91 refs)

Special topics dealing directly or indirectly with the biologic effects of electric and magnetic fields in the extremely low frequency range are presented. The topics covered include the electric properties of cell contact membranes, the production of cataracts with electrical energy, the biologic effects of air ionization, surveys of persons exposed to high-voltage transmission lines, electric field effects on plant life, magnetic fields in the human body, the orientation of deoxyribonucleic acid in a magnetic field, the biologic effects of large magnetic fields (100-100,000 G), proposed mechanisms for the biologic effects of magnetic fields, the regulation of electric field exposure in the Soviet Union, and the development of regulations for magnetic field exposures in the United States and the Soviet Union.

5325 BIOPHYSICAL PRINCIPLES AND A BIOPHYSICAL DESCRIPTION OF EXPOSURE TO 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 (4) 1-28; 1977. (37 refs)

Biophysical relationships associated with exposure to extremely low frequency electric and magnetic fields are discussed. Topics covered include energy density in electric fields; dielectric properties and conductivity of biologic materials; electric field distortion by human bodies; electric fields inside the body; power loss inside the body; current flow into cells; cell size, shape, and membrane potential in an electric field; electrostatic induction; human capacitance; discharge effects; electrophoresis and dielectrophoresis; electromagnetophoresis; problems in dosimetry; and electric shock currents. When a body is placed in an external alternating current electric field, currents flow through the body, and the current density is uniform to the extent that the body is uniform. The interior electric fields necessary only to drive the interior current are smaller than the external field impinging on the surface of the body. The original field is distorted, and the fields at the body surface may be intensified several fold depending on the shape, position, and orientation of the particular surface. Reasonable estimates of the properties of cell membranes and the division of current between the cell and the surrounding solution show that only a small fraction of the current passes through the cell membrane so that the cell membrane potential is virtually unchanged by any reasonable external currents or fields. If there is an effect directly on the cell membrane, it must occur by means more subtle than a direct effect on the cell membrane potential. Moderately strong magnetic fields can cause circulating currents in the body comparable in magnitude to those induced by strong electric fields. The magnitude of currents induced by a magnetic field depends on the size of the current loop. For a circuitous path encompassing the dimensions of the body, the current density is greatest; whereas, over a very small volume in the body, the induced current density is very small. Because the magnetic permeability of living beings is essentially the same as for free space, the body appears transparent to magnetic fields. Therefore, the field is not perturbed, and all parts of the body experience the same field.

5326 SUMMARY. *(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. (2) 1-37; 1977. (75 refs)

A summary of a review on the biological effects of electric and magnetic fields in the extremely low frequency range is presented. Topics covered include electric and magnetic fields in the environment, fields in the body, fields involved in normal biologic functions, the effects of external fields on animals and humans (neurophysiological and behavioral, biochemical, clinical, physiological and behavioral, and reproductive), and the effects of strong external magnetic fields on biological systems. A long history of industrial experience with electric fields indicates that intermittent exposure to even the strongest of such fields has no obvious effect on health or sense of well-being, even after years of repeated exposure; however, this observation must be tempered by the fact that there has been no full scale epidemiologic study of utility workers. Compared with electric fields, magnetic fields associated with electrical currents may be an environmental factor of equal or greater importance. As with electric fields, a long history of exposures to magnetic fields of 50-60 Hz suggests that no obvious risks are associated with acute exposures to fields of moderately great strength (below 100 G); however, no scientific study among persons regularly exposed supports this observation. Evidence from human experimental investigations suggests that there may be biologic effects of uncertain significance at fields as low as 1 G. One firm conclusion that emerges from a review of of the existing literature on extremely low frequency electric and magnetic fields is that relatively weak fields of this type are capable of evoking neurophysiological or behavioral effects. This is suggested by behavioral experiments on monkeys, biochemical studies on the calcium efflux in brain tissue, the experience of Soviet substation workers exposed to electric fields and the experience of other industrial workers exposed to magnetic fields, and by preliminary evidence for both electric and magnetic effects on the steroid hormones in animals.

5327 INTERNATIONAL TRENDS IN ELECTROMAGNETIC RADIATION BIOEFFECTS RESEARCH (MEETING ABSTRACT). *(Eng.)* Dodge, C. H. (Science Policy Res. Div., Library of Congress, Washington, DC 20840); Zorach, G. R. *J Microwave Power* 12(1): 41; 1977. (0 refs)

The international literature (circa 1970-1975) on biologic and clinical phenomena associated with exposure to microwave and radio frequency electromagnetic fields (EMFs) is reviewed. Mechanisms by which EMFs exert their biologic effects are becoming better understood as investigative technology and methodology improve. Some recent evidence in the West supports Soviet and East European claims that EMFs can affect nervous system function and morphology in small mammals, birds, and invertebrates at power levels below those defined as thermogenic in the West. These experimental findings coupled with the pressure of public opinion may eventually lead to the establishment of revised occupational exposure limits and concurrence regarding maximum permissible exposures. At present, the level established in the Soviet Union is 0.01 mW/cm^2 for a work day, while the United States adheres to 10 mW/cm^2 averaged over 0.1 hr. However, Russian and East European reports of psychophysiologic dysfunctions and impairment of a reversible nature as a result of chronic exposure to EMFs of relatively low power density (<10 mW/cm^2, and occasionally <1 mW/cm^2) have not been

corroborated in the West. Additionally, there is no evidence to support speculation that modulated EMFs can be used to remotely control human behavior. Interaction between the concerned research and development communities in the East and West has increased substantially in the 1970's. Such interaction may enable resolution of differences in doctrine, experimental methodology, protocol, and the interpretation of biologic and clinical phenomena.

5328 EFFECTS OF ELECTRICAL FIELD STIMULATION ON ION TRANSPORT BY RABBIT ILEUM IN VITRO (MEETING ABSTRACT). *(Eng.)* Hubel, K. A. (Dept. Medicine, Univ. Iowa, Iowa City, IA). *Gastroenterology* 72(5, Part 2): 1072; 1977. (0 refs)

The effect of electric field depolarization of nerves on ion transport was studied in the intrinsic plexus of full thickness rabbit ileum mounted in a flux chamber. Unidirectional fluxes (μEq/hr/cm^2) of ^{22}Na, ^{36}Cl, potential difference (mV), and short circuit current (SCC, μA/cm^2), measured during a 20-min control period, were contrasted with measurements made during a 20-min period of stimulation with current passed parallel to the mucosa for 30 sec of each min as a bipolar square wave of 10 Hz, 600 μsec duration, 600 msec/sec train. A second control period followed. The SCC increased, Cl was secreted, and the net flow of Na across the jejunum did not change significantly ($p<.05$). Cl was secreted because serosal to mucosal flow of Cl across the jejunum rose. To assess whether the changes were neurally mediated, tetrodotoxin (TTX, 10^{-7} M) was added to the bath fluid. TTX alone reduced the SCC and prevented the changes in Cl flux and SCC caused by electric stimulation. TTX did not prevent the increase in SCC caused by adding glucose to both sides of the mucosa, or the reduction in SCC caused by epinephrine (10^{-5} M). Electrical stimulation did not increase SCC when only muscularis was mounted, suggesting that the increment in SCC was not caused by ions moving passively in response to an asymmetric electric field. It is concluded that stimulation augments the SCC by increasing serosal to mucosal flow of Cl across the jejunum. The low concentrations at which TTX affects SCC (10^{-7}-10^{-10} M) suggests that nerves mediate the response. TTX may affect liberation of hormones by paracrine or endocrine cells, or the transport of epithelial cells directly. If the latter is true, TTX does not affect ion transport systems that are sensitive to glucose or to epinephrine.

5329 POWER DENSITY ZONES IN THE VICINITY OF RADAR ANTENNAS (MEETING ABSTRACT). *(Eng.)* Plavcic, Z. (Coll. Aeronautical Engineering, Zagreb Airport, 41 150 Zagreb, Yugoslavia). *J Microwave Power* 12(1): 44; 1977. (0 refs)

To evaluate potential radiation hazard in the vicinity of powerful radar stations, calculations of power density around the antenna were performed. As a representative, a surveillance Radar LR-23 used in air-traffic control was examined. The radar peak power was 2.2 mW, the average power 2.64 kW, and the wavelength 23 cm. As a radiator, a reflector type antenna of high gain (36 dB) was employed. The space around the antenna could be divided into two regions. The near-field or Rayleigh region extended to the distance $R = 0.3\ D^2/\lambda$, where D was the vertical dimension of the antenna and λ, the wavelength. In this region the power density on the antenna axis was constant and equal to $16P/\pi D^2$, where P was the transmitted power. For the evaluated radar, the near-field region extended to 106 m and the maximum average power density was 16.6 mW/cm^2. The power densities at various distances from the antenna in the far/field region also were calculated. The calculated values agreed with the experimental results. It is concluded that there is no radiation hazard in the areas accessible to the public, but special safety measures should be taken by maintenance and repair personnel working in close proximity to the operating radar antennas.

5330 MICROWAVE HYPERTHERMIA, CHEMOTHERAPY, AND CO-60 RADIATION IN THE TREATMENT OF HAMSTER MELANOMA (MEETING ABSTRACT). *(Eng.)* Traub, R. J. (Sch. Pharmacy and Pharmacal Sciences, Purdue Univ., West Lafayette, IN 47907); Vetter, R. J.; Stoetzel, G. A. *J Microwave Power* 12(1): 40; 1977. (0 refs)

The effect of microwave hyperthermia alone and in combination with ^{60}Co radiation and a cytotoxic agent, *p*-fluorophenylalanine (PFP), on tumor growth rate and mortality in hamsters was investigated. Approximately 10^6 amelanotic melanoma cells were injected subcutaneously in the rear flank of golden hamsters. On the average, tumors reached a volume of 1 cm^3 10 days after injection. In all cases, animals were treated every other day for five treatments. Animals received a low temperature microwave treatment (2.450 MHz, 42-43 C for 12 min), high temperature microwave treatment (2.450 MHz, 44-47 C for 12 min), 25 mg/100 g PFP intraperitoneally, or sham microwave exposure (control). Microwave treatments were applied locally, and temperatures were measured immediately after treatment in the approximate center of the tumor. Preliminary observations revealed that the growth characteristics of the control tumors fit the typical sigmoidal growth curve. The tumor growth patterns in the PFP treated animals were similar to those of controls except the growth rate was slightly accelerated following the final PFP injection. The increased growth rate may have been due to toxicity of the PFP. The microwave treatments significantly disrupted the growth pattern of the tumors. Experiments on the synergistic action of all three agents are in progress.

5331 MORPHOLOGIC ALTERATIONS IN HAMSTER BLOOD-BRAIN BARRIER AFTER MICROWAVE IRRADIATION (MEETING ABSTRACT). *(Eng.)* Albert, E. N. (George Washington Univ. Medical Center, Washington, DC); Grau, L.; Kerns, J. *J. Microwave Power* 12(1): 43-44; 1977. (0 refs)

The morphologic effects of microwave irradiation on the blood-barrier of adult Chinese hamsters were investigated. The hamsters were divided into sham-irradiated control and irradiated experimental groups. Experimental animals were exposed to 2,450 MHz at 10 mW/cm^2 for 2-8 hr. Immediately following exposure, the animals were anesthetized with nembutal and injected with horseradish peroxidase via the femoral vein. Five min later, they were fixed by vascular perfusion with 1% paraformaldehyde- 1.25% glutaraldehyde and stored in situ overnight at 4 C. The brains were dissected and incubated with 3-3' diaminobenzidine and hydrogen peroxide in Tris-HCl buffer, which formed a reaction product with the horseradish peroxidase. Tissues were subsequently post-fixed in osmium tetroxide, dehydrated, and embedded in Epon-Araldite. Alterations in the blood-brain barrier were recognized by locating regions of leadage in the microvasculature. Brown reaction product was visible at the gross and light microscopic level and appeared as electron dense material at the electron microscopic level. In control animals, extravascular reaction product was present only in brain regions normally lacking a blood-brain barrier (i.e., area postrema, pituitary, median eminence, and chorold plexus). In contrast, experimental animals showed extravasated reaction product in additional brain regions (i.e., cerebral cortex, hippocampus, thalamus, hypothalamus, cerebellar cortex, and medulla). At the ultrastructural level, horseradish peroxidase reaction product was present in the basal lamina of brain microvasculature and in the extracellular spaces around affected vessels. The effects may have been due in part to alterations in tight junctions in the capillary endothelium, which normally maintain the blood-brain barrier. Some glial cells contained reaction product in their cytoplasm, but this was not observed in neuronal cell bodies, dendrites, or axons. These observations suggest that the normally impermeable brain microvasculature can be rendered permeable to various degrees by microwave irradiation.

5332 HUMAN PERCEPTION OF MODERATE STRENGTH LOW FREQUENCY MAGNETIC FIELDS. *(Eng.)* Tucker, R. D. (Ph.D. dissertation, Univ. Minnesota, 1976); 106 pp. (available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-19,068). (27 refs)

Studies designed to determine whether subjects deprived of clues incidental to the generation of a magnetic field can successfully sense, or be taught to sense, the presence or absence of either uniform or gradient 60-Hz moderate strength magnetic fields are reported. Two different sets of Helmholtz coil systems were used for the experiments. A large coil system was capable of providing a uniform magnetic field (7.5 G root mean square, RMS) or field gradient (13 G RMS/m) in a man-sized space. The second or small coil system produced a uniform field (15 G RMS) or field gradient (70 G RMS/m) that was approximately head-sized. The experiments were conducted under both nonisolated and isolated conditions to determine the possible effects of auditory vibrational clues on the subjects' responses. The results are interpreted as being compatible with either of two conclusions. The human subject may have a very weak sporadically-appearing ability to perceive magnetic fields, which is not strongly exhibited in any one individual or in any one series of tests. Alternatively, the subject may have no real field perception at all but is able over a long series of trials to get traces of mechanical, acoustical, or other undetermined clues that cannot be eliminated completely by isolation design. In both conclusions, the trace effects do not indicate an immediate health hazard.

5333 MICROWAVE HEATING EFFECT ON THE DOG THYROID GLAND. *(Eng.)* Magin, R. L. (Lab. Chemical Pharmacology, Div. Cancer Treatment, Natl. Cancer Inst., Bethesda, MD 20014); Lu, S-T.; Michaelson, S. M. *IEEE Trans Biomed Eng* 24(6): 522-529; 1977. (31 refs)

Dog thyroid glands were exposed in vivo to 2,450-MHz continuous wave microwave fields for 2 hr using a dielectrically-loaded waveguide applicator. Specific absorption rates of 58 ± 24, 131 ± 44, and 190 ± 45 W/kg in the center of the thyroid gland resulted in temperatures of 38-39 C, 40-42 C, and 44-46 C, respectively. Thyroid glands heated to 38-39 C showed a step-type increase in thyroxine release rate to twice equilibration period values. Thyroid glands heated to 40-42 C and 44-46 C showed peaks in thyroxine release rate after 50 min into the exposure period, which amounted to three times the equilibration period value for thyroid glands heated to 40-42 C and six times the equilibration period value for thyroid glands heated to 44-46 C. After these peaks, the thyroxine release rate fell for the remainder of the exposure period. The triiodothyronine release rate followed that of thyroxine for all temperature ranges tested. Unheated control thyroid glands maintained a temperature between 36-38 C and did not show significant increases in hormone release rate. A plateau in hormone secretion rate observed for thyroid glands heated to 38-39 C indicates continuous stimulation, showing a general increase in the gland's metabolism probably due to heating.

5334 MICROWAVE OVEN IRRADIATION AS A METHOD FOR BACTERIAL DECONTAMINATION IN A CLINICAL MICROBIOLOGY LABORATORY. *(Eng.)* Latimer, J. M. (Dept. Pathology and Pediatrics, Univ. Utah Coll. Medicine, Salt Lake City, UT 84132); Matsen, J. M. *J Clin Microbiol* 6(4): 340-342; 1977. (4 refs)

The use of microwave oven irradiation for bacterial decontamination in clinical microbiology laboratories was investigated. The exposure of 10 frequently isolated clinical pathogens to 2,450-MHz microwave irradiation resulted in total sterilization within 60 sec. Whereas, a vegetative culture of *Bacillus subtilis* showed no viable organisms after a 30-sec exposure to microwave irradiation, the time necessary to destroy 1.3×10^9 *B. subtilis*

spores/ml extended beyond 11 min. Exposure of *Bacillus stearothermophilus* strips to microwave irradiation resulted in sterilization after 5 min. Clinical isolates (including *Escherichia coli*, *Proteus mirabilis*, *Pseudomonos aeruginosa*, *Serratia marcescens*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, and enterococcus) were killed by a 5-min exposure to microwave irradiation. Exposure of contaminated petri plates to microwave irradiation resulted in total sterilization within 5 min. The above data indicate that the utilization of microwave ovens for bacterial decontamination in clinical microbiology laboratories is entirely feasible.

5335 ELECTROMAGNETIC POWER DEPOSITION IN PROLATE SPHEROID MODELS OF MAN AND ANIMALS AT RESONANCE. *(Eng.)* Barber, P. W. (Dept. Bioengineering and Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *IEEE Trans Biomed Eng* 24(6): 513-521; 1977. (15 refs)

The Extended Boundary Condition Method is used to calculate electromagnetic power deposition in prolate spheroid models of animals and man. The mathematic models consisted of homogeneous distributions of muscle tissue, although in the case of the human model calculations, a model consisting of homogenized muscle, fat, and bone was also considered. Calculations were made for bodies isolated in free space and irradiated by a plane wave. In general, three particular incident waves were considered—one from the end-on direction and two from the broadside direction. In the case of the human model, a resonant frequency of about 70 MHz was predicted for a 6.34:1 prolate spheroid muscle tissue model; the corresponding absorption efficiency was 3.7. For a human model of average homogenized tissue, the resonant frequency increased slightly, and the absorption efficiency increased to 4.6. A graphic representation of the average power absorption as a function of normalized dielectric constant (normalized to the dielectric constant of muscle tissue) for a 6.34:1 prolate spheroid muscle tissue man model due to an E-parallel broadside incident wave is presented. Over frequencies ranging from 10-70 MHz, it is suggested that it is more reasonable to use a dielectric constant for homogenized tissue than for muscle tissue alone. This is especially true at frequencies in the high frequency range where the curves are steeper than in the very high frequency range. At 10 MHz, for example, about 30% more power absorption would be expected for a model of homogeneous tissue than for one of muscle tissue.

5336 EFFECT OF 2,450 MHZ MICROWAVE RADIATION ON MICROORGANISMS. *(Eng.)* Wu, J. F. (Ph.D. dissertation, North Texas State Univ., 1977); 134 pp. (available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-19,694). (169 refs)

The effect of 2,450-MHz microwave radiation over a wide dose range on soil microflora was studied under laboratory and field conditions. Radiation and thermal profiles showed that heterotrophic bacteria, spore-forming bacteria, fungi, and actinomycetes were not affected by exposure to a net microwave radiation input of 1 kW intensity over periods ranging from 0-80 sec. Nitrogen-fixing bacteria and nitrifying bacteria were also resistant to these doses. Soil microorganisms were inactivated by exposure to 1 kW of continuous microwave radiation over periods ranging from 80-480 sec. Resistance to microwave radiation was primarily associated with the degree of moisture content of the microorganism. The radiation appeared to leave no residual effect in the soil, and the microwave-induced effects on microorganisms seemed to be nonselective; the one exception was that fungi appeared more susceptible to microwave-induced inactivation. A heat-shock activation of microbial spores was observed during the experiments. The data imply that microwave treatment of agricultural fields for the purpose of killing weed seeds and insects has no effect on the soil microorganisms. Studies of the relationship between temperature generated in dry and wet organisms and the pattern of destruction of inoculated bacteria by microwave radiation revealed that inactivation was a function of cell hydration. Bacterial cells do not absorb microwave energy; the lethal effect of microwaves is due to direct energy transfer to cell water and to the temperature increase of the suspending medium.

5337 BIOLOGICAL EFFECTS OF X-BAND MICROWAVE IRRADIATIONS ON *E. COLI*. *(Eng.)* Hsieh, S. T. (Ph.D. dissertation, Tulane Univ., 1974); 155 pp. (available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 77-19,503). (65 refs)

Theoretical and experimental studies on the interaction of X-band microwave radiation with cellular metabolic systems under isothermal conditions are reported. Theoretic analysis derived a modified growth rate equation based on a spherical cell model of *Escherichia coli*. The aerobic growth rate was modified to include localization of the *E. coli* respiratory enzymatic system. With this model, an interaction analysis with electromagnetics predicted a radio frequency diffusion mechanism, which interfered with the cellular metabolism of *E. coli*. Other mechanisms, such as, radio frequency transport and induced membrane potential, were also implied. The incorporation of radio frequency diffusion effects with modified cellular growth predicted microwave-induced nonthermal effects on cellular respiration. Experiments with *E. coli* cultures, which were exposed to long-term, low-intensity X-band microwave radiation, were performed to verify the theoretic predictions. The cultures were incubated and exposed to microwave frequencies ranging from 7-12 GHz at power levels of 100, 60, 30, and 5 mW (or less). Microwaves consistently had definite effects on the deceleration growth phase of the cultures in the absence of temperature changes. A mathematic analysis of the experimental growth curves showed the frequency

response of such observed growth effects to be in good agreement with the theoretic predictions.

5338 EFFECT OF MICROWAVE ON STEROIDS PLASMA LEVELS IN MALE RATS (MEETING ABSTRACT). *(Eng.)* Deschaux, P. (Laboratoire de Physiologie Cellulaire, Universite Claude Bernard 69621, Villeurbanne, France); Pelissier, J. P. *J Microwave Power* 12(1): 46-47; 1977. (0 refs)

The effects of microwaves on steroid plasma levels in male Sprague Dawley rats (C.D. strain) were studied. The animals (60 days old) were irradiated by microwaves (2,450 MHz) for 24 hr. After irradiation they were divided into four groups of five; controls were treated similarly without radiation. At sacrifice (10 min [1st group], 3 days [2nd group], 8 days [3rd group], and 15 days [4th group]), the rats were decapitated in an adjacent room within 15 sec after removal of their case. Systematic blood was collected, centrifuged, and the plasma was removed and stored at -20 C until assayed. Testosterone was determined by radioimmunoassay. The plasma samples were extracted with ether, and the dried extract was chromatographed on a cellite column to separate the dihydrotestosterone from testosterone. Plasma corticosterone level was determined by competitive binding radioassay. The plasma testosterone level was significantly higher in animals until 8 days (at 3 days $p \leq 0.05$; at 8 days $p \leq 0.1$); at 10 min and 15 days there was no significant difference. The plasma corticosterone level was significantly modified by microwave irradiation in the first 3 min. It is concluded that microwaves have specific receptors on particular organs in the organism.

5339 BOLUSING TECHNIQUE FOR BATCH MICROWAVE IRRADIATION OF TUMORS IN THE FAR FIELD (MEETING ABSTRACT). *(Eng.)* Cheung, A. Y. (Univ. Maryland Sch. Medicine, Baltimore, MD 21201); McCulloch, D.; Robinson, J. E.; Samaras, G. *J Microwave Power* 12(1): 42-43; 1977. (0 refs)

A technique for batch irradiation of superficial tumors in mice for microwave-induced hyperthermal cancer therapy was developed. Tumor-bearing mice were enclosed individually in a shield, with the tumor drawn through a slot for placement in the microwave heating field. To achieve replicable and uniform heating in the tumor, it was encapsulated in a much larger (60 g) "bolus" of tissue-equivalent material. For the size of bolus used (5 cm diameter of simulated brain) microwave energy deposition was peaked at a central site where field gradients were small. When a tumor was encapsulated at this site, steady state heating was uniform to within ± 0.1 C at 45 C. When unencapsulated, the tumor was difficult to heat due to poor field coupling and temperature was grossly non-uniform (± 1 C at 40 C). For batch irradiation, a standardized bolus geometry enabled heating to be nearly independent of tumor size, provided that the mass of the bolus was much larger than the mass of the encapsulated tumor and the tumor-bolus system was on an equipower surface in the far-field. Simultaneous microwave treatment of up to 12 animals with encapsulated tumors was possible by exposing the animals on equal power density contours in a 2.5 x 2.5 x 2.5 m anechoic chamber. The animals were spaced 2 wavelengths apart and confined to a far-field area approximately 1 m^2. One site was reserved for a range calorimeter to monitor temperature.

5340 INTERDISCIPLINARY AND INTERNATIONAL CONTRIBUTIONS TO ELECTROMAGNETIC BIOLOGICAL-EFFECTS RESEARCH: PAST PERFORMANCE AND CHALLENGES FOR THE FUTURE. *(Eng.)* Johnson, C. C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 2; 1977. (0 refs)

Interdisciplinary and international contributions to electromagnetic biologic effects research are highlighted. Teams of biologists, physicists, and engineers have developed a variety of small nonmetallic thermal sensors for measuring tissue temperatures during electromagnetic radiation. Major progress has been made in investigating with precision the absorption of electromagnetic energy in models of animals and man at different frequencies and orientations. A region of "resonant" absorption has been identified near 70 MHz for the case of man exposed to a polarized field in free space. Extrapolation from data on animals to man is now possible, allowing specifications to be made of fields that will produce comparable effects in man. In Western countries, notable achievements have been made in research on thermal effects, instrumentation, and dosimetry, and Eastern countries have pioneered in and emphasized studies of long-term low-level irradiation, basic biologic mechanisms, behavioral and central nervous system functions, and epidemiologic phenomena. The establishment of interdisciplinary research teams and the availability of new engineering tools and techniques will enable identification of hazardous interactions, discovery of basic mechanisms, extrapolation of infra-human data to man, and development and extension of medical applications of electromagnetic energy.

5341 SOME PERSPECTIVES ON RESEARCH INTO THE BIOLOGICAL RESPONSE TO NON-IONIZING ELECTROMAGNETIC RADIATION. *(Eng.)* Sharp, J. C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 3; 1977. (0 refs)