Impulse photolysis produced by a UV light source generating impulses with a 2-nsec period and a 340-nsec wavelength was used for this study. In a 1 molar (M) aqueous solution of serum albumin transformed to a 0.1 M NaCl solution, a magnetic field (10-50 kOe) increased the effectiveness of hydrated electron recombination with ion radicals by 1.5 ± 0.2%. The influence of the magnetic field on the recombination rate of photosensitive hydrated electrons and albumin ion radicals was due to Zeeman frequencies of the reacting radicals. In a 10^{-4} M aqueous solution of methylene blue transformed by photolysis to a 10% ethanol solution, a magnetic field of 10 kOe increased the hydrated electron recombination with ion radicals by 7.1 ± 0.5%. These experiments demonstrated the use of magnetic fields to study the transformation of short-lived ion radicals or radical pairs that are important in photosensitive biologic processes during the condensation phase.

6317 RESPONSE OF THE AMPULLAE OF LORENZINI TO A HOMOGENEOUS ELECTRIC FIELD. *(Rus.)*
Brown, H. R. (I. P. Pavlov Inst. Physiology, USSR Acad. Sciences, Leningrad, USSR); Il'inskii, O. B.; Krylov, B. V. *Neirofiziologiia* 11(2): 158-166; 1979. (9 refs)

The reactions of the ampullae of Lorenzini of *Raja clavata* in a homogeneous electric field were studied; the duration of the current pulses was 10 or 100 msec and the field intensity was 0.01-50 μV/cm. The intensity of the impulse reaction was found to be a linear function of the projection of the ampullary duct on the field vector, which indicated that the potential difference between the pore and the capsule was the effective stimulus of the ampulla. The intensity of the impulse reaction decreased with the decrease in the length of the ampullary duct. The absolute sensitivity threshold of the ampullae was 1-3 μV. The latent period, which was dependent on the length of the ampullary duct and on the intensity of the stimulus, was 9-150 msec.

6318 FOA ANIMAL EXPERIMENTS SHOW THE PHYSICAL AND PSYCHIC EFFECTS OF MICROWAVES. *(Swe.)*
Olsson, P. U. (No affiliation given); Ericsson, R. *FOA Tidningen* 16(3): 7-9; 1978. (0 refs)

Experiments carried out on the effects of microwave radiation at frequency of 2,450 MHz on male mice at the FOA Section for Biological Environmental Technique are reviewed. In one experiment, four mice were simultaneously exposed to microwaves at 100 mW/cm^2 intensity and acoustic pulses (twelve 2-sec/min, frequency 8 kHz) for 6 min. The acoustic reaction and the respiratory activity decreased. Two of the four mice died by the end of the 6-min exposure; their body temperatures were 42.2 C and 43 C, respectively. The two other mice survived; they maintained their respiratory activity, but demonstrated a suppressed acoustic reaction. Their body temperatures were 41.8 C and 39.7 C, respectively, at the end of the exposure. The acoustic reaction normalized after 1 hr, and the respiratory activity and the body temperature normalized after 6 hr. In another series, mice were exposed to 100 mW/cm^2 for 3 min; the acoustic reaction disappeared after 1 min, and the respiratory activity increased rapidly from 1.5 min until the end of the exposure. The acoustic reaction returned after 20 min, and the respiratory activity and the body temperature normalized after 2 hr. Runwheel tests showed reduced running time and number of running periods beginning on the 7th day after exposure. The running time and the number of running periods normalized after 17 and 21 days, respectively. The hemoglobin level, which was normal during the first few days after exposure, decreased and then returned to normal 21 days after exposure. Mice that were exposed to 10 mW/cm^2 for 30 min showed no loss of the thermoregulatory capacity due to the reduction of the respiratory activity after the first 15 min. The respiratory activity normalized 15 min after the exposure. The acoustic reaction was suppressed after 15 min of exposure. The findings are of great importance in view of the fact that the maximum allowable microwave radiation intensity is 10 mW/cm^2 in the United States.

6319 A MECHANISM FOR HIGH-FREQUENCY ELECTROMAGNETICAL FIELD-INDUCED BIOLOGICAL DAMAGE? *(Eng.)*
Nilsson, B. O. (Res. Lab. Electronics, Chalmers Univ. Technology, Goteborg, Sweden); Pettersson, L. E. *IEEE Trans Microwave Theory Tech* MTT-27(6): 616-618; 1979. (6 refs)

A mechanism for high-frequency electromagnetic field-induced biologic damage is presented. It is shown that microscopic wedge-shaped boundaries between regions with different dielectric constants are likely to be present in the mammalian body and may give rise to local fields, with extension on the order of 10^{-9} m, about 100 times larger than the macroscopic fields. Field-induced local damage could therefore occur at 10^4 times lower incident radiation intensities. This phenomenon might explain biologic effects at low radiation power levels, especially in the case of low duty-cycle pulsed radiation. Although, quantitatively, only two-dimensional wedges were considered, three-dimensional structures with sharp tips are likely to be equally dangerous. Electron micrography of different body tissues revealed numerous structures with sharp edges or tips. Generally, there is no information readily available about the dielectric properties of the different microstructures. It is known, however, that the relative dielectric constants of fat and bone are small, of the order of 3-10, depending on the frequency. Therefore, wedges or tips formed by boundaries between these materials and water-rich tissues deserve special attention.

6320 CORAZOLE-INDUCED ENHANCEMENT OF CHANGES IN THE BRAIN BIOELECTRIC ACTIVITY IN A

CONSTANT MAGNETIC FIELD. *(Rus.)* Smirnova, N. P. (No affiliation given). *Biull Eksp Biol Med* 87(1): 21-24; 1979. (7 refs)

The effect of corazole (20-40 mg/kg injected intraperitoneally) on the background potentials and evoked potentials of the cerebral cortex, hypothalamus, and the cerebellar cortex was studied in 23 albino rats exposed to a constant magnetic field (500, 1,000, 3,000, and 4,000 Oe). Pretreatment with corazole caused a significant increase in the amplitude of the evoked potentials, and additional phases appeared. The amplitude measured after pretreatment and at 500 Oe was equal to that measured in nonpremedicated animals exposed to 1,000 Oe. The number of phases in the evoked potential increased from 1.9 before exposure to 2.5 at 500 Oe, 3.9 at 1,000 Oe, and 5.5 at 4,000 Oe. After premedication and exposure, the number of phases increased to 3.0 at 500 Oe, 4.8 at 1,000 Oe, and 6.7 at 4,000 Oe. The findings indicate that subconvulsive doses of corazole produced a considerable enhancement of the changes in the brain biopotentials induced by a constant magnetic field.

6321 RECOVERY CYCLES OF EVOKED BRAIN POTENTIALS IN THE RAT FOLLOWING EXPOSURE TO CONSTANT MAGNETIC FIELD. *(Rus.)* Smirnova, N. P. (No affiliation given). *Zh Vyssh Nerv Deiat* 29(2): 330-335; 1979. (17 refs)

The effect of a constant magnetic field (first 500-1,000 Oe, then up to 4,000 Oe) on the recovery of the evoked potential produced by the electric stimulation of the sciatic nerve (2-6 V, the intervals between the stimuli were increased from 20 to 120 msec) was investigated. The high-intensity homogeneous magnetic field caused elevations in the excitability level of the cerebral and cerebellar cortices and of the hypothalamus, indicated by the reduction of the length of the refractory (nonreactive) and subnormal periods in the recovery cycle of the evoked potentials. During exposure to "subthreshold" magnetic field (500-1,000 Oe), the double stimulation of the sciatic nerve caused an intensification or provocation of the "magnetic effect" (the appearance of additional oscillations in the structure of the evoked potentials) at certain intervals between the stimuli (above 60 msec).

6322 INFLUENCE OF A CONSTANT MAGNETIC FIELD ON NERVOUS TISSUES: II. VOLTAGE-CLAMP STUDIES. *(Eng.)* Schwartz, J. L. (Laboratoire de Physiologie Animale, Universite de Poitiers, Poitiers, France). *IEEE Trans Biomed Eng* BME-26(4): 238-243; 1979. (15 refs)

The giant axon of the circumesophageal connective of the lobster was used to investigate the influence of a constant magnetic field on membrane potentials and transmembrane currents under voltage-clamp conditions using the double sucrose gap technique. When the axon was exposed for less than 5 min to a constant 1.2-Tesla magnetic field parallel or perpendicular to the axon, neither the membrane potentials nor the transmembrane currents were affected in any detectable manner. Similar experiments were performed for longer exposures (up to 25 min). Although interpretation of these data was difficult because of large leakage currents that often developed as early as 15 min after the beginning of the experiment, again no marked change in membrane potentials was detected. It is concluded that magnetic exposure does not seem useful for the investigation of nerve membrane biophysics.

6323 STATE OF IMMUNOLOGIC REACTIVITY OF THE ORGANISM UNDER THE EFFECT OF SOME NOXIOUS INDUSTRIAL FACTORS. *(Rus.)* Kleiner, A. I. (Clinical Dept., Kharkov Scientific Res. Inst. Industrial Hygiene and Occupational Diseases, Kharkov, USSR); Getmanets, I. Ia.; Smolianinova, N. S.; Krylova, E. V.; Galas', G. S.; Rezenkina, L. D. *Vrach Delo* (3): 98-102; 1979. (6 refs)

The immune status of 45 women (41 were less than 40 yr old) exposed occupationally to high-frequency electromagnetic fields (45-160 V/m) for less than 5 yr was studied. The phagocytic activity of the neutrophils and the serum complement titer for 100% hemolysis were significantly reduced. Autoantibodies to liver, stomach, pancreas, heart, and erythrocytes were found in 20-24% of the women, but the autoimmune reaction was usually weak. The harmful clinical effects of the electromagnetic field that were observed included functional disturbances of the nervous, cardiovascular, and digestive systems. The symptoms were mild and reversible. The findings demonstrate an impairment of the immune status in workers exposed to high-frequency electromagnetic fields.

6324 CHANGES IN TRANSAMINATION IN RAT LIVER AND SMALL INTESTINE AFTER EXPOSURE TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS. *(Rus.)* Faitel'berg-Blank, V. R. (Odessa Agricultural Inst., Odessa, USSR); Lekhan, I. G. *Ukr Biokhim Zh* 51(1): 14-17; 1979. (16 refs)

The activities of transminases located in the liver and small intestine mucus membrane were investigated in 69 male rats after exposure to high-frequency electromagnetic radiation. The animals were exposed to electromagnetic waves of frequency 13.6 MHz and intensity of 160 μA for 10 min and to microwaves (MW) of frequency 2,375 ± 50 MHz and intensity of 12 and 30 $\mu W/cm^2$ for 10 and 20 min. The rats were decapitated following radiation and the levels of alanine and aspartate aminotransferase activities, expressed in moles of pyruvic acid formed per mg of protein during incubation, were measured. Induction heating with short-wave diathermy at 160 μA for 20 min reduced the alanine aminotransferase activity by 69% in the liver and by 45% in the small intestine mucus membrane and reduced the aspartate aminotransferase activity by 52% and 66%, respectively. No significant changes were found in the blood. Irradiation with MW

of intensity 12 μW/cm^2 for 10 min produced no significant changes in the enzyme activities in the liver and the small intestine mucus membrane; however, 20 min of exposure raised the specific alanine aminotransferase activity in the small intestine mucus membrane and raised the activity of aspartate aminotransferase in both tissues. Exposure to MW for 10 and 20 min at 12 μW/cm^2 increased the enzyme activities in the blood. The changes in transamination due to induction heating and MW irradiation at 12 μW/cm^2 disappeared after 24 hr exposure. Irradiation with 30 μW/cm^2 for 10 or 20 min lowered the specific alanine and aspartate aminotransferase activities in both tissues, but did not change the enzyme activities in the blood. The increased transamination activity resulting from irradiation with 12 μW/cm^2 may be due to accelerated gluconeogenesis associated with the mobilization of tissue proteins, which together with increased production of glucocorticoids, may reflect the organism's defense reaction.

6325 NONIONIZING RADIATION: BIOLOGIC EFFECTS--HEALTH ASPECTS OF SAFETY. *(Ita.)* Migliaccio, G. (No affiliation given); Pea, I. *Minis Poste Telecomun* 27(1): 95-108; 1978. (5 refs)

Because there is growing concern over the electromagnetic pollution of the environment, an overview of the biologic effects of nonionizing radiation, including microwaves (MW) and radio frequency (RF) radiation, is presented. In addition, the interaction of biologic tissues with UV radiation is reviewed. The absorption of electromagnetic radiation varies according to the structure, dielectric constant (DC), and water content of the biologic tissue. At a high water content, the DC decreases with increasing frequency, permitting calculation of an empirical relationship. This calculation is not possible for tissues with a low water content. Moreover, absorbed radiation that is reflected in tissues produces a transmission interference that can reinforce or cancel the radiation. When MW radiation is absorbed, most of the interfering reflections are quenched. The effects of absorbed MW and RF radiation depend also on the condition of the individual (e.g., age and physiologic state). A variety of effects have been cataloged: hematologic (variation in cell numbers and osmotic fragility), serologic (chemical and endocrine disturbances), gonadal (histologic damage and decrease in libido), ocular (cataract formation and retinal damage), and central nervous system effects (decrease in reflex and bioelectric activities and hypothalamus dysfunction). UV radiation has its greatest effects on the skin and eyes. Photoallergic reactions, arising from the interaction of UV with other agents in common use today (e.g., antibiotics, cosmetics, diuretics, tranquilizers, and detergents) are a particular problem. The risk of such effects increases with the numerous applications of lasers in research, industry, and medicine. Thus, it is important to analyze the risks associated with lasers and to establish threshold criterion for laser use.

6326 EFFECTS OF MICROWAVE IRRADIATION (2,400 MHz) ON RAT TISSUE DESTRUCTION AND REGENERATION. *(Rus.)* Tikhonchuk, V. S. (Biophysics. Inst., USSR Acad. Sciences, Moscow, USSR). *Biull Eksp Biol Med* 88(7): 29-30; 1979. (9 refs)

The destruction and regeneration of rat tissue following microwave irradiation were studied in 2,072 female rats exposed to microwaves of 2,400 MHz with power density of 60-800 μW/cm^2 and at 20-22 C. To produce the same destructive and regenerative effects, exposure time must be increased as power densities are decreased; thus, the relationship of the rate of destruction to the rate of regeneration is a function of the power density of radiation. This ratio has a greater absolute value for larger power densities associated with smaller degrees of destructive effect. By comparing the experimental data with data obtained from previously published experiments on mice, it was established that mice demonstrate destructive and regenerative effects in a shorter period of time than rats.

6327 CLINICAL AND BIOLOGICAL STUDIES OF LOCALIZED HYPERTHERMIA. *(Eng.)* Kim, J. H. (Dept. Radiation Therapy, Memorial Sloan-Kettering Cancer Center, New York, NY 10021); Hahn, E. W. *Cancer Res* 39(6, Part 2): 2258-2261; 1979. (14 refs)

Clinical and biological studies of localized radio frequency (27.12 MHz) hyperthermia in the treatment of malignant tumors are reported. Temperature measurements on a total of 20 normal and 24 tumor tissues in 12 patients indicated that inductive heating over a 30-min treatment period resulted in tumor temperatures of greater than 42 C in 17 of 24 instances; such temperatures appear to be desirable for achieving a good tumor response when applied after ionizing radiation therapy. Over 50 patients with a variety of cutaneous cancers were treated with heat alone, radiation alone, or a combination of heat plus ionizing radiation; the follow-up period ranged from 4-36 mo. Treatment with 27.12-MHz heating alone (41-43.5 C, 30-40 min/session) produced four complete and six partial responses among 19 patients treated. Radio frequency hyperthermia in combination with ionizing radiotherapy produced complete responses in 42 of 54 patients treated for cutaneous tumors compared with 12 complete responses among 49 patients treated by radiotherapy alone. Investigations with animal tumors indicated that the importance of the site of tumor growth is related to local tumor control by heat alone. Other studies with Dunn osteogenic sarcoma in mice indicated that mild (40.5 C) or moderate (42.5 C) heat alone or in combination with radiation does not increase metastatic spread and that hyperthermia in combination with radiation is effective in preventing dissemination of this tumor.

6328 TEST OF MAGNETIC SENSITIVITY IN THREE DIFFERENT BIOLOGICAL SYSTEMS. *(Eng.)* Iwasaki, T. (Natl. Inst. Radiological Sciences,

4-9-1, Anagawa, Chiba-shi 260, Japan); Ohara, H.; Matsumoto, S.; Matsudaira, H. *J Radiat Res* 19(4): 287-294; 1978. (25 refs)

The effects of a nearly uniform 5,000-G magnetic field on three different biologic systems were investigated. In one experiment, asynchronously growing, monolayered Chinese hamster cells in a plastic flask filled with growth medium were exposed to the magnetic field for 8 hr at room temperature. After the exposure, the cells were dispersed and replated for examination of cell growth and multiplicity and colony forming ability. In another experiment, naturally synchronous plasmodia of *Physarum polycephalum* were exposed to the magnetic field during the S-G_2 or M-S-G_2 stage of the cell cycle for 8 hr at 25 C under dark conditions. They were subsequently examined for any delay in mitosis. In a third experiment, fertilized or early cleavage (2- or 4-cell stage) eggs of *Xenopus laevis* were exposed to the magnetic field for up to 3 days at room temperature and were then examined for hatchability and delay in embryonic development. No significant biologic disturbances were observed in any of the above systems after exposure to the magnetic field.

6329 ABSENCE OF OCULAR PATHOLOGY AFTER REPEATED EXPOSURE OF UNANESTHETIZED MONKEYS TO 9.3 GHz MICROWAVES. *(Eng.)* McAfee, R. D. (Res. Service, VA Hosp., 1601 Perdido St., New Orleans, LA 60146); Longacre, A.; Bishop, R. R.; Elder, S. T.; May, J. G.; Holland, M. G.; Gordon, R. *J Microwave Power* 14(1): 41-44; 1979. (5 refs)

Unfettered and unanesthetized monkeys (*Macaca mulatta*) were individually irradiated with pulsed microwave radiation during 30-40 daily sessions and were observed over a 1-yr period for signs of ocular pathology. The monkeys had been trained to expose their face and eyes to 9.31-GHz microwave radiation with a pulse duration of 0.5 μsec and a pulse repetition rate of 1,050 Hz. The average power density at the locus of the monkey's head was 150 mW/cm^2. During half of the experiment, six adult monkeys were irradiated for 30-40 sessions, while another six acted as controls; during a second set of sessions, the groups were reversed. No cataracts or corneal lesions were observed at any time.

6330 AN RF SOLUTION TO A BEEF CANCER. *(Eng.)* BRINTON, J. B. (No affiliation given). *Electronics* 52(11): 44, 46; 1979. (0 refs)

A portable radio frequency hyperthermia applicator for treating cancer eye in cattle is described. The applicator consists of a 2-MHz oscillator with temperature-control circuitry and produces up to 10 W of power. Within seconds, the applicator brings the cancerous tissue up to a temperature of 50 C, which is maintained for about 30 sec. At this temperature cancerous bovine tissue is damaged, while normal tissue is sufficiently cooled by its blood supply to survive without injury. Remission of the cancer typically occurs within 2-4 wk, and cure rates as high as 90% have been reported in pilot studies. This cancer remission rate is previously unheard of in either animals or humans.

6331 LARGE ANIMAL STUDIES OF HYPERTHERMIA AND IRRADIATION. *(Eng.)* Gillette, E. L. (Comparative Oncology Unit, Colorado State Univ., Fort Collins, CO 80523). *Cancer Res* 39(6, Part 2): 2242-2244; 1979. (18 refs)

Large animal studies of the effect on tumor growth of radio frequency (RF) hyperthermia alone or in combination with ionizing radiation is reviewed. In one study where 24 animals with a variety of tumors (some very advanced) were subjected to four treatments of RF hyperthermia (44 C for 30 min) alone, 50% of the tumors showed marked regression; complete remission for at least 6 mo was observed in nine instances. Included in this group were seven squamous cell carcinomas, and two of these regressed. Complete regression for greater than 10 mo was observed for 6 of 16 tumors subjected to one or two treatments with RF hyperthermia at a temperature of 45 C for 30-40 min. The six tumors controlled included one squamous cell carcinoma, three mast cell tumors, one perianal adenoma, and one basal cell carcinoma. Regression of a canine fibrosarcoma and a feline squamous cell carcinoma was reported following local current field hyperthermic treatment (43 C for 30 min) in combination with 700 rads of ionizing radiation that was given 10 min after hyperthermia. The dog was treated a total of seven times, and there was no evidence of the fibrosarcoma 8 mo after treatment. The cat was treated twice and had continuing regression 12 wk after therapy.

6332 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART I. A SUMMARY OF SOME REAL BUT UNEXPLAINED BIOCOSMIC PHENOMENA. *(Eng.)* Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, Pa 18974). *Physiol Chem Phys* 10(6): 535-540; 1978. (15 refs)

Various biocosmic phenomena that have been reported to affect man and other biologic systems but which are not measurable by present electromagnetic instruments are reviewed. These phenomena include the following: diurnal cycles in antigen-antibody reactions at magnetic electrodes, apparently due to magnetic radiation of an unknown type from the sun; rays from the sun of unknown type that can be detected by sick (an by some sensitive) humans, absorbed by metal plates, and conducted by metal wires; rays from the sun of unknown types that affect human health and can be trapped in bilayer metal boxes; colored clouds (auras) around magnets and man that can be seen by sick people (and by a few sensitive normals) and can be made visible to normals by chemical sensitizers; and grid lines parallel to lines of latitude and longitude that are observable by certain persons (dowsers) but not by conventional magnetic or electric detectors. The above phenomena are explained neither by present classical or modern physics nor by any pre-

sent chemical, biological, or psychological knowledge. The construction and the evaluation of a theory to explain these biocosmic phenomena are presented in two accompanying papers in this series.

6333 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART II. INTRODUCTION TO THE THEORY. *(Eng.)* Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *Physiol Chem Phys* 10(6): 541-545; 1978. (25 refs)

Concepts from advanced theoretical physics, e.g., magnetic dipoles and tachyons, that were used to develop a theory for probably real but unexplained biocosmic observations are briefly described. The existence of magnetic dipoles has been predicted theoretically, but they have never been experimentally observed. Tachyons, which are particles traveling faster than light, have also never been detected experimentally. Despite the lack of physical evidence, some theoretical physicists, however, have theorized that tachyons may have magnetic and/or electric charge. The tachyon theory is closely linked to the magnetic monopole theory. The reliability of this data, particularly as it relates to the use of man as the detector of most biocosmic experiments, is discussed and defended. It is proposed that these phenomena may be understood in a unified manner by the hypothesis that we are surrounded by a gas of electromagnetic (EH) dipoles, each of which may (under special conditions) dissociate into a pair of EH monopoles, some of which are tachyons and which may be emitted by the sun.

6334 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART III. DEVELOPMENT OF THE PHYSICS OF THE THEORY, AND EXPERIMENTAL CORRELATIONS: COSMIC RADIATION DETECTABLE BY MAN, AURAS OR MAGNETS AND MAN, DOWSERS' GRID LINES OF EARTH, MEDIATION OF INTERACTION OF ELECTROMAGNETIC WAVES WITH MAN, INTERACTIONS WITH SOLIDS, AND CALCULATION OF MAGNETIC MOMENT. *(Eng.)* Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *Physiol Chem Phys* 10(6): 547-555; 1978. (27 refs)

A theory is developed to explain probably real biocosmic phenomena that cannot be explained by present scientific theory or measured by electromagnetic instruments. It is postulated that we are surrounded by a gas of electromagnetic (EH) dipoles that accumulate near and in man and other solids in accord with classical electromagnetic laws. However, it is also postulated that some of these EH dipoles are tachyons and thus have special additional properties. Detailed correlations are drawn between the predictions of this theory and the unexplained biocosmic phenomena, and a calculation from nuclear magnetic resonance measurements is given for the magnetic moment of a possible EH dipole (1.4×10^{-9} Bohr magnetons). From this calculation it appears that the magnetic moment of an EH dipole is very much smaller than that of a proton or an electron. Based on information indicating that EH dipoles may be trapped in superconductive microregions in man, it is proposed that electromagnetic radiation incident on man from the outside might perturb those trapped EH dipoles, in turn perturbing the molecular structure in which they are trapped and thus resulting in physiologic effects. This opens up a completely new possible mechanism for the interaction of electromagnetic radiation with man, and the effect of placing man within a metal shield takes on new significance. It had previously been taken for granted that the effect of placing man inside a shielded room was the prevention of interferences from outside electromagnetic radiation. However, if this new mechanism is operative, then placing man inside a metal shield may decrease (or increase) the concentration of EH dipoles trapped within man and thereby change the intensity of electromagnetic interactions. Experimental observations have shown that placing man within a shielded room significantly changes his reaction to electromagnetic radiation and that metal shields in the absence of any artificially applied electromagnetic radiation have effects on physiologic and psychologic behaviors.

6335 TECHNICAL NOTE: UPDATE OF RADIOLOGICAL QUALITY OF THE ENVIRONMENT. *(Eng.)* Anonymous. (No affiliation given). *Nucl Saf* 20(3): 342-344; 1979. (3 refs)

A tabulation of dose data for all sources of ionizing and nonionizing radiation in the United States is presented as part of the EPA's dose-assessment program. These data include both individual and population doses from each category of radiation source. Population doses from the different source categories can generally be added together to gain a perspective on the overall impact. However, doses to individuals vary greatly, and it can be misleading to total the individual doses. Thus, these data show totals only for population doses in the various source categories. For nonionizing electromagnetic radiation, the estimated individual exposure for broadcast towers and airport radars is 10 $\mu W/cm^2$, and the exposure for all sources ranges from 0.1 to 1 $\mu W/cm^2$.

6336 THE ANALGESIC EFFECT OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TNS) IN PATIENTS WITH RHEUMATOID ARTHRITIS. A COMPARATIVE STUDY OF DIFFERENT PULSE PATTERNS. *(Eng.)* Mannheimer, C. (Clinic I, Vasa Hosp., Goteborg, Sweden); Carlsson, C. A. *Pain* 6(3): 329-334; 1979. (9 refs)

The effect of different pulse patterns of transcutaneous electric nerve stimulation (TNS) on severe pain in 20 patients (7 men, 13 women; 20-69 yr old) with verified rheumatoid arthritis was investigated. All patients had symptoms of spontaneous bilateral pain and/or pain on loading from the wrists, the metacarpophalangeal joints, and the proximal interphalangeal joints. Three forms of

stimulation were used: high frequency 70-Hz stimulation, low frequency 3-Hz stimulation, and stimulation with an internal frequency of 70 Hz and 80-msec pulse duration with a repetition rate of 3 Hz (3-70 TNS). Each electrode had an area of 9 cm^2. The electrodes were placed immediately proximal to the patient's wrist with one electrode on the volar side and the other on the dorsal side. The stimulation period was 10 min. For all types of stimulation, the pulse amplitude was increased until the patient experienced paresthesia in all fingers; a final stimulation level immediately below that causing pain was used. The analgesic effect of TNS was evaluated by the patient's own estimate of pain relief and by a loading test in which the length of time the patient could hold a weight before and after TNS was measured. The number of patients who experienced marked subjective improvement was 18/20 after 70-Hz TNS compared with 14/20 after 3-70 TNS and 5/20 after 3-Hz TNS. Loading time was increased by 100% or more in 18/20 patients on 70-Hz TNS, 16/20 patients on 3-70 TNS, and 6/20 patients on 3-Hz TNS. The average duration of subjective effects was 18.2 hr (range, 4-36 hr) for 70-Hz TNS compared with 15.2 hr (range, 4-72 hr) for 3-70 TNS and only 4 hr (range, 3-6 hr) for 3-Hz TNS. No side-effects of TNS were observed. The results show that the analgesic effects of 70-Hz TNS and 3-70 TNS are almost identical, while 3-Hz TNS gives distinctly poorer results.

6337 BRAIN EVOKED POTENTIALS ARE FUNCTIONAL CORRELATES OF INDUCED PAIN IN MAN. *(Eng.)* Chen, A. C. (Dept. Anesthesiology, BB1411, HSB RN-10, Univ. Washington, Seattle, WA 98195); Chapman, C. R.; Harkins, S. W. *Pain* 6(3): 365-374; 1979. (29 refs)

Electric potentials evoked by five intensities of painful dental stimulation (9.6, 17.5, 26.0, 34.0, and 42.0 μA) were recorded at the scalp in 10 male volunteers (24-28 yr old) to determine the relationships between stimulus intensity, subjective judgment of pain, and measures of the evoked potential (EP). For each volunteer, a healthy, unfilled central incisor was stimulated electrically to produce pain. The tooth was stimulated with a 3.5-mm diameter conductive rubber disk electrode (cathode); an anodal electrode was taped on the left zygomatic arch. The electric stimulus was produced by a Grass S-44 stimulator with modified constant current and isolation units. The dental electric stimuli consisted of single square wave pulses of 5-msec duration, delivered manually by the experimenter. Stimulus delivery was intentionally irregular so that expectancy could not contaminate measurement. The interstimulus interval ranged from 2 to 6 sec, with a mean of about 4 sec. At each intensity of painful dental stimulation, EPs were observed between 50 and 400 msec and were characterized by the following four waveform components: N_{65}-P_{120}, P_{120}-N_{175}, N_{175}-P_{260}, and P_{260}-P_{340}. The peak-to-peak amplitudes, but not the peak latencies, of all four EP components systematically increased with increased stimulation. The amplitudes of the two earlier components correlated with stimulus intensity when the effect of subjective painfulness was controlled, whereas the amplitudes of the two later components were associated with subjective painfulness but not with stimulus intensity. A strong linear relationship was observed between subjective painfulness and peak-to-peak amplitude for the EP component observed between 175 and 260 msec. These findings suggest that the earlier EP components may reflect sensory transmission processes while the latter components indicate brain activity when pain is perceived.

6338 CARDIOVASCULAR DISTURBANCES ATTRIBUTABLE TO OCCUPATIONAL FACTORS: APPROACHES TO THEIR STUDY. *(Rus.)* Monaenkova, A. M. (Inst. Industrial Hygiene and Occupational Diseases, USSR Acad. Medical Sciences, Moscow, USSR); Gladkova, E. V.; Radionova, G. K. *Gig Tr Prof Zabol* (4): 23-27; 1979. (0 refs)

Cardiovascular disturbances attributable to long-term exposure to chemical substances and physical factors (noise, electromagnetic waves, and ionizing radiation) are reviewed. Long-term exposure to microwaves can lead to the development of cardiovascular syndromes and changes in the nervous system, especially in the autonomic nervous system. Chronic asthenic symptoms accompanied by sinus bradycardia, arterial hypotension, and hypertonic vegetative-vascular dysfunction, and occasionally accompanied by diencephalic crisis with angiospasms, have been observed. In some cases, angiospasms can lead to coronary and cerebral circulation disorders. Prospective epidemiologic studies are necessary to evaluate the effects of occupational factors.

6339 OCCUPATIONAL HEALTH AND RADIATION HAZARDS. *(Eng.)* Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester Sch. Medicine and Dentistry, Rochester, NY). *Occup Health Saf* 48(4): 28-30, 32-34, 36-37; 1979. (17 refs)

Hazards associated with nonionizing electromagnetic radiation are reviewed, with particular emphasis on lasers and microwaves. The primary hazard from laser radiation is exposure of the eye; long-term exposure of the retina to wavelengths in the visible spectrum at levels not far below the burn threshold may cause irreversible effects. The type of damage inflicted on the eye by laser beams ranges from a small and inconsequential retinal burn in the periphery of the fundus, to severe damage of the macular area with consequent loss of visual acuity, and to massive hemorrhage and extrusion of tissue into the vitreous with possible loss of the entire eye. The biologic significance of exposure of the skin to lasers operating in the visible and infrared regions is considerably less than eye exposure. Effects may vary from a mild erythema to blisters and charring. Such conditions as depigmentation of the skin, ulceration, and scarring and damage to under-

lying organs may occur from extremely high-powered laser sources. The basic biologic effects of microwaves occur in the presence of a significant temperature rise in biologic tissue; this rise requires exposure to relatively high levels of radiation and a substantial exposure duration. At high microwave frequencies, well above the usual heating frequencies, radiation is absorbed almost completely by the skin; these frequencies are felt in several seconds at exposure levels of a few mW/cm^2. At the heating frequencies (918 and 2,450 MHz), the penetration is a few centimeters; at 2,450 MHz, microwave exposure is sensed at levels of 20-50 mW/cm^2 in a few seconds. At lower frequencies, like those of television broadcast, penetration and deep heating both increase. At still lower frequencies, the body shunts out or reflects the field so that less heating results even though the internal field is fairly uniform throughout the body. Thermal damage from microwaves occurs at exposure levels of more than 100 mW/cm^2 over extended durations of many minutes. Protection guides for nonionizing electromagnetic radiation sources in the United States are discussed and compared with the standards in the Soviet Union. In general, the Soviet standards are more numerous and more stringent than the American equivalents. This reflects differences in the concept of an environmental standard, the research applied, and the vigor with which the standards are enforced. Much of the Soviet research on environmental standards is not appropriate for the United States, since their standards are based on the lowest concentration producing measurable biologic damage, regardless of its importance.

6340 ROSES AND CABBAGES: MICROWAVE BIOEFFECTS LITERATURE IN 1978. *(Eng.)* Voss, W. A. (CE247, Univ. Alberta, Edmonton, Canada T6G 2N7). *J Microwave Power* 14(1): 77-78; 1979. (13 refs)

Microwave bioeffects literature published in 1978 is reviewed. One report brings together six introductory papers with basic information on definitions and concepts and includes dielectric and specific absorption data in tissue, an introduction to pathophysiologic effects, and two sections concerning protection standards. A final section on measurement of microwave fields lacks tangible information. Detailed current data on electromagnetic radiation effects in relation to assessing potential health hazards can be found in another study. A clear assessment of current knowledge and future areas of study concerning the environmental impact of 2.45-GHz microwave beams for transmitting power from solar energy satellites has also been compiled. Essential, up-to-date information on dosimetry is available in another publication. The first edition is concerned with the frequency range of 10 kHz to 1.5 GHz and uses spheroidal and ellipsoidal theoretical models of animals and man. The second edition extends the frequency range to 100 GHz; additional mathematic models are used, and considerations of inhomogeneity are included.

6341 ASSESSMENT OF CURRENT HYPERTHERMIA TECHNOLOGY. *(Eng.)* Atkinson, E. R. (American Hosp. Supply Corp., Evanston, IL 60201). *Cancer Res* 39(6, Part 2): 2313-2324; 1979. (614 refs)

Current hyperthermia technology is reviewed. Radio frequency (RF) coupling at frequencies of 100 kHz to 100 MHz appears to be applicable both to superficial sites and to certain deep tissue sites. However, RF energy couples more readily to fatty tissue than to muscle, parenchyma, or connective tissue. The geometric location of in-dwelling electrodes may help to limit the tissue volume to be heated. At present, RF coupling techniques using implanted electrodes for the production of local hyperthermia appear to be ideally suited to the treatment of small, well-defined tissue volumes that are readily accessible. Microwave coupling complements RF coupling to a certain extent in that muscle, parenchyma, and connective tissue are more closely coupled than is fatty tissue. Microwave coupling may be implemented by means of surface contacting applicators or by means of tuned indwelling coaxial lines. Tissues are moderately transparent to microwave radiation; e.g., at a frequency of about 1 GHz, tissue penetration to a depth of 3-5 cm is possible. Depths of this order in many patients should permit tissue heating in virtually any part of the body. At the present time, microwave coupling appears to be ideally suited to the heating of larger regional tissue volumes. It may also be appropriate in whole body hyperthermia as a means of elevating whole body temperature more rapidly than may be accomplished by direct skin or blood thermal conduction heating or endogenous metabolic heat confinement.

6342 MICROWAVE BACKSCATTER DEPENDENCE ON SURFACE ROUGHNESS, SOIL MOISTURE, AND SOIL TEXTURE: PART II--VEGETATION-COVERED SOIL. *(Eng.)* Ulaby, F. T. (Center for Res., Inc., Univ. Kansas, Lawrence, KS 66045); Bradley, G. A.; Dobson, M. C. *IEEE Trans Geosci Electron* GE-17(2): 33-40; 1979. (6 refs)

The feasibility of using radar for measuring soil moisture in vegetation-covered fields is examined by experimentally determining the relationship between radar backscatter coefficient (RBC) and soil moisture for vegetation-covered soil. It is shown that radars with frequencies below 6 GHz and incidence angles less than 20 degrees exhibit minimal vegetation-attenuation effects on the RBC-soil moisture relationship. An examination of the effects of radar look direction relative to crop row direction on the RBC indicates that there are no row direction effects on the RBC if frequencies above 4 GHz are used for HH or VV polarization configurations; for HV polarization, no row direction dependence exists at any frequency between 1 and 8 GHz. The highest correlation between RBC and soil moisture (0.92) is obtained for the combined response of four crop types (corn, milo, soybeans, and wheat) measured at 4.25 GHz, a 10-degree incidence angle, and HH polarization. It is also shown that dependence on soil type can be minimized

by expressing soil moisture in units of percent of field capacity. The possibility of using a single radar for measuring soil moisture for both bare and vegetated fields is demonstrated with a linear estimation algorithm having an experimental correlation coefficient of 0.8.

6343 NORMAL TISSUE AND SOLID TUMOR EFFECTS OF HYPERTHERMIA IN ANIMAL MODELS AND CLINICAL TRIALS. *(Eng.)* Storm, F. K. (54-140 Center for Health Sciences, Univ. California, Los Angeles, CA 90024); Harrison, W. H.; Elliott, R. S.; Morton, D. L. *Cancer Res* 39(6, Part 2): 2245-2251; 1979. (20 refs)

The effects of radio frequency (13.56 MHz) hyperthermia (42-50 C) on both surface and deep visceral normal tissues as well as on spontaneously arising cancers in animals and humans were investigated. Toxicity tests in dogs, sheep, and pigs showed that progressive necrosis of normal and cancer tissue occurred at temperatures above 45 C. However, as normal tissues approached this temperature, intrinsic heat dissipation occurred so that temperatures below 45 C could be maintained; in contrast, most solid tumors did not have this adaptive capacity and could be heated to 50 C with virtually no injury to normal organs, subcutaneous tissue, or skin. In clinical trials, 69 treatments were administered to 36 refractory tumors in 30 patients with 10 types of cancer. Selective heating (45 C or greater) was observed in both primary and metastatic tumors. A total of 19 tumors arising in the skin or subcutaneous tissue were evaluated, and selective heating was observed in 14 (74%). Surface tumors treated to 50 C or more for 15 min on one or more occasions generally showed histologic evidence of coagulative necrosis and sloughed within 10-14 days. Of 17 intrathoracic or intra-abdominal tumors evaluated, selective heating (45 C or greater) was possible in 6 tumors (35%). While intratumor temperatures frequently were not uniform, tumors heated to 50 C or more for 15 min on one or more occasions generally showed coagulative necrosis and intravascular thrombosis. Overall selective heating was possible in 43% of the tumors less than 5 cm diameter and in 73% of tumors 5 cm or more in diameter, indicating that hyperthermia may be uniquely effective against larger tumors. Radio frequency hyperthermia with an absorbed power density of 1,000 W generally was well tolerated with virtually no normal tissue injury.

6344 CHANGE IN THE ACTIVITY OF CALCIUM IONS DUE TO THE MAGNETIZATION OF THE SOLUTION AS A POSSIBLE MECHANISM OF THE BIOLOGICAL EFFECT OF MAGNETIC FIELDS. *(Rus.)* Kartashev, A. G. (No affiliation given); Kaliuzhin, V. A.; Pliushch, R. A.; Vokhmintsev, A. V. *Elektron Obrab Mater* (6): 65-68; 1978. (10 refs)

The effect of permanent and alternating magnetic fields on the biologic activity of calcium ions in aqueous solutions was studied. The effect of alternating and permanent magnetic fields of 320-64,000 A/m and 1-50 Hz on glycolysis by *Saccharomyces cerevisiae* was studied in solutions containing 0.16% Ca or Mg (control) ions. A reduced fermentation rate was observed in the irradiated solutions compared with the nonirradiated controls. In a second experiment, the minimum frequency inducing pessimum of a neuromuscular preparation of the frog was determined. The specimen was incubated in a 0.8% $CaCl_2$ solution and exposed to permanent magnetic field of 64,000 A/m. The magnetization of the solution caused a significant reduction of the minimum frequency by an average of 14 ± 7.5 Hz ($p<0.01$). In a third experiment, the effect of magnetization at 8,000 A/m (gradient 50%) on fibrinolysis was studied in rabbit fibrin clots incubated in a $CaCl_2$ solution. Magnetic treatment decreased the fibrinolytic time from 90-300 min for control solutions to 60-270 min for ($p<0.01$) the irradiated solutions. The experiments demonstrated that the magnetic treatment of $CaCl_2$ solutions produces an effect analogous to the biologic inactivation of calcium ions; there was no significant effect on $MgCl_2$ and NaCl solutions. The findings support the hypothesis of the dominant role of Ca ions in the indirect action of magnetic fields on body fluids.

6345 THERMAL ANALYSIS AND DESIGN CONSIDERATIONS FOR A DUAL-BEAM MICROWAVE APPLICATOR FOR HYPERTHERMIA RESEARCH. *(Eng.)* Hannemann, R. J. (Coll. Engineering, Univ. Maryland, College Park, MD 20742); Robinson, J. E. *J. Biomech Eng* 101(2): 151-156; 1979. (17 refs)

Thermal analysis and design considerations are presented for a dual-beam waveguide microwave applicator that is being used for experimental hyperthermia treatment of implanted mouse tumors. The two waveguide applicators operate in a simulated TEM mode at 2,450 MHz and are in direct contact with either a slab of dielectric material encapsulating the tumor or a stirred, temperature-controlled dielectric bath in which the tumor specimen is immersed. By surrounding the tumor in this fashion with a tissue-equivalent material, the irregular spheroidal tumor boundary is transformed into a rectangular slab, thus promoting effective coupling of microwave energy to the tumor and a uniform field pattern within the illuminated region. One-dimensional models describing the heat transfer in the dual-beam applicator system with a stirred liquid bolus are presented. An examination of the temperature profiles reveals that for steady-state operations, maintaining the stirred liquid bolus near to the required elevated tumor temperature is desirable; setting the microwave power at a specifi field level then results in perfect temperature uniformity. The thermal models are verified by comparing predicted with measured temperatures at the tumor center using a leg-implanted tumor near the femur. The dual-beam microwave applicator system is of additional interest in that the use of four, eight, or even more narrow, coplanar microwave beams to produce highly localized hyperthermic

fields at depth is a potential technique for clinical therapy on humans in the future.

6346 ELECTROMAGNETIC ABSORPTION IN A MULTILAYERED MODEL OF MAN. *(Eng.)* Barber, P. W. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Gandhi, O. P.; Hagmann, M. J.; Chatterjee, I. *IEEE Trans Biomed Eng* BME-26(7): 400-405; 1979. (15 refs)

A multilayered planar model was used to examine the dependence of whole-body electromagnetic power absorption on the configuration of surface layers of the human body (skin, fat, and muscle). Surface characteristics of 79 horizontal cross-sections of human tissue were represented by 3- or 5-layer configurations (skin-fat-muscle or skin-fat-muscle-bone-muscle). Numerical calculations were performed using the dielectric characteristics of the various tissue types for frequencies up to and including 10 GHz, with suitable modifications of the characteristics of electrically polarizable molecules used for frequencies above 10 GHz. It was shown that a semi-infinite planar model can accurately predict the layering resonance for a nonplanar geometry. Specifically, the results for multilayered and homogeneous semi-infinite planar models determine a layering enhancement factor that can be applied to whole-body absorption results obtained from nonlayered three-dimensional geometries to predict the absorption charactertistics of three-dimensional layered geometries. Calculations for a multilayered prolate spheroidal model of man predict an absorption enhancement over homogeneous muscle tissue of 34% at 1.8 GHz and a reduction of 24% at 5.7 GHz.

6347 SOLAR POWER SATELLITES: MICROWAVES DELIVER THE POWER. *(Eng.)* Brown, W. C. (Microwave and Power Tube Div., Raytheon Co., Waltham, MA). *IEEE Spectrum* 16(6): 36-42; 1979. (0 refs)

A 2.45-GHz microwave transmission system for delivering the sun's power from space to earth through a network of solar power satellites (SPS) is described. The SPS network, with a 5- x 10-km photovoltaic array on each satellite, would convert the sun's energy to electricity prior to transmission. The microwave transmitting antenna on each satellite would be 1 km in diameter, and the ground stations would have 10- x 13-km elliptical receiving-rectifying antennas (rectennas). The microwave transmission system envisioned is comprised of three stages: the conversion of direct current (dc) power (from the photovoltaic cells on the satellite) to microwave power; the formation and control of microwave beams precisely pointed to fixed locations on the earth's surface; and the collection of the microwave energy and its conversion into dc electric energy at the earth's surface. Safety features such as a pilot beam for the transmitting antenna to track are planned to keep the microwave beams from wandering off target and affecting people. While the microwave beam transfers a large amount of power, the large-diameter beam has most of its power at the center, where the density is 23 mW/cm^2. At its edges, the beam's density is 1 mW/cm^2 or only 10% of the continuous exposure standard of 10 mW/cm^2 in the United States. An exclusion area surrounding each rectenna is proposed to hold the risks to humans near the target site to a minimum. Furthermore, the microwave beam focusing system, which employs the pilot beam, has a "fail-safe" feature; in case the beam should untrack, it would defocus to 0.003 mW/cm^2.

6348 THERMAL DOSIMETRY AND TEMPERATURE MEASUREMENTS. *(Eng.)* Christensen, D. A. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *Cancer Res* 39(6, Part 2): 2325-2327; 1979. (19 refs)

Problems associated with temperature monitoring during tissue heating by electromagnetic radiation are discussed along with some nonperturbing measurement methods for avoiding or minimizing these problems. The use of conventional metallic thermometers can cause severe errors due to reradiated fields, high internal heating, and electronic interference. To avoid these problems, both probes, which use conventional thermistor sensors in conjunction with very high resistance lead wires to reduce interaction, and optical probes, using plastic or glass fibers as the communicating link to a liquid crystal sensor, have been developed. An advantage of high resistance lead probes is that the thermistor sensor is relatively accurate, reproducible, and stable. Disadvantages are the need for highly sensitive electronics, limited length of the probe leads, and the relatively large diameter (about 1-2 mm) of the probe tip. Disadvantages of the optical fiber probes are chemical instability of the sensor material, hysteresis during temperature cycling, and the relatively large diameter of the tip (1.5-2.0 mm). A small semiconductor sensor in conjunction with an optical fiber probe has been developed with the advantages of inherent sensor stability, range, and small tip diameter (0.25 mm, unsheathed but coated), making it attractive for tissue implantation. A new noninvasive approach uses ultrasound-computed tomography and relies on the change in the speed of sound versus temperature to achieve maps of internal tissue temperature. It appears that the eventual temperature resolution of this technique may be about 0.1-0.3 C with a spatial resolution on the order of a few millimeters.

6349 THE MATURING OF ELECTROMAGNETIC RADIATION HAZARD INSTRUMENTS. *(Eng.)* Aslan, E. (Narda Microwave Corp., Plainview, NY). *Microwave J* 22(5): 83, 84, 88, 90; 1979. (10 refs)

Advances in the measurement of electromagnetic (EM) radiation hazards are reviewed. Isotropic probes, with their independence of polarization, direction of propagation, true square law characterists, and broad bandwidth, have overcome the uncertainties

associated with field intensity meters with directive antennas. The latter cannot reliably measure complicated EM fields such as those with reactive near field components, multipath reflections, arbitrary polarization, multiple frequency components, complicated modulations, and larger field gradients. Current isotropic radiation monitors cover the frequency range of 10 MHz to 40 GHz. In the high frequency region above 300 MHz, only the electric field is generally measured. Below 300 MHz, both the electric and magnetic fields are measured. Calibration of the probes is accomplished using standard field methods. Above 1,000 MHz, horn antennas corrected for near zone gain and an anechoic sled, which is used to average out multipath interference, are the fundamental components of the calibration system. A calibration cell of the type developed by the NBS is used for calibration below 500 MHz. This cell is essentially a section of extremely large air dielectric 50 ohm rectangular coaxial line. A standard field is generated between the inner and outer conductors as a result of a known power transmitted down the line. At frequencies between 500 and 1,000 MHz, a technique based on propagating the fundamental TE 01 mode in a side wall slotted waveguide section is used. Although a number of personal dosimeters for avoiding exposure to EM energy have been developed over the last 10 yr, no unit exists that can be worn on the body and that meet the requirements of a reliable personal radiation hazard monitor.

6350 EFFECT OF GENERAL ANESTHETICS ON MICE AFTER MICROWAVE IRRADIATION. *(Rus.)* Koldaev, V. M. (Vladivostok Medical Inst., Vladivostok, USSR). *Biull Eksp Biol Med* 87(5): 425-427; 1979. (2 refs)

The effects of general anesthetics (sodium thiopental, 60 mg/kg; sodium oxybutyrate, 10, 50, and 500 mg/kg; hexenal, 60 mg/kg; urethan, 800 mg/kg; ftorothan, 1:10,000 concentration; chloroform, 1:5,000; and ethyl ether, 1:1,000) on male and female albino mice irradiated with high doses of microwaves (unspecified doses) were studied. In one experimental series, the anesthetics were administered immediately after microwave irradiation. The survival, determined 3 wk later, was 48% in the controls that were irradiated only and 30% (significantly lower by 1.45-1.6 times) in the groups treated with chloroform, ftorothan, sodium thiopental, and sodium oxybutyrate (500 mg/kg). The reduction in the survival rate was insignificant after microwave irradiation that was immediately followed by ethyl ether, hexenal, urethan, and the lower doses of sodium oxybutyrate. In a second experimental series, the anesthetics were administered 0-10 days after irradiation, and the time elapsing until the animals assumed a lateral position was determined. This time increased by 15-48% compared with the controls when the anesthetics were given immediately after irradiation, but it decreased gradually when they were given at later dates. Compared with the controls, the time increased by 8-14% when ether, ftorothan, hexenal, and sodium thiopental were administered immediately after irradiation. When ether was administered at later dates, the time increased gradually by 48%. When ftorothan was administered 10 days after irradiation, it decreased by 34%. Hexenal and sodium thiopental administered 2 days after irradiation caused a 28-36% decrease, which reached the control level when the anesthetics were given on day 4. The findings indicate that high-dose microwave irradiation results in varying sensitivities of mice to several general anesthetics.

6351 AN INVESTIGATION OF THE THERMAL AND ATHERMAL EFFECTS OF MICROWAVE IRRADIATION ON ERYTHROCYTES. *(Eng.)* Peterson, D. J. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Partlow, L. M.; Ghandi, O. P. *IEEE Trans Biomed Eng* BME-26(7): 428-436; 1979. (11 refs)

Rabbit red blood cells (RBC) heated to the same temperature by either microwave irradiation or by conventional techniques were examined for loss of hemoglobin (Hb) and potassium (K^+). Microwave irradiation was performed at a frequency of either 2.45 GHz or at 0.5-GHz swept frequency regions in the 12.5-18 GHz range. Sample tubes containing RBC were irradiated in the far field of a horn antenna in all cases. A vertical rotating sample holder was used to provide uniform microwave exposure for multiple RBC samples. When rabbit RBC were irradiated with 2.45-GHz microwaves at a power density of 10 mW/cm^2 for 45 min, a temperature rise of 3.7 C was achieved, resulting in a final temperature of 28.7 C. However, no differences in the amount of leakage of either Hb or K^+ were detected among microwave-irradiated RBC, conventionally-heated RBC, and RBC held at room temperature. When RBC were heated to 37 C (power density 86 mW/cm^2 initially, then 35 mW/cm^2 for maintenance) both microwave- and conventionally-heated samples released significantly more Hb (1.7 times) and K^+ (1.4 times) than RBC samples held at room temperature; however, there was no significant difference between the effects of microwave heating and conventional heating. When RBC were heated to and maintained at 41.5 C by either 2.45-GHz microwave (power density 112 mW/cm^2, then 93 mW/cm^2) or conventional heating, the leakage of Hb and K^+ from the samples was 22.3 and 7.0 times greater, respectively, than the loss from corresponding samples maintained at room temperature. However, again no differences were observed between microwave heating and conventional heating. At frequencies between 12.5 and 18 GHz, similar results to those obtained at 2.45 GHz were observed for rabbit RBC. When human RBC were warmed to 37 C by 2.45-GHz microwaves or by conventional heating, the amount of leakage of either Hb or K^+ did not differ from that for RBC maintained at room temperature. Human RBC membranes are apparently more resistant to both microwave heating and conventional heating than are rabbit RBC. Any increased loss of either Hb or K^+ from microwave-irradiated rabbit RBC was attributed to thermal effects on erythrocyte membrane stability or permeability.

6352 SAFETY CODE-6: RECOMMENDED SAFETY PROCEDURES FOR THE INSTALLATION AND USE OF RADIOFREQUENCY AND MICROWAVE DEVICES IN THE FREQUENCY RANGE 10 MHz-300 GHz. *(Eng.)* Stuchly, M. A.; Repacholi, M. H.; Zuk, W. M.; Waight, P. J.; Ghosh, G. K.; Muc, A. M. (Radiation Protection Bureau, Health and Welfare Canada, Ottawa, Canada). 39 pp.; 1979. [available through Information Directorate, Dept. Natl. Health and Welfare, Brooke Claxton Building, Ottawa K1A 0K9, Canada, Environmental Health Criteria Document No. 79-EHD-30]. (8 refs)

Safety requirements, installation guidelines, and maximum exposure levels for use in Canada with stationary radio frequency devices that operate in the frequency range of 10 MHz to 300 GHz are presented. For microwave radiation workers receiving whole- or partial-body exposure (with exception of the extremities) to either continuous or modulated electromagnetic radiation (EMR) from one or more sources operating in the frequency range of 10 MHz to 1 GHz, the following levels must not be exceeded over a 1-hr period: root mean square (RMS) electric field strength, 60 V/m; RMS magnetic field strength, 0.16 A/m; and power density, 1 mW/cm^2. When averaged over a 1-min period, these same parameters must not exceed 300 V/m, 0.8 A/m, and 25 mW/cm^2, respectively. Maximum exposure levels for microwave radiation workers receiving either whole- or partial-body exposure to radiation in the frequency range of 1 GHz to 300 GHz when averaged over a 1-hr period are: RMS electric field strength, 140 V/m; RMS magnetic field strength, 0.36 A/m; and power density, 5 mW/cm^2. When averaged over a 1-min period, these parameters must not exceed 300 V/m, 0.8 A/m, and 25 mW/cm^2, respectively. For exposure of the extremities to continuous or modulated radiation at frequencies ranging from 10 MHz to 300 GHz, the following levels must not be exceeded when averaged over a 1-hr period for microwave radiation workers: RMS electric field strength, 200 V/m; RMS magnetic field strength, 0.5 A/m; and power density, 10 mW/cm^2. For whole- or partial-body exposure of any member of the general public to either continuous or modulated EMR at frequencies ranging from 10 MHz to 300 GHz, the following levels must not be exceeded when averaged over a 1-min period: RMS electric field strength, 60 V/m; RMS magnetic field strength, 0.16 A/m; and power density, 1 mW/cm^2. Also covered in the safety code are siting and installation requirements for open-beam heating devices, medical devices and electromagnetic interference, microwave ovens, radar and communications systems, and electroexplosive devices. Other topics include safety procedures for operators and maintenance personnel, the protection of the general public, radiation surveys, and the use of warning signs.

6353 INJURY AND RECOVERY OF THE MOUSE AFTER MICROWAVE (2,400 MHz) IRRADIATION. *(Rus.)* Tichonchuk, V. S. (Inst. Biophysics, USSR Acad. Sciences, Moscow, USSR); Antipov, V. V.; Davydov, B. I.; Galkin, A. A. *Biull Eksp Biol Med* 88(7): 55-57; 1979. (8 refs)

The relationship between the effects and the duration of exposure at different power densities of microwaves (MW) was studied in 2,200 female mice. Equations are presented to determine, at different power densities, the distribution of deaths in relation to the duration of exposure and the rate of destruction in relation to the rate of regeneration. The animals were exposed to MW irradiation of frequency 2,400 MHz and power densities of 800, 500, 300, 200, 100, 80, or 60 $\mu W/cm^2$ for 30 days. With MW power doses under 40 ± 10 $\mu W/cm^2$, the biophysical mechanisms regulating the heat balance of mice were so effective that heat was eliminated in a shorter time than that of exposure. The relationship between MW power dose and length of exposure can be expressed exponentially and the dependence between the speed ratio of tissue destruction/regeneration and the power density approached the exponential function. Thresholds of power dose and length of exposure were determined for death levels not exceeding 0.1%. The revealed dependencies quantitatively characterize the adaptational capabilities of the mouse to microwave irradiation.

6354 ON THE MECHANISM OF MAGNETIC FIELD EFFECTS IN BACTERIAL PHOTOSYNTHESIS. *(Eng.)* Haberkorn, R. (Institut fur Physikalische und Theoretische Chemie, Technische Universitat Munchen, D-8046 Garching, W. Germany); Michel-Beyerle, M. E. *Biophys J* 26(3): 489-498; 1979. (39 refs)

The magnetic field-dependence of the primary steps in the bacterial photosynthetic reaction center is analyzed by solving a simple model with only one proton, representing the many magnetic nuclei with which the unpaired electrons in the radical intermediates interact. Analytic expressions are given that can be used to study the influence of the rates of the primary electron transfer reactions and the exchange interaction on the yield of excited triplet states. It is shown that at least the order of magnitude of the reaction rates obtained can be expected to be correct. The triplet recombination rate found in this analysis is larger than the singlet rate; this can be readily understood in view of the different exothermicities of electron transfer reactions. A small value obtained for the exchange interaction in this analysis is somewhat puzzling. It indicates that the overlap of the wave functions of the first excited singlet state of bacteriochlorophyll dimer and the bacteriopheophytin anion is very small; if the interaction between the electrons were mainly of a magnetic nature (a possibility that cannot be excluded), the overlap could be close to zero. On the other hand, the electron transfer step leading to the formation of these radicals proceeds extremely rapidly (within 10 psec). There is some evidence that a geometric change occurs in the reaction center after this fast electron transfer step, which perhaps involves an increase of the distance of the radicals. Another possibility is delocalization of one of the unpaired electrons

and thus the subsequent increase in their average distance in the radical pair state. A model system in which this feature is realized consists of an organic crystal with dye molecules adsorbed at its surface. After excitation by light, a radical ion pair is formed, one charge of which may even diffuse into the crystal bulk. The electric current thus generated and the triplet species formed have been found to be magnetic field-dependent.

6355 TEMPERATURE DEPENDENCE OF THE MICROWAVE PROPERTIES OF AQUEOUS SOLUTIONS OF ETHYLENE GLYCOL BETWEEN +15 C AND -70 C. *(Eng.)* Macklis, J. D. (Cryogenic Engineering Lab., Massachusetts Inst. Technology, Cambridge, MA 02139); Ketterer, F. D.; Cravalho, E. G. *Cryobiology* 16(3): 272-286; 1979. (21 refs)

The temperature dependence of the microwave properties of aqueous solutions of ethylene glycol (EG) between +15 C and -70 C was investigated in connection with difficulties involved in the microwave thawing of whole organs stored at subfreezing temperatures. Values of the dielectric constant and loss tangent were determined for pure distilled water and for EG at concentrations of 1 molar (M), 2 M, 3 M, 4 M, 5 M, 10 M, and 100% EG. An operating frequency range of 1.40-1.55 GHz was used so that the results could be applied directly to both 0.915-GHz and 2.450-GHz studies. Strong temperature and concentration dependencies were found; low concentration solutions of EG tended to behave similarly to water, while higher concentration solutions were more independent. Peak values and discontinuities occurred at different temperatures, depending on the concentration of the EG solution. A 5-M solution of EG appeared to be a near optimal concentration based on toxicity, cryoprotection, and microwave power absorption considerations. The data suggest that it may be possible to blend two cryoprotectants to increase electric activity while at the same time decreasing toxicity.

6356 ANATOMICAL LOCALIZATION OF HUMAN DETECTION OF WEAK ELECTROMAGNETIC RADIATION: EXPERIMENTS WITH DOWSERS. *(Eng.)* Harvalik, Z. V. (5901 River Drive, Lorton, VA 22079). *Physiol Chem Phys* 10(6): 525-534; 1978. (16 refs)

Positive responses in the form of dowsing signals were evoked in 14 male dowsers exposed to artificial electromagnetic fields. A total of 691 hits were scored versus 33 misses. During all trials, a high frequency generator (HFG) was mounted on a wooden surface 90 cm above ground level. The 5-cm beam width at the origin dispersed at a cone angle of 17 degrees. Thus at 2.5 m, the distance from the HFG to the path to be followed by the subjects, the axes of the generator coils were horizontally adjusted to point perpendicularly to the path. One subject was sensitive enough to detect microwatt-level signals in the frequency ranges of 42.83 MHz and 58.55 MHz. The other 13 subjects were able to detect milliwatt-level signals at frequencies ranging from 58.55 MHz to 6 GHz. In experiments where the kidney area was shielded with aluminum, positive responses to the artificial electromagnetic fields were not observed, suggesting that magnetic sensors probably exist in the renal vicinity (hypothetically, the adrenal gland regions). Extinction of response was also observed when the head was shielded, suggesting the existence of an additional magnetic sensory apparatus in the brain. A signature processor is proposed to account for transduction of the magnetic stimulus to a physical response (dowsing signal and L-rod movement) and to explain the apparent discrimination among magnetic signatures when a dowser responds to the signature for water, for example. Although hard evidence is lacking, numerous measurements and observations during the present experiment suggest that this processor is possibly associated with the sensory mechanism in the pineal region of the brain.

6357 A MICROWAVE COMPATIBLE MIC TEMPERATURE ELECTRODE FOR USE IN BIOLOGICAL DIELECTRICS. *(Eng.)* Larsen, L. E. (Dept. Microwave Res., Walter Reed Army Inst. Res., Washington, DC); Moore, R. A.; Jacobi, J. H.; Halgas, F. A.; Brown, P. V. *IEEE Trans Microwave Theory Tech* MTT-27(7): 673-679; 1979. (6 refs)

A four-terminal temperature electrode design for in situ use in tissues other than bone during microwave exposure is described. The design is based on hybrid microwave integrated circuit construction; the fabrication methods include a combination of thick- and thin-film techniques. Thick-film techniques are used for the four-terminal transducer subassembly, and thin-film techniques are used for the transmission line. Electrothermal matching is used to prevent artifacts in either of two directions: heat sourcing and heat sinking. The electrode is relatively free from heat sinking or heat sourcing for 2,450-MHz fields at a power level of 250 mW/cm^2 within phantom brain and air environments for the transducer subassembly and flexible hyperthin line, respectively. At the electrode tip, heat sinking is on the order of 0.15 C. Further development will require total system operation in a microwave environment with freedom from radio frequency interference and temperature coefficient effects in the temperature encoding and telemetry electronics.

6358 MICROWAVE APPLICATORS HELP TREAT CANCER. *(Eng.)* Anonymous. (No affiliation given). *Des News* 35(11): 83; 1979. (0 refs)

The use of localized microwave hyperthermia in cancer therapy is reported, with particular emphasis on the development of new microwave applicators. The principle of microwave hyperthermia in cancer therapy is related to the ability of heat in the range of 42-43 C to destroy malignant cells selectively while sparing normal tissues. In clinical studies involving patients with cancerous lesions on the skin or slightly below its surface, improved

rates of tumor regression were observed when microwave hyperthermia was used alone or in conjunction with radiotherapy. Recently, coaxial applicators have been developed that can be inserted into body cavities, thus making microwave hyperthermia available for the treatment of certain deep-seated lesions. Initial experiments with animals at frequencies of 2,450 and 915 MHz have been performed with these coaxial applicators (results not specified). The coaxial probes consist of a coaxial cable terminating in a radiating antenna. Heat can be induced within a spherical volume, thus allowing the use of these applicators in a body cavity with the aid of a catheter. To achieve directive heating, a metallic reflector can be used opposite the area treated. Other experimental applicators include dielectric-filled waveguides that are electrically matched to muscle tissue. These minimize reflections of microwave energy from the interface between the applicator and the adjacent muscle. Typically, more than 85% of the microwave energy entering these applicators can be transmitted into the muscle.

6359 AN INVESTIGATION OF ENERGY DENSITIES IN THE VICINITY OF VEHICLES WITH MOBILE COMMUNICATIONS EQUIPMENT AND NEAR A HAND-HELD WALKIE TALKIE. *(Eng.)* Lambdin, D. L. (Electromagnetic Radiation Analysis Branch, Office Radiation Programs, EPA, P.O. Box 15027, Las Vegas, NV 89114). 52 pp.; 1979. [available through the EPA, Office of Radiation Programs. EPA Report No. ORP/EAD 79-2]. (4 refs)

Electric field energy densities were investigated in and around nine separate vehicles using mobile communications equipment as well as in the near vicinity of a hand-held walkie talkie. The vehicles were equipped with 60- and 100-W transmitters broadcasting at frequencies of 164.45 and 41.31 MHz, respectively. The antennas used were either the ASP 446 base-loaded with 3 dB gain or the Phelps Dodge 551-509 base-loaded whip antenna with 2.5 dB gain. The walkie talkie operated at a frequency of 164.45 MHz with an output power of 1.8 W. The only instance in which the current American National Standards Institute standard of 177 nJ/m^3 was exceeded occurred within 6 inches of an active antenna. In most cases, the antenna was installed at a point on the vehicle where human contact or approach within 6 inches would be minimized (roof mounts). Two vehicles had antennas on or near fenders where exposure levels exceeding 177 nJ/m^3 to part of the body would be possible. In the case of a cowl-mounted antenna on a Chevrolet van, high exposures to the head area would be possible to a person working in the windshield area. Exposures exceeding 177 nJ/m^3 would be most likely to occur with the hand-held walkie talkie (200 nJ/m^3 at the eye). Several other areas, inside and outside of each vehicle as well as near the walkie talkie, showed exposures exceeding 10% of the current standard (17.7 nJ/m^3). Of the major sites measured and tabulated in the near vicinity of passenger sedans, about 5% of the exposures exceeded 18 nJ/m^3. Approximately 10% of the measured values close to and inside two vans exceeded 18 nJ/m^3, and nearly 40% of those associated with pickup trucks exceeded that value. Exposure levels at 6 feet or greater from any vehicle were much lower than 18 nJ/m^3. Since the two carrier frequencies investigated (41.31 and 164.45 MHz) were transmitted with 100 and 60 W, respectively, it is believed that these measured exposures represent maximum probable exposure from typical mobile communications systems. The walkie talkie represents the worst possible situation since the antenna is located within 3 inches of the eye.

6360 NUMERICAL STUDIES OF ABSORPTION OF ELECTROMAGNETIC ENERGY BY MAN. *(Eng.)* Hagmann, M. J. (Ph.D. dissertation, Univ. Utah, 1978); 160 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 7901556]. (10 refs)

A new synthesis procedure is developed for the design of antenna arrays where stepwise variation is desired in the radiation pattern, and the procedure is used to design a waveguide slot array for use in microwave biologic effects research. The procedure is based on weighted least squares and appears to provide better approximation than is possible with either Fourier synthesis or the Cesaro, Fejer, or Lanczos modifications of Fourier synthesis. Convergence criteria are established for moment-method solutions in electromagnetics, and the criteria are found useful in computations for one-, two-, and three-dimensional problems. Two new procedures are developed for improving convergence of numeric solutions in the two-dimensional electromagnetic problem, and two interpolants are developed that improve convergence of numerical solutions in the three-dimensional electromagnetic problem. It is suggested that interpolants should find general usage as a follow-up to moment-method solutions. A realistic model of man is made using an array of 180 cubical cells to represent the form of the 50th percentile standard man. Calculated values of energy deposition in the homogeneous model are in good agreement with experimental values for homogeneous phantom models. Ground, reflector, and multibody effects are treated numerically with models of man for the first time, and the dependence of energy deposition on frequency and spacing from reflectors is found to be consistent with antenna theory. Multibody effects, first predicted from antenna theory, are confirmed with numerical calculations and animal experiments.

6361 BRAIN INTERACTIONS WITH WEAK ELECTRIC AND MAGNETIC FIELDS. *(Eng.)* Adey, W. R. (Univ. California, Los Angeles, CA); Bawin, S. M. *Neurosci Res Program Bull* 15(1): 7-129; 1979. (377 refs)

Reports of behavioral, electrophysiological, and biochemical interactions with key regions of the extremely low frequency (ELF), radio frequency, and microwave spectra are discussed in a review of the limited range interactions of weak nonionizing